Carl Reidsema · Lydia Kavanagh
Roger Hadgraft · Neville Smith *Editors*

The Flipped Classroom

Practice and Practices in Higher Education

Springer

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Foreword

When I helped pioneer the flipped class model in 2007, some skeptics criticized it because of a lack of research, or thought of it as a fad that would soon go away. Many questioned the model because of perceived problems that have been easily solved by creative practitioners. Now after almost ten years of being at the forefront of flipped learning, I can categorically say that the flipped class model is having a huge impact on learning across the globe. I have personally seen flipped classrooms work in primary, secondary, and university classrooms, as well as with adult learners. There is a growing body of research which is proving that when done well, flipped classrooms are having a significant impact at every level and in every conceivable discipline. It is time to stop arguing about the efficacy of the flipped classroom and instead focus on determining best strategies for implementation.

With that backdrop, this book provides sound academic research, case studies, and practical strategies to implement flipped learning better. The authors each took a risk by flipping their classes, which required a considerable amount of time. These university professors took the time to conduct quality action research in conjunction with their regular teaching load. Then, they did the hard work of reflection, synthesis, and authorship. The result from their hard work is this book.

I believe that there is no one way to flip a class. The model must be customized and contextualized by each educator. A flipped math class should look different than a flipped science class. And a flipped art class should look different than a flipped engineering course. The authors of this book have done just that. They have taken the principles of flipped learning and applied them in their contexts to meet the needs of their students.

If you are still sitting on the fence about flipped learning, I encourage you to dive into this book. You will find practical suggestions coupled with quality research. Ultimately, how professors teach their courses matters, because the end users of university studies are students who deserve the best-quality education possible.

Jon Bergmann
Flipped Learning Pioneer
Author and Teacher
Lake Forest, Illinois
USA

Preface

New Ways of Learning

> This story brings another important point about social learning: it doesn't happen in isolation. A story like this is embedded in a broader context — a context that involves many different stakeholders…
>
> (Beverly and Etienne Wenger-Trayner, Interview, 2015)

Beverly and Etienne's thoughts on planning and evaluating a social learning framework for new educational times, speaks to the genesis of this book, whose shape emerged not in isolation but rather embedded within a broader context and guided by the involvement of many stakeholders from many academic and disciplinary backgrounds.

As authors, we began by wanting to share our goal of pursuing a new way of thinking, bringing into being the kind of curriculum that focuses on preparing students for the complexity of the modern world but from within the hallowed halls and ivory towers of institutions steeped in tradition. Through our engagement with like-minded colleagues and learning partners emerged a sense that what we sought to achieve through flipping the classroom could also provide us with much more than minor improvements to learning, but just possibly the first stumbling steps to a new way of learning, a new way of thinking about what might be possible.

Discussing these ideas with Beverly and Etienne served to highlight why we think this book is important in terms of the urgency that is required to transform our approaches to teaching in light of the rapidly changing nature of work and the problems we encountered due to the much slower processes of change to practices within higher education institutions.

Beverly Wenger-Trayner is a social learning consultant who works with organizations to develop strategies and practices for cultivating communities, networks and other forms of social learning.

Etienne Wenger-Trayner is a globally recognized thought leader in the field of social learning and communities of practice. He has authored and co-authored seminal articles and books on the topic, including Situated Learning, where the term "community of practice" was coined.

Urgency Versus Old Learning Models

> We're living in a time when things are moving fast. The rules of the game are changing. Science is changing. Technology is changing. Geo-politics is changing. Learning fast is the only mode of survival. But here's the crazy thing: our models of learning have not kept up. For many people, learning starts with something that's known. It's then transmitted to someone who doesn't know it. But for the projects we're involved in, this simple view doesn't work. In the real world things are too dynamic and complex.
>
> (Beverly and Etienne Wenger-Trayner, 2015)

The world of work has changed, but our students are for the most part still constrained by traditional transmission models of learning. If the flipped classroom, through technology, can now quickly, and with high quality, deliver the necessary concepts and facts which can guide action, then perhaps we can reimagine our campuses as places of activity and experience guided by more participatory expertise arranged in more authentic ways:

> …very often in teaching situations what is viewed as very problematic is the transmission of knowledge and information, and application is assumed as something that will follow. In our learning theory, applying what you learn is actually very creative, problematic, full of learning itself; so what we mean by a social learning space is we include in the learning the issues of applying that learning to practical situations.
>
> (Beverly and Etienne Wenger-Trayner, 2015)

If you are feeling trepidation at the thought of change at this moment, let us validate those feelings. All of our own stories began in the same way with the decision to move forward and begin to flip our courses, some with a toe in the water and some head first crashing through the bush, but all of us firmly grounded in the research, with many years of practice in teaching and learning at university. Larry Leifer, our esteemed colleague and mentor from Stanford's Design Research Centre and School originator, encourages us with his metaphors of "way finding" and "hunting" which require us to begin, somewhere, anywhere. The research is there to consult those that have gone before you are eager to guide and support you, and this book will hopefully provide you with new ideas to help you frame, understand, and approach whatever hurdle you may face within your own unique context.

Immediate Value and Potential Value

> You meet others who understand you, talk shop, think together, have fun, get to know each other, feel inspired. You get value from just participating. We call this immediate value. All going well, this activity gives you confidence, new insights, good ideas, new perspectives, unexpected solutions, a new contact … We say that these things represent potential value, because they may – or may not – end up being helpful to you. For many people learning ends there. Not for us.
>
> (Beverly and Etienne Wenger-Trayner, 2015)

Having started flipping our classrooms, we found ourselves connecting with others interested in the idea and made many allies with whom we could share ideas and experiences. The essence of this book is essentially the immediate value we created through these connections. In 2014, we ran thirteen invited workshops across institutions, disciplines and countries; we exposed our techniques and our practices to over a thousand academics in that twelve-month period. Many of the contributors to this book engaged in these workshops, sharing and learning about our flipped classroom practices. Their stories, like the story we share in Chap. 9, which is located in Part II of this book, are a collection of practical experiences of implementing flipped classroom approaches involving the trials, tribulations, and jubilations in making the change.

What is also unique about our contributors' chapters are the broad-based disciplinary backgrounds their stories hail from. This reflects the true nature of the new working world that our students will experience in which boundaries are seen as hindering change. It is through negotiating these cross-disciplinary boundaries that the sharing of knowledge facilitates greater positive change and this is much needed within higher education. As Beverly and Etienne Wenger identify, community boundaries have become blurred and complex and it is important that we practice and embrace this if we are still to be the academic gatekeepers:

> …the communities that we are asked to facilitate have become more complex. In the past you had for example engineers trying to form a community … But more recently… there are more communities among people that would not work naturally. They are being brought together and they may well be thinking 'what am I doing here?' we have nothing in common with these people.
>
> (Beverly and Etienne Wenger-Trayner, 2015)

We hope this book can act as a catalyst for change to your practice or at least stimulate a conversation among you and your colleagues as to the potential value that flipping your class can provide. We leave the last words to Beverly and Etienne as to why we feel it is important to at least try and change your practice:

> Applying things in practice is not only a creative act but it is also something that may be successful or may fail and what you learn from it being successful or what you learn from it being a failure or anything in between is a significant part of the learning.
>
> (Beverly and Etienne Wenger-Trayner, 2015)

Brisbane, Australia — Carl Reidsema
Brisbane, Australia — Lydia Kavanagh
Sydney, Australia — Roger Hadgraft
Brisbane, Australia — Neville Smith

Reference

Wenger-Trayner, B., & Wenger-Trayner, E. (2015). *Social learning theorists and consultants.* Retrieved from http://wenger-trayner.com/

Overview and Acknowledgements

Flipped classrooms seem to be all the rage in higher education, but what is a flipped classroom, what are the arguments for it, and how would you go about it? This book sets out to answer these questions by sharing the practice and practices of innovative academics from across the globe who have seen and acted on the opportunities that rapid changes within higher education have created.

Employers, parents and students are demanding better value for money and more work-ready graduates. MOOCs and social media combined with ubiquitous mobile computing are transforming how students learn, together with their expectations of a university education. Is the flipped classroom an answer to the unique opportunities that this time in history offers?

This book arose from early innovations at the University of Queensland, Australia, in flipping a large (1200 students) first-year engineering course resulting in Australian Government funding support from the Office for Learning and Teaching (OLT) for a global learning partnership led by the University of Queensland, Purdue University, Stanford University, University of Sydney, RMIT University, and University of Pittsburgh.

The collaboration spawned an explosion of national and international workshops to share best practice, ideas, and support allowing the gathering together of a wide range of responses to many of the developing ideas. While these workshops are continuing, as more universities are implementing various flipped classroom models, it is an opportune time to share what we have learned so far.

This book brings together some of the ideas of the core project team that define good practice (Part I: Practice) together with a broader set of case studies demonstrating diverse practices (Part II: Practices), mostly in the STEM (Science, Technology, Engineering, and Mathematics) disciplines. We hope that you will find the case studies useful. We have categorized them using various criteria in Chap. 6, so that you can dip into those most appropriate for your own circumstances, based on class size, discipline, year of study, etc.

A book such as this is the product of many contributions. First, we gratefully acknowledge the case study authors, who have generously provided their time and expertise to articulate the nature of their own flipped classrooms. Second, we acknowledge the various members of the OLT project team, who have contributed to the project from the concept stage. Apart from them, the project team members included Phillip Long (the University of Queensland, now the University of Texas), Abelardo Pardo (the University of Sydney), Mary Besterfield-Sacre (the University of Pittsburgh), Robin Adams and David Radcliffe (Purdue University), and Larry Leifer (Stanford University). We would also like to make special mention of Ellen Juhasz, our wonderful project manager. Finally, we acknowledge our friends Etienne and Beverly Wenger-Trayner whose value in contributing knowledge to this book as pioneers in social learning helped to plot a course in the direction we sought from the outset. Their contribution is highlighted in the preceding preface.

We encourage you to dip into this book at random. The provides a quick overview of why we think the flipped classroom has emerged at this point of time and what it has to offer both students and academics; The outlines some of the key ideas covered in Part I. The remaining chapters might be read in any order depending on your need.

Finally, best wishes for your own experiments. We would like to hear about them.

Carl Reidsema
Lydia Kavanagh
Roger Hadgraft
Neville Smith

Contents

Editors and Contributors

About the Editors

Roger Hadgraft is a professor of civil engineering with more than 20 years of involvement in improving engineering education. He has published many papers on problem- and project-based learning and used online technology to support student-centered learning to meet the needs of engineering employers. He was instrumental in introducing a project-based curriculum in civil engineering at Monash University in 1998 and in civil, chemical, and environmental engineering at RMIT from 2003 to 2006, with special emphasis on new, project-based subjects in first year. Roger was the foundation director of the Engineering Learning Unit at the University of Melbourne, assisting with the introduction of the Melbourne Model, 2007–11. He coordinated the new program in sustainable systems engineering at RMIT from 2012 to 2013 and was deputy dean for learning and teaching at CQUniversity, 2014–15. He is currently the director of educational innovation and research in the Faculty of Engineering and Information Technology at the University of Technology Sydney. Roger has consulted on PBL to universities both nationally and internationally.

Lydia Kavanagh is a chemical engineer who returned from industry to academia over a decade ago. She is currently employed by the University of Queensland as the director for first-year engineering and as such has oversight of 1200 students each year. Lydia's research focuses on engineering education and includes issues such as work-integrated learning, graduate competencies, successful student teamwork, online learning, and strategies for transition to first year. Currently, she is involved in an international project concerning "flipping the classroom" and establishing learning partnerships. Lydia won a national teaching award for excellence in 2012 for her work with students, curriculum and teaching scholarship. She is an associate editor for the Australasian Journal of Engineering Education.

Carl Reidsema is an associate professor who is a mechanical design engineer with over 12 years of industry experience. Beginning his academic career at the University of New South Wales in 2001, he led the faculty development of the first hands-on active learning team-based first-year common course in engineering design "ENGG1000-Engineering Design and Innovation" involving over 1100 students. In 2010, he was appointed to the position of director of teaching and learning for the Faculty of Engineering at the University of Queensland where he led the successful development of the flipped classroom model for integrating theory with design practice in a first-year engineering design course "ENGG1200-Engineering Modelling and Problem Solving" with over 1200 students. Carl's work is centered around the notion of transformational change in higher education which is reflected by his success in securing grants and industry funding for research and development in this area. These include a 2008 Australian Learning and Teaching Council (ALTC) Project "Design based curriculum reform" and the 2013 Office for Learning and Teaching (OLT) Project "Radical transformation: re-imagining engineering education through flipping the classroom in a global learning partnership" partnering with Stanford, Purdue, Pittsburgh, Sydney and RMIT universities.

Neville Smith is a Ph.D. student in the field of education having completed a bachelor of education (Honors), a bachelor of behavioral studies, and a bachelor of education (Middle Years of Schooling). Neville's Ph.D. interest and topic is centered on change and transition, particularly in the area of exploring the lived experiences of transition for international Ph.D. students in Australia. He previously worked as a researcher on the 2013 Office of Learning and Teaching (OLT) Project "Radical transformation: re-imagining engineering education through flipping the classroom in a global learning partnership." Neville also has tutored extensively for the previous six years in the School of Education and Faculty of Health Sciences where he also held a position as a coordinator for a large-scale faculty-wide first-year program.

Contributors

Dr. Yasir M. Al-Abdeli is a teaching research scholar in mechanical engineering with interests in energy/thermofluids and engineering education. Recognitions: University Vice-Chancellor's Award for Engagement in Learning and Teaching (2010); and proceedings coeditor/Technical Chair for the 22nd Annual Conference for the Australasian Association for Engineering Education (2011). He has a Ph.D. (2004) from the University of Sydney as well as master's (1994) and bachelor's (1990) degrees from the University of Technology—Baghdad.

Dr. Mary Besterfield-Sacre is an associate professor and Fulton C. Noss faculty fellow in industrial engineering at the University of Pittsburgh. She is the director for the Engineering Education Research Center (EERC) in the Swanson School of Engineering and serves as a center associate for the Learning Research and Development Center. Her principal research is in engineering assessment, which has been funded by the NSF, Department of Education, Sloan Foundation, Engineering Information Foundation, and NCIIA. Dr. Sacre's current research focuses on measuring the impact of engineering international experiences on students' global competencies. She has served as an associate editor for the JEE and is currently the associate editor for the AEE Journal.

Katie Brooker is a Ph.D. student with the Queensland Centre for Intellectual and Developmental Disability at the University of Queensland. Katie's research is focused on the relationship between physical activity and social support for people with intellectual disability. Katie is also interested in exploring the use of qualitative methods when conducting research with people with intellectual disability.

Jan Carlstedt-Duke is a professor of molecular endocrinology, dean emeritus and senior adviser, rectorate, and chairman of the Steering Committee for the undergraduate medical program at Karolinska Institutet, Stockholm. In 2008, he was appointed as director of Medical School Project at Nanyang Technological University (NTU), Singapore, to develop a new Medical School at NTU, the Lee Kong Chian School of Medicine, which has been established in collaboration with Imperial College London. He is now a member of the Governing Board of the school.

Renee Clark has 23 years of experience as an engineer and analyst. She serves as the director of assessment for the University of Pittsburgh's Swanson School of Engineering and its Engineering Education Research Center (EERC), where her research focuses on the assessment of engineering education research projects. She has also most recently worked for Walgreens and General Motors/Delphi Automotive. She received her Ph.D. in industrial engineering from the University of Pittsburgh and her MS in mechanical engineering from Case Western.

William W. Clark is a professor of mechanical engineering and materials science at the University of Pittsburgh where he has been an active researcher and teacher in the field of dynamic systems and controls for over twenty years. His teaching experience includes courses in dynamic systems, measurements, controls, mechatronics, and design, as well as a never-ending search for ways to improve his effectiveness in the classroom.

Dr. Kate van Dooren is a public health researcher whose work has concentrated on improving the health system for people with disability and those who have experienced incarceration. She is currently Associate Lecture at La Trobe University.

Esther Fink is the eLearning Educational Designer for the Faculty of Engineering, Architecture & Information Technology at the University of Queensland, Australia where she supports both faculty/school teaching and learning leaders and academic staff with the design, development, implementation and evaluation of online and blended learning. Her experience in higher education and vocational education spans 3 continents and 20 years.

Dr. Lisa Fitzgerald is Lecturer at the University of Queensland School of Public Health. Her research interests include the social determinants of health of vulnerable and marginalised populations, social research that uses innovative qualitative research methods to gain rich insights into the lived experience of marginalised and vulnerable people. Lisa has a strong teaching portfolio that extends beyond her classroom and incorporates successful teaching-based grant applications, publications, and presentations, including a keynote at the National Council of Academic Public Health Institutions Australia (CAPHIA) Annual Forum (Fitzgerald, 2013). Lisa's teaching awards draw testament to the work she does to motivate and inspire a diverse cohort of students through a values-based curriculum grounded within an active learning model.

Greg Fowler is Adjunct Lecturer in Health Systems and Policy at the University of Queensland. He is also Principal Advisor to the Premier of Queensland on health related public policy.

Paul Gagnon is a founding director of e-learning and IT services at the Lee Kong Chian School of Medicine, NTU, Singapore. He is a pioneer in the integration of e-learning systems to support a blended learning pedagogy. Most notable is his roll-out of what he and his team have termed: "The LKCMedicine Learning DNA: the alignment of the strands of technology and curriculum via a Team Based Learning (TBL) pedagogy."

Anne Gardner is a senior lecturer in the Faculty of Engineering and IT at the University of Technology Sydney. Her research in engineering education is focused on improving understanding and assessment of collaborative learning, workplace learning by professional engineers, and professional development for engineering education researchers. She is currently a UTS future learning fellow, a role requiring leadership in demonstrating and disseminating innovative teaching and learning practices throughout the university.

Cathie Gillan is a health policy practitioner who works for Queensland State Government and formerly worked for Sydney South West Area Health Service in NSW. She is interested in the translation of research and theory into practice and exploring the development of rich learning environments in classrooms and workplaces.

Geoff Greenfield is a lecturer in strategy at the University of Queensland Business School. He has published in the area of technology acceptance and specifically in the area of user acceptance in the not-for-profit sector. His teaching is focused on business management and strategy.

Anthea Groessler had been a learning designer for over ten years in tertiary education with a master of education, majoring in education technology. She is with the Institute for Teaching and Learning Innovation at the University of Queensland delivering academic development principally around the flipped classroom and supports and advises teachers in pedagogy and technology. Anthea is currently undertaking a collaborative research project on technology-enhanced assessment connected to the International Society for the Scholarship of Teaching and Learning.

Paul Hibbert is a dean of the Faculty of Arts and Divinity and professor of management at the University of St Andrews. His research is principally concerned with collaborative and relational processes of organizing and learning and is published in leading international journals. His pedagogic interests focus on reflective and reflexive practice and critical approaches to education, especially in relation to management studies.

Dr. Julie McCredden is the Educational Researcher of the first-year engineering project in the Faculty of Engineering, Architecture & Information Technology at the University of Queensland, Australia. Julie's background is in cognitive psychology where she has over 15 years of research experience in addressing fundamental issues in cognitive processing, such as the limits to human processing capacity, development of relational schemas, analogical reasoning, and the early development of fundamental concepts. Julie's research focus has been finding methods for assisting students to learn complex concepts, such as metacognitive activities, scaffolding of complex concepts, and finding tools for recording hand-drawn diagrams and sharing them online. Julie's future aims are to embed methods for teaching complex concepts into engineering courses, to find methods for promoting online critical discourse between students, and to develop methods for instilling the art of reflective practice into both teaching and learning at all levels of tertiary programs.

Dominic McGrath is a learning designer in the Institute of Teaching and Learning Innovation at the University of Queensland. Dominic has a particular interest in how academics learn as professionals and innovate. He is currently collaborating on technology-enhanced learning projects to support teachers new to UQ, engage teachers in peer observation, and develop institution-level-recommended technology-enhanced learning practices.

Patricia McLaughlin is currently employed at RMIT University, Australia. Her background includes lecturing in project and construction management. Prior to academia, Tricia was employed by the Parliament of Victoria as executive officer, for the Parliamentary Inquiry into the Building Industry. She worked in the Australian construction industry, held positions on industry skills council, and was employed as an advisor in the Hawke Government. She has been the recipient of a number of competitive research grants and a number of university and national teaching awards. Her research publications, including three books, span both her discipline and the scholarship of learning and teaching.

Redante Mendoza is a trained medical doctor and pathologist and is the deputy director of pedagogy for the Lee Kong Chian School of Medicine. His focus is on team-based learning, a flipped classroom approach. He assists professors and teaching assistants at NTU, Singapore, in the implementation of the TBL pedagogy to foster and support innovation in teaching and learning.

Negin Mirriahi currently teaches in UNSW Australia's Graduate Certificate of University Learning and Teaching, coordinates the Foundations of University Learning and Teaching Program, and coteaches the Learning to Teach Online MOOC. Her research focuses on investigating student learning and experience in online, blended, and flipped classroom settings and learning analytics to inform course design and pedagogical practice.

David Mitchell is an associate professor in land administration and management. David holds a B. App. Sci (surveying) and a Ph.D. in land administration. David has over 16 years of teaching experience at RMIT University and has maintained close connections with industry. He teaches undergraduate courses in cadastral surveying and land development. In 2013, he was the recipient of the RMIT Science Engineering and Health Award for Teaching Excellence.

Allyson Mutch is a senior lecturer in health systems and the director of teaching and learning at the University of Queensland's School of Public Health, and her research focuses on the social determinants of health and the health and well-being of people who are marginalized and experiencing disadvantage. She also focuses on the role of primary care and community-based systems in supporting people who are experiencing disadvantage. Allyson has been teaching undergraduate health sciences for many years, and her scholarly focus is on improving the understanding and assessment of student collaborative learning with a teaching team approach as well as professional development for health education researchers. In 2014, she and her team flipped the classroom for the first time and continued to refine the flipped classroom approach based upon student and teaching team's feedback and reflections.

Cindy O'Malley is a medical scientist with a keen focus on teaching and learning. She has experience in laboratories and universities in Australia and the UK. She is a fellow of AIMS and IBMS, is a chartered scientist, was accepted on to the register of practitioners of the Higher Education Academy in 2005, and is the Teaching Innovations Fellow for 2015 in Science, Engineering and Health at RMIT. Her passion is to engage students with active learning in classes and to encourage her colleagues to do the same.

Kriengsak Panuwatwanich is a senior lecturer and program director for the bachelor of engineering in civil engineering at the Griffith School of Engineering, Griffith University. He teaches in the subject of engineering project management at both undergraduate and postgraduate levels. His research expertise encompasses the areas of engineering, construction, and project management as well as engineering education. He is 2014 Chairman of Engineers Australia's Gold Coast Regional Group and currently serves as Vice President of the Association of Engineering, Project, and Production Management.

Abelardo Pardo is an associate head of teaching and learning and a senior lecturer at the School of Electrical and Information Engineering, the University of Sydney, and research fellow at the Learning Innovation and Networked Knowledge Research Lab, the University of Texas, Arlington. He is the director of the Learning and Affect Technologies Engineering Laboratory specialized in the design of adaptive and personalized software systems for learning.

Pauline Porcaro is currently a project manager for the Global Learning by Design project at RMIT University. With over 20 years of teaching experience, she is committed to working with teaching staff to develop excellent teaching practices as a means for student engagement and has been heavily involved in upskilling academics in the methodology of the “flipped classroom.” A trained teacher, she holds a master’s degree in education from Monash University.

Cassandra Ranatunga has been part of the first-year public health teaching team for over 6 years. Her experience in health education has also involved facilitation and professional development of various groups in settings that have included other professionals, school and university students. Cassandra completed her Master of Public Health at The University of Queensland in 2014 and now works in public health and health economics research.

Linda-Dianne Willis is a teacher-educator and researcher at the University of Queensland where she lectures in curriculum studies and directs the master of teaching (primary) program. She is the coeditor of *Practical Literacy*. Her tertiary teaching focuses on contemporary strategies for effective teaching in English and the humanities and social sciences. She is recognized for her innovative pedagogical approaches such as flipping the classroom and collaborative strategies such as coteaching and cogenerative dialoguing.

April Wright is an associate professor in strategy at the UQ Business School at the University of Queensland. She has published research in institutional change processes, professions, and management education in leading international journals. Her teaching is focused on large undergraduate courses in introductory management and strategy.

Dr. Charlotte Young is Associate Lecturer at the University of Queensland School of Public Health (SPH). Charlotte’s research centres on primary care practice, public health policy and delivery of care to vulnerable populations. As an early career academic committed to student learning, Charlotte teaches numerous courses and plays a leading role in the development and delivery of teaching innovations across SPH.

Part I
Practice

Chapter 1
Introduction to the Flipped Classroom

Carl Reidsema, Roger Hadgraft and Lydia Kavanagh

Abstract It is Monday morning, bright and early, as Laura rushes from the bus stop to the massive event centre, where her first-year engineering workshop is being held. It is the second week of the course and she knows that she is falling behind a bit because she did not watch the recommended pre-learning podcast for this workshop that, she seems to recall, is something to do with setting your learning goals. She is still a bit puzzled because this course is not like any of her other courses in first-year engineering. The professor called it a flipped classroom and although she is not exactly sure what that means, she knows that there are not any lectures, which kind of irritates her a bit. The purpose of beginning our book "Flipped Classroom Practice and Practices" with this example is that it provides us with one of the most audacious, yet promising implementation of the flipped classroom approach that we are aware of. Successfully integrating fundamental disciplinary knowledge with active, authentic practice at such large scales challenges some of our most dearly held beliefs about learning in higher education (i.e. the lower the student/staff ratio the better) and also shines a light on a range of issues that are systematic to the culture and organisational structure of today's universities. These issues must be resolved if we are to successfully adapt to the social and technological changes we currently face. And this is why we flipped our classroom.

Keywords Flipped learning · Collaboration · University transition · Social media · Educational technology

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A Vignette It is Monday morning, bright and early, as Laura rushes from the bus stop to the massive event centre where her first-year engineering workshop is being held. It is the second week of the course and she knows that she is falling behind a bit because she did not watch the recommended pre-learning podcast for this workshop that, she seems to recall, is something to do with setting your learning goals. She is still a bit puzzled because this course is not like any of her other courses in first-year engineering. The professor called it a flipped classroom and although she is not exactly sure what that means, she knows that there are not any lectures, which kind of irritates her a bit.

She had already started to make decisions on which lectures she needs to come to campus for and which ones she is just going to watch the video recordings at home (sometimes fast forwarded) in her own time. But this class is different because they are doing lots of group-based and hands-on stuff on campus. They are apparently going to be learning how to collect data from laboratory testing machines and using it to solve a murder mystery in a few weeks' time. That sounds pretty crazy she thinks as she hustles down the hallway.

She still cannot believe the number of small tasks that they are asking her to do and figuring out how to manage her time certainly seems to be occupying a lot of her thinking lately. Not many of these small tasks attract a lot of marks either, which is also a bit annoying, but they do seem to be helping her to keep building towards the larger assessment tasks that include designing and building a flight vehicle that will be launched across the football field in an end of course competition.

As Laura enters the huge room, she looks around for Sam and Kath who she met in last week's session. They are both civil engineers and doing a different semester long major project than she is. They all got to choose their projects when they enrolled in the course and she chose the aerospace project, but the workshop this week is on setting learning goals which applies to everyone in the 1200 student, first-year modelling and problem-solving course, so she gets to decide where she will sit. Looking across the room, she can just see them amid the boisterous sea of 600 faces and she heads quickly over to grab the one empty seat at the oversized round table that they are sitting at with six other students who she has not met before.

Just in time too as one of the two professors who run the course begins to talk, catching them up on the main points from the podcast that they were supposed to have watched and then he asks "How many of you watched the podcast? Raise your hand". Last week hardly anyone raised their hand but as Laura scans the room she sees that more than half of the students and even three at her own table have their hands in the air.

She feels a little bit guilty and decides that she had better set aside some time tonight to start working through the videos that they have told her she needs to do for the smaller workshops that are scheduled later in the week around engineering materials. If she does not do these, her team might rate her poorly in the online peer assessment, which means she will lose marks for the half of the course that is team work and she will not be on top of things by the end of the week when she has to do the weekly online quiz on materials fundamentals.

She looks at the template they have given her to work with and as one of the four floor tutors wanders past her table, she decides to ask him what she is supposed to do if she missed watching the podcast? “Well”, he says over his shoulder as he scoots past to another group of raised hands, “looks like you’re going to have to ask someone at your table who has watched it. If you get stuck, raise your hand and I’ll come back!”

It is going to be a long semester, Laura thinks to herself as she looks across the table and considers how to approach the well-prepared international student who is hard at work filling out her template.

1.1 Why We Flipped

Laura is a student in “ENGG1200 Engineering Modelling and Problem Solving”, a second-semester, first-year engineering course at The University of Queensland which is fully flipped without a single lecture in sight and lays claim to being one of the (if not the) largest fully flipped classrooms anywhere in the world.

In 2010, a small team of academics set out to design an entirely new course (ENGG1200—Problem Solving and Modelling) from a completely blank slate for over 1200 first-year engineering students (Reidsema et al. 2014). The task was to see whether it was possible for students to learn all of the core concepts (or theory) of introductory engineering materials that had been successfully taught in a traditionally run course with lectures, tutorials and an examination by integrating the theory with an active-learning, student-centred approach to developing engineering modelling and problem-solving knowledge and skills. The learning outcomes for the new course would be delivered through a semester long hands-on design and build project, with students working in teams of six.

The purpose of beginning our book “Flipped Classroom Practice and Practices” with this example is that it provides us with one of the most audacious, yet promising, implementations of the flipped classroom approach that we are aware of. Successfully integrating fundamental disciplinary knowledge with active, authentic practice at such large scales challenges some of our most dearly held beliefs about learning in higher education (i.e. the lower the student/staff ratio the better) and also shines a light on a range of issues that are systemic to the culture and organisational structure of today’s universities. These issues must be resolved if we are to successfully adapt to the social and technological changes we currently face. And this is why we flipped our classroom.

1.2 What Is a Flipped Classroom?

Although research on the flipped classroom is still in its infancy, most publications (peer reviewed or otherwise) offer up definitions that describe the flipped classroom as a type of blended learning (Abeysekera and Dawson 2015). While blended learning can be considered to be the marriage between "online learning" and "on-campus face to face learning" activities, the flipped classroom is not just blended learning re-badged. There are a few very important differences.

In the flipped classroom, students are required to engage in or complete some form of preliminary learning online in preparation for a structurally aligned learning activity on campus with their instructors and peers. The structural alignment between these two activities is an important distinction for those who may think that simply uploading their lecture recordings will suffice. In flipped mode, students will be meeting a topic for the first time online usually via short and to the point videos, rather than through attending a lecture as has been traditionally the case. This sudden change in direction (often referred to as "reverse teaching") can be quite confronting to students whose conceptions of university teaching are that new material should be presented by a professor in a lecture that they have paid good money to attend.

Paradoxically, this reliance on the lecture has led to one of the most common reasons that flipping in higher education became an attractive proposition. Most universities now provide online recordings of lectures and some of our students have decided that actually attending lectures is therefore optional preferring instead to watch them later.

However, it is not just this characteristic of temporality that distinguishes the flipped classroom from more traditional methods of instruction including blended learning. By requiring our students to prepare for on-campus learning activities, we set in motion a number of important changes which could rightly be seen to be either distinct threats or profound opportunities for the teacher as well as the student. Let us pause a moment and consider what this means.

When we insist that our students prepare in advance of our direct involvement with them, we are likely to be interfering with our student's conceptions of teaching and the student–teacher relationship. While the degree of acceptance to which this new proposition will be received will vary with age, year of study, previous curriculum experiences and current institutional practices, there will be some very strong feelings triggered from both students and teachers.

Teaching from the lectern can at times feel very challenging, but this pales in significance to what we imagine it might be like when suddenly faced with a room full of students who are prepared for intellectual battle. Having insisted that our students take responsibility for their learning, we can be assured that many will come armed with clear expectations that their effort should be rewarded. What do we do then with students who are no longer simply a passive audience and who rightly expect something more than a didactic lesson? Flipping the classroom therefore not only alters the traditional role of the student but also necessitates an equal commitment to change from the academic. This then is another important difference between the flipped classroom and blended learning.

Considering what this might mean to the way in which we conceive of our teaching, we can indeed see that there is more to this than just putting videos up online for students to watch before coming to campus. In order to recast the traditional learning environment, we will need to determine what learning activities we will deploy and how they will be arranged into (and supported by) a narrative. This narrative or story helps us to create the meaning necessary to ensure our students are engaged when we step down from the lectern. Shifting from the role of "Sage on the Stage" is to grapple with letting go of what to many of us, is one of the more pleasurable and rewarding parts of our role as university teachers. Despite the wall of evidence telling us otherwise, many of us will simply refuse to admit that lectures are limited in their ability to both adequately engage our students and achieve the best gains in their learning. Typical knee jerk reactions that students nowadays just are not what they used to be will not suffice. For those of us who are willing and able to take the plunge, we are now on a surer pathway to being the masters of our apprentices and immense satisfaction as well as frustration awaits us.

Shifting our reliance on lectures as the default means of providing students with their first exposure to important concepts is perhaps one of the single most important challenges currently facing higher education and looks like remaining so well into the future. While there is no need to worry that lectures are dead, this didactic form of learning almost certainly is—with notable exceptions such as the "interactive learning" and "peer learning" approaches being led by Carl Weiman (Deslauriers et al. 2011) and Erik Mazur (Crouch and Mazur 2001). If decades of solid research in the learning sciences have taught us anything, it is that active learning is a more effective method for developing conceptual knowledge and understanding. There are also very limited opportunities to develop professional practice knowledge and skills within the confines of a lecture theatre. If this is the case, then surely our goal must be to identify these types of ineffective learning activities and replace them wherever possible with active learning across a range of space types on campus.

The good news is that with careful curriculum design, the evidence suggests that students learn in flipped mode just as well, and usually better, than they do if they are simply attending a lecture. This is actually great news because those precious minutes on campus which would consist of sitting quietly in a lecture theatre facing forward, listening, and watching and, perhaps asking questions and taking notes, can be replaced by doing things and thereby engaging in practice.

In ENGG1200, flipping first exposure to content out of face to face time allows engineering students to get hands-on practice with machines and tools, physically experience materials, tackle complex authentic problems individually and in teams, and deal with significant inter- and intra-personal challenges. These are the kinds of challenges that develop important learning skills that improve students' academic success and which lead to high-performing professional graduates who can plan and prepare ahead of time for important events, arrive on time able to handle difficult interpersonal communication and collaboration challenges, engage with diverse cultures and competently acquire and value-add knowledge from a range of sources.

Flipping the classroom allows us to be able to cover both the theory and the practice of engineering rather than having to settle with only covering the content and leave the rest to industry. We can choose from a huge array of possible learning activities from focusing on deepening conceptual understanding to integrating entirely new narratives, for example, activities where our students act as student engineers, apprentice research engineers, or young professionals in practice.

Let us return to the vignette at the beginning of this chapter with Laura rushing from the bus stop to her class.

1.3 Student Challenges

Laura is typical of first-year students who arrive fresh from high school, new to the demands of university study where they find that they must take significantly more responsibility for their learning.

Within the cohort that we see entering first-year engineering in Australia, we encounter students who would score relatively low on Perry's nine-point scale of epistemological development (Perry 1970). That is, these students find it difficult to deal with ambiguity, tend to view knowledge in absolute terms as either right or wrong, and expect authority figures, such as a professor, to transfer learning to them. Although there have been many recent changes in K-12 pedagogy, school assessment for the most part is still geared towards examinations designed to gain entry to university. It is therefore little wonder that many of our incoming students use surface learning approaches that are strongly grade oriented. These students confronted with the flipped classroom pedagogy often find themselves at odds with the challenge and discipline required to complete pre-learning and engage in co-construction of knowledge via on-campus collaborative learning activities. We should persist, however, as this is at the exact heart of the knowledge and skills that industry and society are demanding we develop in our students. It also happens to be exactly the type of knowledge and skills that academics believe that our students need in order to develop as high-achieving academic students.

Let us take another look at these "millennials" who we now greet at the doors of our ancient and esteemed institutions as they are perhaps the most diverse cohort we have ever encountered (Coomes and DeBard 2004). As bright and intelligent as any who have come before them, they carry their smart devices everywhere they go, seemingly completely at home in the world of social media and the Internet. By contrast, it is only recently that academics have begun to realise the full extent of the technologically driven social disruption, and one of the most unsettling facts is that the majority of our senior academic staff, those that are in a position to make critical decisions, were born before the advent of the Internet and the personal computer. Even our younger staff were born before Facebook, Twitter, Google and Wikipedia which are all second lives and second nature to our students (Bexley et al. 2011). We are clearly at a turning point in regard to the way in which we engage these students in their learning.

In our vignette, Laura encounters course expectations and challenges that are clearly outside her comfort zone. In ENGG1200, students are given lots of specifically designed small activities that challenge them to construct their own learning. As the course has matured, an increasing array of targeted learning tools have been tried, tested and developed. These tools do not just provide first exposure of engineering materials concepts and content, they also provide visual learning pathways that support the student in navigating through the course with extensive thought given to supporting peer–peer and peer–teacher communication. A more in-depth explanation of how a flipped classroom can be designed to support students in authentic practice can be found in Chap. 7.

1.4 Academic Challenges

As industrialised countries steadily transition towards a product-service economy that is increasingly reliant on information technology, the demand for more undergraduate degrees has increased. Universities have been quick to cater to this market by increasing their student intakes, but with limited higher education budgets and productivity as a major institutional goal, they have not been so quick to increase their teaching staff.

The initial enthusiasm by senior management for the flipped classroom had an element of wishful thinking: if the number of lectures could be reduced by putting them online, perhaps time could be freed up to allow high (institutional)-value researchers to develop research instead of teaching. However, while there are definitely benefits to be had in reducing the number of lectures, the concomitant time required to develop and deliver both online materials and on-campus learning activities far outweighs the relatively small amount of time typically invested in updating and delivering a lecture.

So the situation appears to be that staff to student ratios are decreasing, the impetus to excel in terms of research performance is stronger than ever, and flipping requires additional effort. Added to that is a growing sense of frustration that universities are not keeping up with the changing demands of society for what is perceived as a value for money, quality education: an education that offers more relevant and personalised educational experiences.

1.5 Flipped Learning—Where to from Here?

So, where are we going with flipped learning? Will we see much the same practices in 20 years' time? Will we still be discussing flipped learning then?

There are some inescapable trends. Support for online learning is becoming ubiquitous: Wikipedia, the Khan Academy, Udacity, Codecademy, Lynda.com, Skillsoft and thousands of other sites.

Skillsoft claims (on their website): *We train more professionals than any other company in the world, 400 million users, one billion learning modules and counting*.

Similarly, Lynda.com provides a wide range of business, computing and design modules, among many others. The future of learning skills is online.

So, if everything is online, will we have universities, as we know them, in 20 years?

We believe that flipped learning is an important transition stage. It is moving both students and academic staff away from traditional lectures, an approach that has been in use since the middle ages. Classrooms are becoming places for activity rather than information transfer. Students can get information online, increasingly in video format, rather than text—the oral tradition, suppressed by the printing press since 1440, is re-emerging.

Whether the students watch the videos before class or after class may not matter too much. What matters is that they are deeply engaged in real problem-solving.

There are a range of pedagogies that emphasise active learning—problem-based learning, project-based learning, inquiry-based learning, team-based learning to name a few. Each of these approaches, like flipped learning, expects students to find information for themselves and share it with the team—an important skill for future workplaces.

These pedagogies represent the next step beyond flipped learning. Students acquire knowledge and skills online and use them to solve or address a real problem or opportunity. Teachers may still provide some scaffolding in this process, particularly in first year of university. However, that will diminish over time as more and more students are independent learners by the time they get to university.

Activity-based learning enables more open-ended and self-paced learning. Increasingly, students will use an e-portfolio to document their learning achievements and to plan their next steps from both a career and learning perspective. Students will come together to work on projects in multi-age settings, working with mentors, often from industry. Their e-portfolio will be the sum total of these experiences, demonstrating achievement of fundamental knowledge and the ability to apply such knowledge in complex situations.

Some of these learning experiences will be in the workplace. In fact, the days of four years of full-time study at university may be over for many students.

Currently, students come to university and endure at least the first two years learning the basics, mostly through drill and practice classes, delivered in traditional ways. There is usually at least one subject where they get a sense of what it is that a professional does and how they do it (usually some kind of problem-solving). Years 3 and 4 are often application years and extensions of the fundamentals into deeper understanding of the discipline.

Flipped learning is transforming years one and two. Students can move ahead at their own pace and use class time to catch up with academic staff in case of difficulties. The Khan Academy is already supporting this kind of learning at school and beyond.

In most engineering, science and health curricula, there is a clear separation of theory and practice—learn scientific analysis skills in one subject and practise those skills in another subject, applying them to a real situation, for example, a design task, an experiment, or a clinical situation.

However, in the workplace, analysis is usually done with computing tools. Should we redesign the curriculum around investigation and/or design, rather than analysis? This would enable us to engage the students from week 1 with some of the global grand challenges, with knowledge and skill acquisition following, rather than leading, the problem-solving process. Students would simply learn new fundamentals online as required.

For example, at New Start University, students are required to address a particular problem, say, pedestrian safety outside the University, where students must cross a 6-lane road from the bus stop. One group of students chooses to address this problem with a footbridge. They need to design the basic structure, so they jump online and learn some basic mechanics and structural design. Disabled access is also a key requirement, which means they need to read key sections of the relevant code of practice and interview stakeholders. The footings need to be designed too, requiring further online learning.

Students who get interested in structures might then take a follow-on project where they need to develop a deeper understanding of structural theory and practice. This might lead to design of a commercial building, for instance.

Students continue to pick and choose projects to deepen and broaden their professional capabilities. Wherever possible, students work in multidisciplinary projects. For instance, a Green Building Studio might involve architects, structural engineers, mechanical, electrical and telecommunications engineers, quantity surveyors, interior designers, ergonomists, business practitioners and project managers.

A project-driven curriculum could be radically different from what we now think of as normal. We currently focus on bodies of knowledge that must be first preloaded into students' brains. Once that is complete, students can do some application and practice, with a capstone project seen as the final step of integration of the body of knowledge.

In a project-driven curriculum, every project should be an embodiment of all of the required graduate outcomes—define the problem, apply a systematic problem-solving process, use modelling tools as required, manage the project as a team, communicate effectively with the client and, of course, learn online and from mentors and teammates and constantly reflect about one's own learning.

This process starts at a manageable scale in first year in order to teach these process skills. Not everyone will be comfortable with this process on day one of university. However, that will increasingly be so in the future.

Students then begin to pick and choose their next adventure (project). Graduation in a major might require a certain number of credit hours earned in major-related projects. A minimum number of hours spent in multidisciplinary projects will also be required.

It is likely that such a scheme would benefit from a new look at timetables. Rather than a student undertaking several subjects simultaneously, they might benefit from taking only one at a time, perhaps a small project over 4 weeks and a larger one over 8 weeks or even longer. We could truly keep universities open 12 months of the year, though each academic may only "teach" for 6–8 months of the year in concentrated blocks.

One thing is for certain; we will engage students in a very different manner. Professional practice will be the focus, not knowledge acquisition. This will have long-term implications for staffing.

1.6 Practice and Practices of Flipping

Returning to the present day, successfully introducing a flipped classroom approach within higher education and particularly at scale, requires a range of considerations which we believe (in keeping with the best traditions of research) are best approached through examining the efforts of those who have had first-hand experience. To this end, we have organised this book in two parts.

Part 1 of the book focuses on the "practice" or "praxis" of flipping which we believe embodies much of what we have learned along the way and which we hope will guide you through the major issues and questions surrounding the flipped classroom.

We begin in Chap. 2 Design Considerations by laying out a "methods-based" and "context-first" design approach that we have developed that result in a model which emerged over a six-year period of designing, developing, operating and evaluating ENGG1200. The methodology and model were subjected to peer review and iterative refinement through its use in over 20 academic workshops on "How to Flip a Classroom and Land on Your Feet" that we have delivered to over 1400 academics from a range of disciplines throughout Australia, Asia, North America and the UK.

In Chap. 3, we examine the issue of selecting the best technology for your flipped classroom. Many of those who attend our workshops are relieved to know that this (in our opinion) is one of the least important considerations when approaching the design of a flipped classroom.

Quality education requires adopting an evidence-based approach to curriculum design, and in Chap. 4, we present a range of theoretically grounded evaluative instruments and protocols for assessing student engagement and learning in the flipped classroom that have been successfully used within a number of flipped classrooms in the higher education environment.

Chapter 5 explores reflective and reflexive practices as a means of dealing with the not insignificant intra- and interpersonal developmental challenges that the flipped classroom poses to the traditional roles of both the student and the academic. Written reflections have proved to be a valuable tool within ENGG1200 not only as a means of developing student learning but as a rich source of data of how students engage with the flipped classroom.

In Chap. 6, we have pulled together a framework which you can use as a guide to the wide range of case studies of the flipped classroom presented in Part 2 of the book.

In Part 2, you'll find case studies from a broad and diverse range of disciplines which we hope will shed some light on the complexities involved in flipping, provide answers to your questions, as well as to many others that you did not know you had. While we had originally proposed a comparative study of a smaller number of similar courses that were implementing the flipped approach, we realised that to do so would remove the all-important "situatedness" that governs the inputs, processes and outputs that vary across different institutions, academics, disciplines and course designs. This had the positive effect of creating an opening for many more contributors to the book than we had anticipated which we hope will speak to your own situation.

1.7 A Final Word

There is likely nothing all that revolutionary about the flipped classroom. Rather, the unabridged excitement and rush to learn more about this cleverly named pedagogical method owes itself more to a confluence of larger phenomena including:

1. global increases in the demand for undergraduate education with more students, and bigger classes;
2. a subsequent need to be accountable for achieving quality student learning, while recognising limits to funding and staff resources;
3. the increased affordances of high-speed Internet, ubiquitous computing and seemingly limitless data storage;
4. an increasingly digitally aware and consumer-oriented student cohort; and
5. a refocusing/shifting of higher education towards skill sets underpinning employability.

Nevertheless, it is one thing having all the opportunities/pressures in place and quite another to be facing the need to make fundamental changes in the way that we teach. We do appear to be in the early phases of a disruptive transformation to the way in which universities deliver education in much the same way that the taxi (Uber), hotel (AirBnB) and many other industries have been forced to adapt to massive social–technological changes.

Changing the core of what universities do cannot succeed just by focusing on technological innovation or by mandating the flipped classroom. While we are beginning to see the benefits that flipping the classroom can provide our students, we are also seeing the gaps that have been exposed in our organisational structures and cultural practices. It is worthwhile keeping things in perspective. In a recent report examining the seemingly glacial pace of change within higher education (Graham 2012) that draws upon a large global sample of academics involved in successful change (70 interviews from 15 countries), successful and substantive change was found to be "interconnected and wide ranging" and requiring the active support and leadership of senior academics. The key to leveraging the full potential of the flipped classroom will reside in how we collectively might reconceive the on-campus student experience while ensuring that change is balanced with the abilities and limitations of our cohorts and institutions.

We have written this book in the hope that you will find something within that you can identify with to help you redesign your own teaching practice. The practices described herein should provide some reassurance that you are not alone and are part of a much larger and very active community. We encourage you to reach out to each and every one of us should you wish!

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Chapter 2
Design Considerations

Lydia Kavanagh, Carl Reidsema, Julie McCredden and Neville Smith

Abstract The quality of student learning depends largely on how well we design our curriculum and the pedagogies we use within this curriculum. A successful Flipped Classroom (FC) is no exception: to engage students and ensure learning requires carefully considered design and implementation. This chapter teases out, and more closely examines, the key critical success factors from the perspective of the changes that are required in both student and facilitator expectations and roles. In addition, a model for designing a FC provides a structured approach that emphasises a 'context-first' strategy.

Keywords Curriculum design · Transforming learning · Student-centred learning · Classroom design · Evaluation · Learning resources

2.1 Introduction

To design an effective Flipped Classroom (FC) we can begin with a methods-based approach requiring an understanding of the inputs (what we do to students) and outputs (what students can do at the end) supplemented by the all-important connecting factors between these two end points: how and what students learn. As

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the FC reverses the traditional order of learning by replacing the lecture as the first point of contact between the student and their learning with online 'Pre-Learning' followed by a 'Facilitated Active Learning Session', we must understand the mechanisms needed to ensure learning in this context (Pawson and Tilley 1997). This means we must focus on the combinations of activities and experiences that the students are to be involved in, and on the learning and developmental processes that are occurring within the students while engaged in these activities.

This ability to merge understanding with activity forms the basis of 'active learning' which is an umbrella term (Barkley 2009) used for a range of methods such as Experiential Learning (Kolb 1984), Situated Cognition (Brown et al. 1989; Resnick 1988; Schoenfield 2014), Situated Learning (Lave and Wenger 1999), Inquiry-Based Learning (Prince and Vigeant 2006), and Collaborative Learning (White and Fredrickson 1998). While there is much overlap in these learning theories, they all share a common component of 'cognitive apprenticeship' (Collins et al. 1989) where students learn to do authentic tasks by emulation (i.e. watching others, then doing the tasks themselves), in the context of guidance, feedback from, and collaboration with the facilitator and/or their peers, who then pass onto, or co-construct with the student, the cognitive and practical tools of the discipline. The notion of authentic learning (Lombardi 2007) is important in designing a FC as it intentionally brings into play multiple disciplines, perspectives, ways of working, habits of mind, and community.

Community underpins our understanding that learning is predominantly collaborative: much of the tacit and pragmatic understanding is gained interpersonally from peers and others within a community of practice (Toulmin 1972; Lave and Lave 1991; Wenger 1998). The FC should be designed to use and maximise the benefits of collaborative learning and thus requires the creation of an environment of active and engaged learning, the conditions for increasing the student cohort's ownership of learning, and the development of higher-level thinking skills in the individual. This is important whether the FC is being designed to address students' conceptual understandings or, at the other end of the spectrum, attempting to reconceive curriculum by increasing active learning in order to develop, and move towards the assessment of, student competencies.

All active learning methods specify both active and conceptual components. Activity is required because without hands-on experiences '*classroom instruction in a discipline is like studying recipes without ever cooking anything*' (Greeno 1991, p. 117), and conceptual learning is required, as general principles need to be extracted from the experience so that they may be transferred to other contexts (Anderson et al. 1996; Bereiter 1997; Wineburg 1989; Blumenfeld et al. 1991). For example, students do not learn science from activity alone; the understanding of concepts and principles needs to be added in a structured way (Puntambekar and Kolodner 2005; Penner et al. 1998; Schnittka and Bell 2011).

The FC therefore needs to be designed such that students learn by applying their cognitive understanding to authentic problem-solving contexts, and where the facilitator, the learning environment, their peers, and the community of practice all provide multiple sources of knowledge and assistance to help them achieve their goals.

This first requirement that students must be able to apply their cognitive understanding moves towards another pillar of the FC, that of the student owning their learning.

We should emphasise here that the FC is not a panacea, nor are we advocating that all classes must be flipped. If the existing delivery achieves the desired learning outcomes and students are happily engaged in their learning, then there are likely better things to do with your time. Under no circumstances should a class be flipped solely because of institutional (or similar non-learning) drivers. Specifying a FC should be based on a need to:

- help students master a particular concept or knowledge that is tricky and not being adequately mastered through a current delivery method;
- engage students with material that may have been deemed 'boring' or 'irrelevant' by past cohorts; and/or
- facilitate the development of skills that use the new knowledge or concepts.

Partial flips may also be considered; it is not necessary to flip an entire course.

This chapter addresses the need to change the practices of all stakeholders (Sect. 2.2), and the considerations and elements that need to be brought together in a FC design (Sect. 2.3). The design elements include evaluation of the FC, for either course improvement or research and dissemination purposes, as we believe this is an important consideration for any teaching innovation. Finally, the chapter provides a checklist that can be used to evaluate a design (Sect. 2.4).

2.2 Changing Practices

2.2.1 Transforming Your Practice

It has often been said that flipping the classroom requires academics to flip their practice (Bruton 2012) and this indeed is fundamental to the success of flipping. What might not be apparent until you actually make the decision to flip is the extra amount of energy required to keep students engaged, enquiring, and learning and to ensure that their learning outcomes are the ones that you intend in comparison with traditional 'chalk and talk' pedagogy. Your role as an educator must be rethought, and none of your strongly held beliefs about what you think you know about teaching and learning can go unexamined. Moving from the role of lecturer ('Sage on the stage') to facilitator ('Guide on the side') requires not only that we also become learners, but that we explicitly define learning as mutually constructed meaning (Baxter Magolda 2012).

By its very definition the FC is constructivist: we require students to become actively involved in their learning rather than passively recipients of information. The focus is therefore switched from the teacher to the learner, and the challenge inherent in this should not be underestimated. Stepping out from behind the lectern is a daunting proposition both figuratively and literally and also one that students may not readily accept. One of the difficulties in co-construction can be the

Table 2.1 Elements of constructivist learning design

Stage	Element (Gagnon and Collay 2006)	FC consideration
1	Develop a ***situation*** for students to explain—include what you expect them to do and how they will construct their meaning	Pre-learning activity
2	Decide on ***groupings*** of materials and/or students to facilitate cooperative learning	Facilitated session planning
3	Build a ***bridge*** between what students already know and what they need to learn	Overall FC design
4	Anticipate ***questions*** to ask and answer that facilitate learning; use Bloom's taxonomy to elicit higher-level thinking	Facilitated session planning
5	Encourage students to ***exhibit*** a record of their thinking by sharing it with others; this should also demonstrate student learning	Facilitated session activity or post-facilitated session activity
6	Solicit student ***reflections*** about their learning and thus encourage them to cognitively acknowledge what they have learnt	Post-facilitated session activity

epistemological development of younger (17–20 years old) students. They tend to be low on Perry's taxonomical scale (Perry 1970), suggesting that they do not see knowledge as constructed but rather as immutable and received. Establishing trust is therefore critical and should be made an explicit element in the narrative to ensure consistency of word and action (integrity).

The facilitator's role in the FC can be explained using elements from the Constructivist Learning Design proposed by Gagnon and Collay (2006) that are 'designed to provoke' thinking about student learning processes, and these elements used to plan the FC (Table 2.1).

The work of Baxter Magolda and King (2004) around assessing learning goals and learner capacities can also help in understanding what is required of a FC facilitator. They suggest that successful constructivist learning requires a Learning Partnership to be created between students and the facilitator in which students take ownership of their learning. This ownership is a central pillar without which the FC will fail and so forming a Learning Partnership must be an aim of the facilitator. Note that the Learning Partnership does not need to be made explicit and named as such, but it should be reinforced wherever possible. The principles (Baxter Magolda 2012) behind this partnership and their links to constructivist learning (Table 2.1) are that:

1. Knowledge is socially constructed (Stages 2 and 5),
2. We have to respect and validate what learners know (Stages 1 and 3),
3. Learning has to be situated in learners' experiences (all stages),
4. Meaning is mutually constructed (Stages 4 and 5).

The first principle, that learners need to share ideas and work through their implications with others to make sense of content, means that we have to make sure our strategies for allowing this to happen actively support the process and that we don't just expect it to happen 'naturally'. The FC emphasis on fostering self-directed, peer-to-peer collaboration provides a good starting point, and the rest of the principles give us guidance on how to bring it about.

In describing the second principle, validating learners' capacity to know, Baxter Magolda suggests methods such as 'solicit learner perspectives', 'trust their judgement', and 'respect their beliefs'. Most project-based courses generally require students to refine their understanding of a problem and its solutions using such techniques. The difference in the FC is that this validation of the learners' capacity to know happens continually at every level of activity, in every session.

The third principle, drawing on learners' experience, requires attention to well-established curriculum design principles for effective learning which include considerations of scaffolding as well as constructive alignment (Biggs 1999) to ensure that new knowledge is meaningfully and appropriately connected to old knowledge (Stage 3, Table 2.1). In the FC, freeing up class time provides an opportunity to explore options for 'experiential learning' where meaning is obtained through direct experience. The FC does not generally allow either for 'passive learning' or for 'passive teaching', but we acknowledge that there may be a demand for the occasional inspirational event such as an iconic guest speaker.

The final principle, that meaning is mutually constructed, is not possible unless the facilitator makes learning meaningful and focuses on the development of the student. It requires the facilitator to enter into the learning process with the learners, help them to discover meaning, and in the process, challenge and reorganise their own thinking as well. As previously mentioned, this relaxation of intellectual authority may be difficult for some teachers and it also clashes with the expectations of many students. In actuality, the FC may have several sources of authority including a MOOC component, external information sources, teaching staff, and unfortunately, cultural barriers to change which can appear to be an unreasoned insistence on the familiar resulting in a resistance to anything that does not resemble traditional learning processes.

As a facilitator, you need to examine the ways in which these principles are evident in your practice and how they might underpin the design of your FC.

2.2.2 Transforming the Student's Practice

One of the first questions we get asked when we run workshops for academics on FC design is '*What do students make of the FC?*'. Then we get asked about the completion rate of Pre-Learning and what happens if students don't do it. Leaving aside the second question, as this is addressed in Sect. 2.3, the first is fundamental to transforming each student's practice.

Our experience, and that of others, is that some students will push back when asked to own their learning and engage actively in the FC. Just as it is difficult for us to transition to becoming facilitators, it is difficult for students to transition to making the running when it comes to learning, especially if they have come from a more traditional system of lectures, tutorials, and practicals. We have learnt to confine this pushback to a minor fraction of the cohort through a number of strategies.

Firstly, as a fully FC will not have a lecture stream to provide direction and orchestrate continuity between modules and topics, it is important to ensure that these functions are satisfied in some other way. One approach is to consider the use of **a narrative with explicitly stated learning aims and objectives**. A narrative is the story that unfolds within a course allowing students the opportunity to personally identify with the course and its learning objectives in some way. The narrative as 'story' can be further defined as a representational structure consisting of a mix of meaningful and interrelated elements threaded together in sequence (Eng et al. 2008). This narrative as structure is essential in establishing and reinforcing a shared understanding with students on what is relevant and consequently fundamental to achieving the intended course learning objectives. The narrative is firmly based on constructivist theory that requires the negotiation of meaning. Without a narrative, students can be overwhelmed, frustrated, and quite unhappy with their first experience meeting the FC requirement to construct their own learning from online materials prior to arriving on campus. Different types of learning activities carried out in disparate settings can easily seem incoherent. The issue can be compounded as the facilitator is usually primarily concerned with helping learners deepen their understanding of the online content rather than addressing the narrative. A narrative therefore should be incorporated in the FC design.

As an example in the use of narrative as 'story' and as 'structure', let's consider The University of Queensland course ENGG1200: Engineering Modelling and Problem Solving (see Chap. 7). This course was designed to introduce first-year engineering students to structured problem-solving. In its first iteration, students were given the following narrative story to describe the importance of what the course was about and how it would be run:

> Engineers design, manufacture and test artefacts using materials in a structured process of thinking, acting and doing. We use models to represent an engineering problem and its solution such that we can make economic decisions and accurate predictions of the behaviour of a built artefact.

As will become clear below, the narrative did not resonate with students as evidenced by their negative feedback to the relevance of both course content and course organisation.

The course required students to learn about engineering materials as well as problem-solving in order to design and manufacture a functionally predictable prototype for the final week of the course. This prerequisite knowledge was delivered in the first six weeks of the 13-week course: engineering materials through online modules and quizzes followed by hands-on collaborative workshops applying these concepts, and problem-solving through team-based workshops. Students were assessed on their understanding of this knowledge in a traditional mid-term examination. In the first iteration of the course, prominent and engaging guest speakers from research and industry presented state of the art work in areas that were aligned to the weekly concepts through a one hour lecture. Part of this lecture was used to facilitate the narrative development and provide feedback to the students, in other words to provide a narrative structure.

However after the second week, over 50% of the students stopped attending the lecture. When asked why, more than one student explained that despite the quality of the lecturers, the activities were perceived as not relevant. In addition, course evaluations indicated that the students were dissatisfied with the structure of the course. So what had gone wrong?

As a response to this failure, the lectures were replaced with 10-min podcasts and followed by integrated learning workshops that were preludes to major assessment activities, team organisational activities, and through which a shared understanding of the course narrative could be developed. There was a significant positive change in terms of students' perceptions of both course organisation and the clarity of course details. In addition, observation of the workshops and analysis of open-ended comments concerning the course showed that students had constructed their own narrative and thus managed to make sense of what they were learning. As course content, content delivery, and assessment were not changed, these findings can be attributed to the introduction of the workshops (Kavanagh and Reidsema 2014) and with them the development of narrative through negotiation of meaning and connection of activities.

We have also had success in reinforcing the narrative through the use of a custom-built system, integrated with our institutional learning management system (Blackboard) that clearly shows students what they 'Need to know' and what they 'Need to do' in any particular week (Fig. 2.1). This tool has been called the Learning Pathway and is discussed in more detail in Chap. 3 (Technology).

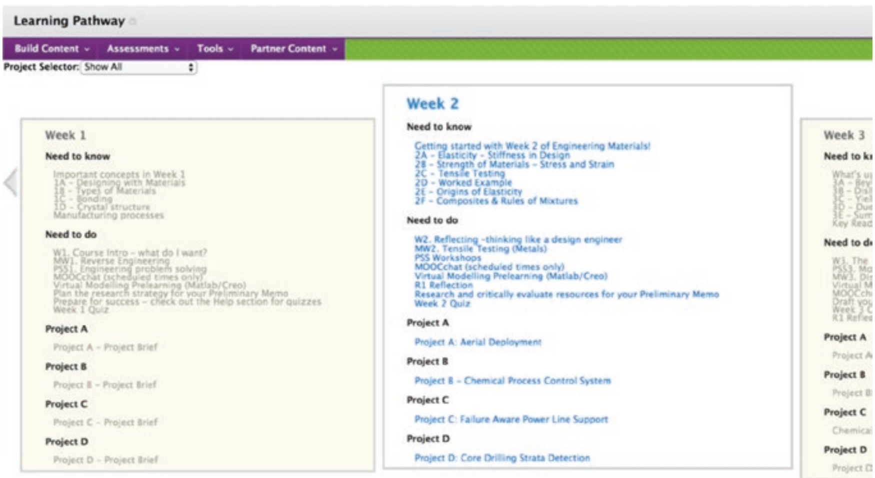

Fig. 2.1 Learning pathway tool

Secondly, it is important to ***make the process of the FC explicit***. Students respond well to being given meta-level explanations of the delivery methods of a particular course and, if invited to be a 'true' participant in the process, can be a very valuable source of feedback and evaluation. This 'true' participation in the process resonates with the tenets of Learning Partnerships that a facilitator should nurture as part of developing their FC. It means that the facilitator should always be ready to listen to, and act on, the voice of the students, and hence, we recommend that opportunities for the student voice to be heard be deliberately designed for. These opportunities could range from the simple use of a Minute Paper (Angelo and Cross 1993) to a focus group session.

Lastly, students need to be ***transitioned into the practice of the FC***. The first FC our students experience is one that is taken in their very first semester of university. In this course, we begin the semester with a few lectures that run in parallel with the flipped mode. The follow-up course in second semester has no lectures and is totally flipped. We find that the initial pushback from students towards the required ownership of learning is lessened by this gradual approach, and external evaluators have observed that both the preparation for and level of active collaboration of students within the Facilitated Session increases with exposure and experience. It should also be noted that the majority of our students take these flipped courses in conjunction with three other courses per semester that use a more familiar lecture/tutorial/practical delivery method and thus are not similarly challenged in every course. They often tell us that they enjoy the FC but are glad that not all their courses are so demanding.

2.2.3 Changing the Learning Environment

As discussed above, we need to change behaviours of both the teacher and the student and in the process develop a Learning Partnership. Entwistle and Peterson (2004) propose a conceptual model that is useful here (Fig. 2.2). It illustrates the links between teachers' (boxes below the Quality box) and students' (top 3 boxes) conceptions of what it is to be a learner and the influential contextual factors (Influence of academic community and Influence of department boxes) in terms of the quality of learning. In many cases, the facilitator (teacher) and course designer will be the same person but in the eventuality that it is not, both people will need to understand what is required in terms of change in practices.

The model highlights the fact that changing student and teacher practices requires a change in the learning environment. The elements of the figure are covered in more detail in the following sections.

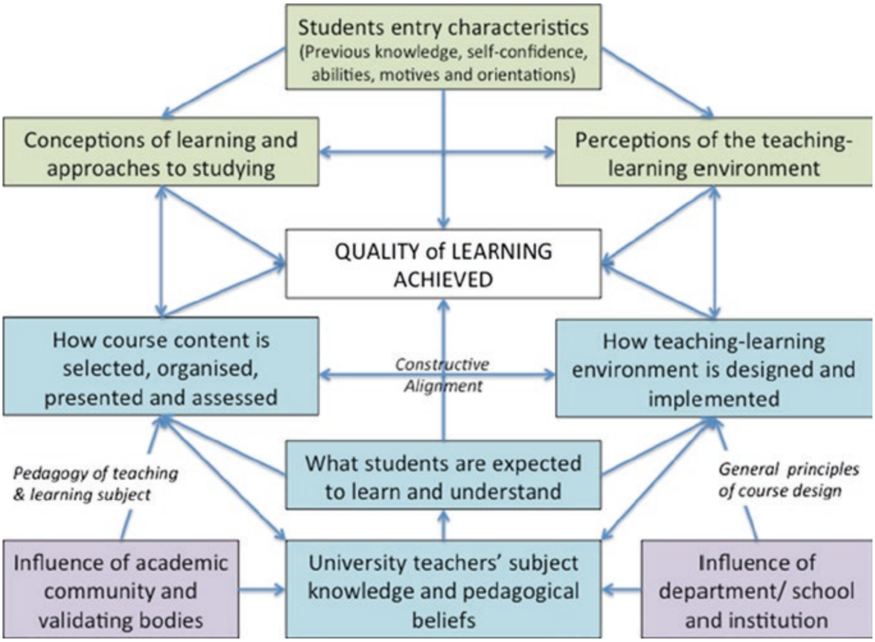

Fig. 2.2 Teacher, student, and learning environment connection (Reprinted from Entwistle and Peterson 2004, with permission from Elsevier)

2.3 Flipped Classroom Design Considerations

2.3.1 A Design Process

Creating successful active learning activities is not straightforward as the goal is for students both to be willingly engaged in the activity and to learn the required concepts and their applications (Blumenfeld et al. 1991). To be successful therefore, a FC approach will necessarily involve careful educational design to ensure that course structure and activities (both contact and non-contact) are constructively aligned to create the desired integration of learning with doing. As described in the introduction to this book, the emphasis here is not on the testing of a new method for learning or engagement, but rather on practical considerations for designing a successful FC course.

Focusing on the design process for creating a course helps us conceive of the eventual product (a FC) in terms of a prototype. Prototypes allow us to make the invisible visible, communicating the course architecture, along with the content and processes whose function is to produce the required knowledge and skills in students. Prototypes are also useful in communicating our design intent to all stakeholders including senior administrators, and colleagues as well as students, thus building in purposeful feedback. As with any curriculum innovation, the product evolution is not complete after the first iteration and thinking in terms of prototypes is a good reminder of this.

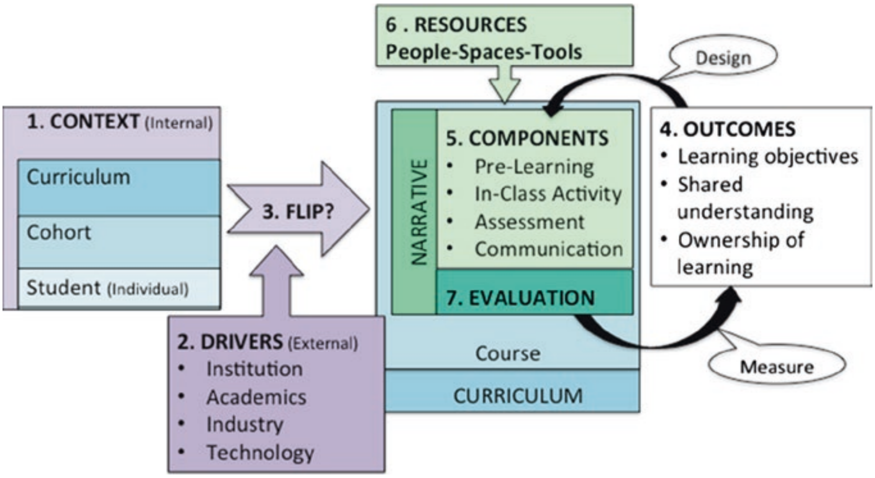

Fig. 2.3 FC design elements

To aid with the design of the FC, we have split the considerations into a number of design elements; these are discussed in the following sections and their interconnections shown in Fig. 2.3.

The numbering of each element in Fig. 2.3 is primarily for identification and not to be interpreted as requiring a mandatory or linear sequencing. The ordering of the design elements does, however, emphasise the importance of focusing on both the Context and Drivers as the basis for deciding on the merit or feasibility of flipping or not. In our own particular experience (Chap. 9), the situational analysis of the Context and the Drivers occurred concurrently with a set of outcomes that we intended to deliver. As with any design process diagram, iteration is a fundamental characteristic, even more so after the decision to flip (Element 3) has been made.

It is also worth noting that looking at Context (Element 1) will most probably occur in conjunction with a rough knowledge of the course outcomes (Element 4). There should also be a continual comparative analysis happening with regard to the differences between current and best practice. For example, with our own first-year engineering design and build course, we looked at what Olin College of Engineering and Purdue University were doing and found opportunities to incorporate elements of their practices in our FC. In addition, our Executive Dean wanted a focus on authentic learning, and hence, our FC design began with all these elements in tandem.

2.3.2 Element 1: Context

It is important to understand the full context in which the FC will be offered. A fundamental precept of design is that a good solution requires an excellent understanding of the problem and therefore context is everything. While the second element, ‘Drivers’, is concerned with external factors, Element 1 considers the internal context in which the FC is to be offered which includes the curriculum, the cohort, and the individual students themselves.

You may not have too much influence on the context in which the course is offered, but it will certainly influence the design of your FC. For example, the following questions can be asked of the context in terms of:

- the curriculum:
  - How is the course integrated into the curriculum?
  - Does the course cover fundamentals that are to be developed later in a degree programme?
  - Are learning objectives to be built on previous courses/knowledge/skills?
- the cohort:
  - How many students do you have in the cohort?
  - What percentage are international and/or non-native English speakers?
  - What year level are they: first year, undergraduate, postgraduate, etc.?
  - Do they have any previous experience with the FC?
  - What is their mode of study: on-campus, distance, or mixed?

We must drill further in terms of students and identify the learning mechanisms employed by students in context in order to specify the mechanisms that need to occur within the learning environment that will support their learning.

The general mechanisms that we need within students have been specified within the literature on how people learn. Cognitive psychology describes how effective learning eventually produces experts with the required knowledge and skills, processes, strategies, principles, heuristics, schema, and mental models required for their discipline (Bransford et al. 1999). A FC design must support these mechanisms and account for the likely learning capacities of students. We should think about:

- the underlying assumptions about knowledge, self and working relationships students hold;
- the way that students are used to constructing knowledge and the difference between this and the methods we will employ in the FC;
- their expectations of how we will deliver knowledge and aid their development; and
- the value they place on peer learning and collaboration.

If the gap between where we will be operating and where the students expect to be working is too large, bridging activities will need to be provided that, as per Sect. 2.2, involve students in the process of learning, and can transition them to the FC. For example, an activity that asks students to produce a creative model of the course and its delivery can engage students in cognitively understanding the expectations of the course. In the past we have had engineering students write music, rap, and haiku, draw mind maps, and produce various diagrams or analogies through this activity. We always showcase the best models, and reward with prizes, thus bringing a competitive gaming element to the activity.

2.3.3 Element 2: Drivers

Such things as institutional support or lack thereof, student experience with the mode of delivery, and the availability of technology and tools, can aid or constrain the design of the FC. The facilitator will need to identify these drivers and capitalise on the positive and ameliorate the negative. As an opening, the following questions might be asked of:

- the institution:
  - Does it support FCs? (Are there spaces available?)
  - Is it actively trying to enrich the on-campus student experience? (Is there funding available?)
  - Is teaching innovation recognised? (What's in it for you?)
- your colleagues:
  - Are they flipping? (Can they provide you with advice and support?)
  - Will your move towards flipping affect their courses? (What do they need to know about what you're doing? What would they like to see developed in the students?)
- industry:
  - Do they want to input into the process? (Is the course of interest to them?)
  - Can they help with authenticity? (This will depend on your aims, expectations, and learning objectives.)
- technology:
  - What do you have available?
  - What can you use from elsewhere?
- best practice:
  - What does the discipline educational literature say?
  - What are other institutions doing?
  - What do external evaluations (accreditation bodies) say?
  - Horizon scanning? Where is your institution heading in relation to the big picture globally? Can you align your design to leverage this?

2.3.4 Element 3: Flip?

The main question to ask here is whether a flip is warranted or whether more traditional and/or existing methods are suitable to achieve the intended learning outcomes. If you determine that a flip will be beneficial, the level of flipping should be determined; for example, would a partial flip work? Perhaps you flip only those classes within a course that delivers tricky or difficult knowledge to a disengaged cohort and/or there is a need to transition learning outcomes from content comprehension to practical application.

Secondly, the various methods available for successfully facilitating active learning that are applicable for FC design should be considered. We hope that the following list will give you some ideas to cherry pick and the epistemology for further research.

- **Project-based learning (PBL)**: PBL uses a complex, real-world project to engage students in collaborative problem-solving overseen by facilitators and sometimes experts. Knowledge and skills are acquired just in time, or previously acquired and built on. PBL is more focused on application of knowledge than acquisition of knowledge and uses more real-world applications than problem-based learning (Mills and Treagust 2003). The method enacts situated cognition (Blumenfeld et al. 1991) and thus promotes learning mechanisms that are well aligned to those of a successful FC. In a FC, projects could be used within a particular class to develop a specific learning objective, or as a vehicle to allow application of learning throughout the course. We often give open-ended design and build projects (e.g. an automated black box detection craft that will locate and retrieve a metallic item from a small pool, a deployable bridge that can be constructed by others and support a nominal weight, and a greywater treatment unit for a third world community) to student teams at the beginning of semester, and require them to apply course content progressively in order to deliver a finalised solution at the end of semester.
- **Situated learning** is a model of learning in a community of practice (Lave and Wenger 1991) connected to PBL. The term recognises that learning takes place in context, so the classroom and/or task should strive to be authentic, and as part of a social process. As with collaborative learning below, situated learning comes about from constructing meaning and knowledge with the help of others.
- **Collaborative learning (or Team-based learning)**: Collaborative learning was mentioned in the introduction to this chapter, and we think it so important to the success of the FC that we mention it here again. In collaborative learning, students working together share experiences and knowledge and therefore create meaning and achieve learning that is not possible with an individual task (Chiu 2000). We set student teams tasks that require more than one individual to solve; they range from projects lasting a number of weeks to smaller problems that may only take an hour. These tasks facilitate the process of students asking each other questions, evaluating their answers, and synergising responses. For example, the automated black box detection craft, mentioned above as an open-ended design project, required software engineering students to develop code for an Arduino board and a search strategy, mechanical engineering students to design a watercraft and propulsion system, and electrical engineering students to connect sensors, power, and circuits. In order to produce a working prototype, the students needed to collaboratively learn and apply engineering design, communication and project management principles. Explicitly setting up collaborative learning moves both teacher and student to the change in practices outlined in Sect. 2.2.

- **SCALE-UP** (Student-Centered Active Learning Environment with Upside-down Pedagogies) is a collaborative learning method (Beichner and Saul 2005) that facilitates purposeful interactions between students by setting short, thought-provoking tasks. It is a FC approach, content is delivered outside formal class time and students given the responsibility for self-directed learning, that specifies round tables of nine students, thus providing flexibility as smaller groups of three may interact as necessary. SCALE-UP was initiated for physics courses where it was shown to improve students' ability to solve problems, reduce failure rates through increased conceptual understanding, and generally increase student satisfaction (Beichner et al. 2007).
- **Technology assisted**: Technology can assist teachers with providing content information (Blumenfield et al. 1991). The Internet has made many different types of delivery possible: text, videos, podcasts, and interactive tools for students to do their own research and learning or to annotate provided content. It is possible to use technology to enable the sharing of information and collaboration (Stahl et al. 2006), thus facilitating collaborative learning. If your cohort is not physically on-campus then designing for online collaboration will be essential. The opportunities that technology provides are discussed in more detail in Chap. 4 (Technology and Tools).
- **Distributed scaffolding**: Puntambekar and Kolodner (2005) coined the term *distributed scaffolding* as an approach to support hands-on inquiry learning in a classroom in a distributed, multi-agent way. They found that providing students with multiple forms of support and multiple learning opportunities was able to help them to learn science from design activities. Support can be from people such as facilitators or peers, software, learning environments, and other resources. We include this method as a prompt for the FC design to consider the various ways that learning can be facilitated.

A specific type of *distributed scaffolding* is **Blended learning**: the combination of 'face-to-face instruction with computer mediated instruction' (Bonk and Graham 2006) using digital or online media. Besides the advantage of scale (i.e. many more people can access online content) the method allows students to choose when and where they will access the online instruction. The FC, where Pre-Learning is delivered via a podcast or similar, is blended by nature.

The Case Studies in Part 2 (Practices) of this book may also provide initial ideas about pedagogies that may be used in your FC.

2.3.5 Element 4: Outcomes

Now that the internal and external contexts have been considered and an informed decision to flip has been made, it is important to clarify the desired outcomes of the class, as these are what the FC must achieve. If outcomes are not made explicit then it is not possible to measure success (Element 7). These outcomes can be categorised by three key elements:

1. **Learning Objectives**: Learning objectives focus on the purpose of the course and are often best phrased by considering the assessment that will be set to measure the things that the students should be able to do as a result of the class. These objectives should take into consideration the level at which the student is working (i.e. novice, expert) and therefore fit into the curriculum as relevant;
2. **A Shared Understanding**: As previously mentioned, the FC necessitates a Learning Partnership be established in order to allow meaning to be mutually constructed. The facilitator must therefore understand what students already know and facilitate the connection to the new knowledge. If we return to Table 2.1 (Elements of Constructivist Learning Design), the need for developing a shared understanding can be factored into Stages 3 and 4 where the connection is established and questions are asked and answered. In this way, the knowledge gap between students and the facilitator should be minimised; and
3. **Ownership of Learning**: Ownership of learning can be simply explained as a conscious decision on the part of the student to participate fully in the FC; this means that they engage with pre-learning to a degree that allows them to take full advantage of the following flipped activity. In such a way, students can situate their learning in terms of what they need to know, and what they need to do, and achieve the necessary learning objectives. In the longer term, students associate value in what they are learning because they have taken responsibility for, and control over their learning.

Note that here we recognise not only immediate learning outcomes (i) but also outcomes that result from the FC process (Elements 2 and 3).

2.3.6 Element 5: Components

The FC design solution uses the understanding provided by elements 1–4 and combines activities and learning components to create an overall *architecture* for a learning environment. Remember that the learning activities should be related and that there should be an activity, tool, and/or resource that reminds the students how the FC components work together to achieve learning outcomes (i.e. a narrative). It is also useful here to refer back to Table 2.1 as a reminder of the flow of FC events as planned by the facilitator.

The design of the components should also recognise any distinctive challenges to learning the content. If there are cognitive problems, i.e. difficult or threshold concepts, the need for prior technical or contextual knowledge should be addressed. If there are likely to be individual problems with the content, then students will need to be able to identify what they know and their level of knowledge so that they can proceed with mutually constructing meaning and receive appropriate support from the facilitator or their peers.

Armed with the knowledge that we need to integrate the FC components and that students have specific needs, we can begin with considering *Pre-Learning* and ask the following questions:

- What information do the students need within the specific course/curriculum? How will you address them (e.g. podcasts, lesson templates, readings)?
- What resources will you need to be able to compile the Pre-Learning?
- Can students generate their own resources? Could this form part of the assessment?
- How will the students access the Pre-Learning?
- Is it imperative that the students complete the Pre-Learning? If it is imperative, then how will you ensure that this is done (e.g. online quiz, assessment or peer pressure in the active session)?
- Is there any preparation that is essential for the Facilitated Session? Does it matter if students complete the Pre-Learning before the Facilitated Session or could they access it afterwards?
- Should Pre-Learning be independent/individual or could it be collaborative?

Having designed the Pre-Learning, the *Facilitated Session*, either on-campus or virtual depending on your cohort, can be addressed. Considerations include:

- What does your Facilitated Session need to achieve? This could be the application of content from the Pre-Learning module, exploration of the common misconceptions around tricky/difficult knowledge, or development of competencies such as graduate attributes (e.g. teamwork, communication, critical thinking). You should always include the need to foster a shared understanding and student ownership of learning in the design of this session.
- What kind of activities will develop the required student learning (e.g. collaborative work in laboratories, prototyping, case study discussion, project-based problem-solving, SCALE-UP activities (Beichner and Saul 2005))? Can the students direct the session themselves and thus increase their ownership?
- If there is a possibility that some students have not completed the Pre-Learning, how will you bring them up to speed? In many cases we find that an initial exercise that directly addresses knowledge of the Pre-Learning helps these students and deepens understanding in those students who have to explain what has gone before.
- What resources will you need? For example, will students need a template to complete or will blank butchers paper be sufficient? Will you need microphones to take comments from the floor or perhaps squares of orange and blue cardboard so that the cohort can indicate answers to particular questions by holding one aloft? You might need to be a little creative; we've seen Lego used to help with chemistry concepts, creative model building, reflection on a situation, and technical drawing.
- How will you foster intra-class communication (e.g. using a whiteboard to keep track of student questions and comments, demonstrating student work using a document visualiser, passing around a microphone)? Perhaps this is not so

important, but a sense of community and a shared understanding can be fostered through an awareness of general cohort opinions, queries, and/or solutions.
- What is the driver for students to participate in the session?
- How will students demonstrate their learning? Is some form of assessment necessary? If assessment is required, will you conduct during the session or after?

2.3.7 Element 6: Resources

Resources are defined here as: manpower, technology/tool access, and spaces. Considerations include:

- Who will you have in your teaching team? Who will you have in your administrative and/or technical support team? Who could be empowered to contribute to the innovation?
- What access do you have to technology? What access will students need to technology?
- What do you already have in terms of tools to help deliver content, enable communication, aid assessment, etc.? What can you borrow and what will you need to create? Can you get funding to help you create necessary tools?
- What sorts of teaching spaces are available? Quite often, flat floor spaces equipped with furniture that allows collaboration between students is all that is required. If you cannot find the space you need, can you utilise other spaces?

It will be rare to find that you have the people, tools, and spaces that fit perfectly with your FC design. More often you will need to find workaround solutions or adapt what you have planned to what is available. We have repurposed gym halls, used open-source software, held classes outside, successfully lobbied industry for funds, and enlisted postgraduate students to help facilitate learning and the development of resources within our FCs.

One strong recommendation that has emerged from our experience is that you should communicate your passion and vision for the FC to your teaching team and then empower them to fill perceived gaps in the offering. Then, tutors become motivated to put together YouTube videos of FAQs, people with software skills develop tools to help with communication, and everyone brings back valuable information about what is working and what is not, provided an opportunity is created to receive this feedback.

You could also consider your students as resources. Asking your students to do things such as develop resources, peer-review work, or take charge of a session satisfies all three required FC outcomes (Element 4): learning objectives, shared understanding, and ownership of learning.

One final suggestion is to recognise when ‘near enough is good enough’. For example, there is no need to produce a Hollywood-standard podcast. Students do not expect this level of polish, and there is little to be gained in terms of learning outcomes. Similarly, resources can easily be developed on the fly as needs dictate.

It is almost impossible to anticipate all student needs, but if you maintain lines of communication with the cohort, it is a fairly easy thing to coordinate an Adobe Connect meeting or prepare a 5-min podcast in answer to a gap in resources.

2.3.8 Element 7: Evaluation

All teaching should be evaluated to ascertain the quality of learning outcomes and from there to determine where improvements could be made. Evaluation also provides an opportunity for academics to embed research approaches within the design of the course and enhance the scholarship of teaching and learning. This latter consideration may be important if you are innovating and need recognition in terms of research quantum.

The first step is to decide what will count as evidence of success and this might include shorter-term outputs or longer-term outcomes. Some examples that we have used are:

- Outputs:
  - levels of attendance,
  - online activity (frequency and duration),
  - assessment results,
  - artefacts created, and
  - student retention.
- Outcomes:
  - change in student attitudes,
  - development of skills,
  - application of learning in other courses, and
  - cognitive recognition of learning.

The next step is to decide how you will measure these items. While outputs are fairly easy to measure through things such as learning analytics, assessment marking, and head counts, outcomes will require considered measurement through things such as observations, interviews, focus groups, and surveys. The use of scaffolded reflection within a course can also provide evidence of both outputs and outcomes. Of course, if the evaluation is for anything other than course improvement, ethical clearance will be required to gather and use the data.

Planning for evaluation should refer back to how you will use any evidence gathered and what will actually count as success for you. Perhaps you could ask:

- How appropriate was the FC for your context?
- To what extent were short- to medium-term goals achieved?
- What were the consequences of the change in content delivery?

- Could the outcomes have been achieved with less effort and expense? (And are there areas where similar outcomes can be achieved?)
- What needs to be done to ensure that the change can be embedded in normal practice?

2.4 Conclusion: Finalising Your Design

If you have followed through Sects. 2.2 and 2.3 and designed a FC, we offer a checklist of the essential components to promote the mechanisms required for successful active learning in any discipline (Table 2.2). Components 1–5 have come from the work of Shoenfield (2014) who has looked at what constitutes a 'powerful classroom', component 6 is recommended by Darling-Hammond and Youngs (2002), and component 7 is underpinned by the work of Hadgraft and Dane (2014). Some of the items in Table 2.2 have not been explicitly covered in the

Table 2.2 Checklist for FC design

Part 1: knowledge and skills	
☐	Concepts are connected with procedures and contexts. Knowledge and skills include facts, procedures, frameworks, models, principles, and contextualised heuristics and strategies
☐	Problem-solving uses real-world practices
☐	Discipline specific habits of mind are fostered
Part 2: cognitive demand	
☐	Activities create and maintain a productive level of intellectual challenge
☐	Sufficient instruction is given that students are facilitated but not directed
Part 3: access to content	
☐	Activities invite and support engagement with discipline content
☐	All students are involved in the core concepts being explored
Part 4: agency, authority, identity	
☐	Collaborative group activities facilitate presenting and debating ideas and building on one another's ideas as equal contributors (including the facilitator)
☐	Recognition for solid contributions is given
☐	These are used together to build a sense of identity as a practitioner
Part 5: use of assessment	
☐	Tests reveal current thinking
☐	Feedback is given that builds on understanding or addresses misunderstandings
☐	Opportunities to move forward are given
Part 6: facilitator experience	
☐	Facilitators have good knowledge of the subject matter and its application
Part 7: collaborative spaces	
☐	The Facilitated Session is conducted in a physical or virtual space that affords collaborative interactions

preceding text as they underpin all good teaching not just FC teaching. They have been included here for completeness, and the reader is referred to the appropriate reference for more detail.

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Chapter 3
Technology in the Flipped Classroom

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Abstract Digital technologies can play an integral role in the success of the flipped classroom: from the capacity to support and engage students, to understanding how students learn through learning and assessment analytics. The increasing ubiquity of enabling technologies allows for an array of opportunities for educators to augment teaching and learning strategies for the flipped classroom (Chap. 1). However, technology continues to be an ongoing challenge for educators. Bergman (2013) identifies technology as the "second hurdle" to implementing a flipped classroom. Part of this challenge is that while technology can be integral to the flipped classroom, the specific technologies and how they are used need to be deeply connected to the context in which the classroom is offered. This chapter focuses on the function and role of technology in supporting effective flipped classroom design. While we do not wish to dismiss or diminish the role of technology, this chapter looks at why design takes precedence over technology, as well as the challenges and benefits of using technology in the classroom. We propose frameworks for using technology within your design context, and the types of questions to be considered to guide the design process as well as providing some examples of technology to help you.

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3.1 Introduction

3.1.1 The Flipped Classroom and Technology

Flipped classrooms manifest themselves in many and varied ways depending on a wide range of contextual factors, such as discipline, class size, year level, demographic, learning spaces, resources, and institutional support. However, the common theme of any flipped classroom is the move from passive to active learning that "involves students in doing things and thinking about the things they are doing" (Bonwell and Eison (1991, p. 2). This move signals fundamental shifts in culture and expectations for both educators and learners, such as:

- requiring learners to take more responsibility for their learning;
- providing opportunities for students to negotiate and co-construct meaning with peers (Baxter Magolda 2012);
- challenging students through activities such as problem- or project-based work and enquiry-based learning methods;
- providing opportunities for personalised feedback;
- providing opportunities to adjust teaching based on student responses;
- using facilitation techniques to engage students; and
- increasing opportunities for formative assessment and feedback (Nicol and Miiligan 2006).

Technology can serve an integral role to augment or enhance the above features of a flipped classroom through administrative and pedagogical affordances. The administrative affordances enable efficiencies in areas such as information dissemination and class management (Chap. 2). The pedagogical affordances of technology can foster "a new means of intellectual expression and creativity" (Laurillard 2009, p. 289) and create opportunities for learning "previously inconceivable" (Puentedura 2006).

Technologies can range from expensive and sophisticated virtual environments to free Internet applications that support collaboration, connectivism, and community (Bosman and Zagenczyk 2011). Regardless of the choice of technology, there is a need for seamless integration into the curriculum and this is where learning design is critical. In a recent study by Keppell et al. (2015), learning design is recommended as a best practice methodology to make "pedagogically informed decisions and effective use of appropriate resources and technologies" (Canole 2013).

Indeed, the experiences shared in this book, particularly in the case study chapters, demonstrate that being guided by the learning design and flipped classroom delivery model you intend for your course will enable you to adopt technology that is fit for purpose.

3.1.2 Technology as a Means to an End

Technology presents both affordances and challenges to teaching and learning, and both require due consideration in the design phase.

For example, the mindful use of technology can provide:

- new ways to:
  - interact in and out of class (e.g. discussion forums, chat rooms, polls);
  - collaborate, share, and create (e.g. wikis, social bookmarking, collaborative documents);
  - showcase, feedback, and peer review (e.g. e-portfolios, online rubrics); and
  - reflect and plan (e.g. journals, shared calendars);
- increased flexibility in time, place, and pace of study as recorded lectures and other online study resources allow students to access resources at their convenience and to suit their pace of learning;
- extended opportunities for discovery (e.g. 3D immersive environments, interactive role-plays);
- better monitoring of student learning and engagement together with increased ability to identify students "at risk"; and
- increased efficiencies in sourcing, producing, and distributing content.

However, there are potential downsides in the use of technology that need further discussion. We begin by debunking the myth that students will naturally make the best use of technology because they grew up with it. In our experience and that of other researchers (Goossens et al. 2008; Kennedy et al. 2010), while the majority of students are "digital natives" there will be a small percentage that struggle and that may not have had the necessary experience to be able to navigate your system with ease. You will therefore need to ensure that there are comprehensive instructions, and readily available IT assistance. Other caveats include:

- technology can (and will) fail. Heavy reliance on technology is risky without a backup plan; for example what is your Plan B if the wireless drops out during a polling session. (Note that we have found students to be very forgiving about technology lapses as long as we took their concerns seriously and explained the underlying reasoning and constraints.);
- technology is not automatically productive. The amount of work required to familiarise yourself and your students with a tool, troubleshoot, or provide technical support can outweigh the desired effect;
- technology can change rapidly and/or go out of date very quickly; and
- the cost of technology acquisition, deployment, and maintenance can outweigh the benefits.

3.2 Selecting Technology

3.2.1 A Learning Design Framework

Conole (2015) claims that technology is not extensively used and that teachers do not make effective use of Open Educational Resources (OER) due to *lack of necessary digital literacy skills,* insufficient time *to experiment with technologies*, and lack of support. What Conole proposes is a strategy that follows a design-based process and moves away from belief-based approaches. Her 7C learning design framework model is aimed at: "*helping teachers and designers make design decisions that are pedagogically effective and make appropriate use of digital technologies"* (Dalziel 2016, Chap. 6, p. 1).

Essentially, the framework moves through four phases: (i) Vision: initiating the design process (Step 1 Conceptualise), (ii) Activities: creating content and delivery mechanisms (Step 2 Create), deciding on communication channels (Step 3 Communicate), brainstorming with others (Step 4 Collaborate), considering how/if tools can be used to promote reflection and assessment (Step 5 Consider), (iii) Synthesis: synthesising what we have found (Step 6 Combine), and (iv) Implementation: taking things forward (Step 7 Consolidate). It's a useful model in that it encourages us to break down the process of deciding on technology, bring in others, and to look at what we can reuse rather than reinvent.

In terms of the flipped classroom, we believe that the model needs to incorporate the learning goals: what are students to learn (Chap. 2), and what do students have to do in order to demonstrate that they have achieved the learning. Therefore, we retrace the seven steps assuming the question of what students are to learn is well considered and shift our perspective to the practical considerations for a flipped classroom.

1. **Conceptualise**—We agree this is a very important first step to take when considering the change to a flipped classroom approach and the associated requirement for technology as it enables the learning design process and your potentially reconsidered learning outcomes to be viewed from different perspectives. At this stage, you should fully outline your context especially in relation to students' access to technology, students' prior experiences, and your institution's support systems.
2. **Create**—Before you begin to develop novel resources, it is important to be aware of the vast array of already constructed resources. Most often, we find that the task is about integration or adaptation: taking the core of things that others have developed and contextualising them in the framework of the class you have to teach. Set aside some time each week to explore the field of e-learning.

   Then, as discussed above, for the flipped classroom an understanding of what it is that will enable students to best develop the learning outcome(s) should drive selection of technology associated with content and activities. This requires constant referral to what it is that you intend students to learn. We also recommend that you consider what a student needs to do in order to demonstrate evidence of learning. It is critical to align outcomes to activities and have these activities paired with assessments designed to distinguish how well an individual student understands the material, ideas, and procedures.

3. **Communicate**—Enabling fast, frequent, and effective communication is important on two fronts. Firstly, a flipped classroom may not have a lecture to make announcements about what and how to study and succeed in the course and therefore there must be another channel for this information to be accessed. Secondly, flipped classrooms require a shared understanding be established between the students and the facilitator(s). Both fronts will require us to understand the nature of the communication (e.g. are students reflecting, challenging, summarising, or critiquing) and to utilise tools that will enhance learning outcomes.
4. **Collaborate**—It is our experience that flipped classrooms require a team of people to design and implement, and hence, it is important that all are involved from the outset. The requisite knowledge of pedagogy, domain expertise, and ability to use technology usually comes in the shape of two to three people. Bringing in a variety of e-learning designers, librarians, and developers can bring new perspectives to the table, and their knowledge of existing systems can be very helpful in Step 2.
5. **Consider**—Take a step back and look at all the technology that you have chosen and ask what happens if it fails, what happens if it goes out of date, and what resources will be required to support it in terms of the learner. Having agreed once more that you have made the best selection, it's necessary to consider how you will evaluate if the tool is effective or if it requires improvement or replacement.
6. **Combine**—Don't underestimate the thought and effort required to bring all the elements together. You should be aware that you are in effect designing a system.
7. **Consolidate**—Considering what worked, can be systematised and shared, we'd like to say that if you've been thoughtful and rigorous in the proceeding steps, you should have all you need to publish, disseminate, and embed. Think about collaboration with different disciplines and other institutions as this can provide extra insight and endorsement.

3.2.2 Questions You Should Ask

Throughout the process of finding, adapting, or creating technology to fit your flipped classroom, there are a number of questions that will be context specific and that might aid the process. Again, we're using the 7C learning design framework to provide some structure to the questions (Fig. 3.1).

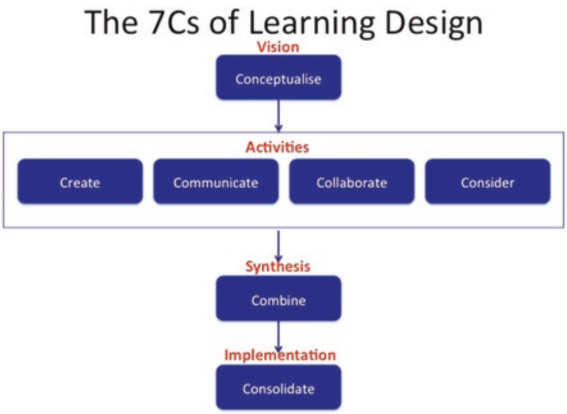

Fig. 3.1 The 7Cs of learning design

1. Conceptualise:
    a. What are you trying to achieve with your flipped classroom?
    b. What is your budget?
    c. How much time do you have?
    d. What support for technology-enhanced learning (educational and technical expertise) is available to you and your students?
    e. How technology savvy are your students? What are their expectations for the use of technology for learning? What is their capacity for learning new tools?
    f. Are there any technology constraints (e.g. bandwidth, operating systems)?
    g. Are there standards, policies, or access limitations that need consideration?
    h. What experience do your students have of a flipped classroom and study in your institution and discipline?
    i. What are students/staff already using (e.g. Facebook, Twitter, Instagram)?
2. Create (beginning with looking at what already exists):
    a. What do you have, what can you borrow, what can you create?
    b. What can you use from other flipped classrooms, MOOCs, and Open Educational Resources?
    c. What support can you find for your students in using technology?
    d. Will this work in our context; does it need adaptation?
    e. Will it make a difference? Is there existing evidence?
    f. What would help expedite the process?
    g. What technology can complement the space to achieve the desired goals?
    h. What is the simplest solution?
    i. Can student skills and understandings in the use of technology be leveraged?
    j. Can technology be used to redefine teaching spaces (e.g. mobile devices, virtual meetings, online resources) and facilitate both on- and off-campus activity?

3. Communicate:
   a. How will you communicate with students?
   b. How will students communicate with you?
   c. How will students or student teams communicate with each other?
   d. When do you need to communicate: before, after, or during an activity? Why?
4. Collaborate:
   a. What are your strengths? What are you comfortable with?
   b. Do you have the right expertise in your team?
   c. Who has done this before? Who can you learn from/with? What do they need to be able to join you?
   d. Are there students/tutors who can help? Can students mentor and support each other (and you?) to use technology?
5. Consider:
   a. How will we know that we've made the right choice?
   b. What measurements do we need to embed in the system?
   c. Are there any risks or implications associated with the privacy, security, or reliability of collected data?
   d. How important is control of your data?
   e. How much work is it to use/support the selected technology?
6. Combine
   a. Have all the necessary elements been addressed? Here you can begin with people, places, hardware, and software. Then perhaps drill down to items such as assessment, information transfer, support.
   b. What will your teaching team and/or support staff need to be aware of all the elements and processes involved in your flipped classroom?
   c. In what way will you communicate to students all the elements of the system?
7. Consolidate:
   a. What evidence is needed to convince potential adopters, collaborators, or journal article readers?
   b. Who will be interested in what you have achieved?
   c. How can you make the next offering of your course better?
   d. Can you share what you've learned and developed to help other teachers flip their classrooms?

The following section outlines a salient case in point of how the use of Conole's 7C model would have been beneficial in the implementation phase of a large-scale engineering course.

3.2.3 An Example of Continuous Improvement

As mentioned earlier, the flipped classroom model will render differently according to context, but also various iterations of the same flipped classroom will often change based on a review of what did and did not work (Consolidate). This process is a natural part of the design cycle, and important lessons can be passed on to others. The following is an analysis of how the use of an existing tool within our large-scale engineering course would have benefited from Conole's 7C model in the initial implementation.

In this flipped classroom instance, 1200 students are introduced to engineering materials, design, and modelling through a project-based course with large (n = 600) collaborative workshops, practical classes, and a suite of online resources and tools. Chapter 9 has more details of this case study. The tool in question is called MOOCchat; it was devised by The University of Berkeley and modified to fit within our course. MOOCchat provides an online forum for students to work collaboratively on a difficult concept set by the instructor; essentially, it is a peer-assisted learning tool that captures data from the chat rooms.

Firstly, we had in our minds that there was a gap that we needed to fill somehow at some time to help students learn *materials* concepts better. We understood that we couldn't use face-to-face time for this purpose as it would have been too expensive, and we were already planning to fully use what face-to-face time we did have in the collaborative workshops for other purposes. The materials mentors within our teaching team reinforced this need for concept checking on the basis of their experience of a previous iteration of the course. So it was something that needed to be addressed and we needed to find some way to do it online.

One of the authors (Reidsema) is part of a global network of experts in e-learning tools, and at the time, they were trialing MOOCchat as a tool for facilitating participant collaborative learning within MOOCs (Massive Online Open Courseware). Its capability to capture chat data was of interest to the network as they had been exploring semantic analysis of student discussions for a while. Reidsema could see how this might solve the problem within our flipped classroom. It wasn't that important that students not collude as long as they got the chance to practice applying a tricky concept.

So we adapted the technology to fit within our institutional learning management system and initially ran MOOCchat as a bonus activity (i.e. there were marks associated with participation, but participation was optional) and evaluated its success by looking at our students' understanding of concepts. We found that it made a significant difference in their understanding and so used it in the next course iteration, but this time we built it into the course assessment schema (i.e. it was no longer optional). In order to do this, we needed to modify the software further so that it could be properly assessed and accessed by the entire cohort.

The modifications were done on a shoestring budget and so there were many bugs inherent in the system. Once again, evaluation showed the value of the tool in terms of student learning, but the bugs in the system meant that students were scathing in their own assessment of the system. (As an aside, we have managed to secure funding to upgrade the software and will bring back an improved version in the next course iteration.)

If we now relate this back to the 7C model, we can see that we:

1. failed to initially Conceptualise the need for this depth of discussion among students in our first flipped classroom offering and may not have achieved deeper learning of some of the trickier concepts, but we recognise that design is an iterative process and there is a need to continually re-conceptualise each offering of a course;
2. through happenstance managed to find what was already available but feel that the Create aspect is still not complete although we get closer with each iteration;
3. have been successful in terms of the Communicate element as MOOCchat enables everyone to have a voice and for shared meaning to be developed;
4. Collaborate(d) with another institution, developers, and materials concept experts;
5. perhaps have not been so successful in terms of the Consider element, and this is probably due to our need to get moving with something without thinking about what failure may mean;
6. have had a modicum of success in terms of Combine in that the system works well within our institutional learning management system, is embedded in the course assessment, and enhances learning within the course; and
7. are currently thinking about how best to Consolidate, which includes this work and exploring how we share MOOCchat with others.

3.3 Overview of Technology

3.3.1 Introductory Thoughts

The purpose of this section is to provide some examples of resources to help you select technologies fit for purpose. We recognise that technology is evolving at a fast pace, and therefore, we focus on resource toolkits that support academics to identify what already exists and could be used. The details provided in this section are not comprehensive. Instead, we have tried to provide some insight into what has worked for us, and also links to the more common resource collections.

We highly recommend that you talk to your colleagues, and search the web as there are some very detailed, practical, user-driven sites that may help and tools can rapidly become outdated or redundant. To begin, there are many other flipped classroom teachers who have shared the resources that they found valuable. Some examples are:

- Bergman (2013). The second hurdle to flipping your class: http://edtechreview.in/trends-insights/insights/1030-the-second-hurdle-to-flipping-your-class

- Centre for Teaching Excellence, The University of Waterloo (nd). Educational technologies: https://uwaterloo.ca/centre-for-teaching-excellence/resources/educational-technologies
- Western Teaching Support Centre (nd). e-learning tools: https://www.uwo.ca/tsc/e-learning/tools.html
- University of Southern Denmark (2015). Teaching for active learning using e-learning tools: http://sduup.sdu.dk/en
- Centre for Teaching and Learning, The University of Washington (2016). Teaching with technology: http://www.washington.edu/teaching/teaching-resources/engaging-students-in-learning/teaching-with-technology-2/
- Centre for Learning and Performance Technologies (2016). Top 100 Tools for e-learning: http://c4lpt.co.uk/directory/top-100-tools/

A final thought is to do with student access to the smart devices necessary for these tools and systems. In our experience, we have found very few students who don't have their own device. Our institution is careful not to specify that students must have their own device and so last year, with a cohort of around 1100, when we wanted to use online tools in class, we asked students who did not have a smart device to contact us. The plan was that we would loan them a device for their session. In all, we had three students who availed themselves of a loaned device.

3.3.2 Producing and Distributing Content

> …while Khan Academy's prominence engenders fear of standardization and deprofessionalization among some critics, Bergmann, Sams, and Smith see instructional videos as powerful tools for teachers to create content, share resources, and improve practice (Stannard 2012).

Video production can be time-consuming and expensive. We recommend that you be realistic, plan well, and remember that it is not necessarily the content that matters, but how students are expected to engage with it. Work with templates that can easily be reviewed, updated, and modified as and when necessary.

Initially, we dreamed of polished multimedia productions for our videos. In the end, we settled for narrated PowerPoint slides and invested the time we saved into the development of challenging quiz questions and better systems for feedback. We found production and distribution alone were not enough to engage our students and that developing activities that challenge students to understand and integrate content are essential. Our students were quite happy, as long as videos helped them understand difficult concepts. Although many claim it is necessary to have high fidelity resources to retain engagement (Lasater 2007), the success of Minecraft (Short 2012), with its pixelated graphics, suggests otherwise. And this resonates with our experience.

Remember too that you may not need to start from scratch as there exist published and open educational resources that are freely available. Also consider the options of getting students involved in creating resources as partners (Healey et al.

2014). If you decide that you do need to create your own online content, then there are a number of tools that can help (Table 3.1). The websites for these tools are included as footnotes to the table.

If you're a first-time user of an application, there are many instructive resources on the web: from videos (e.g. http://www.wikihow.com/Make-a-YouTube-Video) to papers (e.g. Ruffini 2012), to TED-Ed lessons (http://ed.ted.com/), to complete infokits like the JISC resources http://www.jiscdigitalmedia.ac.uk/infokit/models-of-learning/creating-video.

3.3.3 Supporting Communication

One of our first attempts at establishing a communication channel was a discussion board thread called "Things that make me want to scream". Whereas the discussion board, which was part of our institutional learning management system, as a tool did not work well at the scale of our class (1200 students), the conversations did, thus reinforcing the need for communication channels that are appropriate to the learning outcomes and students within the flipped classroom.

In our initial implementation, we were insistent that students use this discussion board. But in later iterations, we decided to use a Facebook group managed through our institution as we noted that nearly every student had a Facebook account. About 80% of the students decided to join, and we found that often students helped each other with general information or to solve problems and hence we have retained this system in all subsequent course iterations. Tutors and lecturers are present in this space to make sure the information is correct, but the notion that peers can help each other first is rewarding.

Online communication tools are some of the most mature and diverse tools available. Kaplan and Haenlein (2010) developed a model to explore different dimensions of online communication (Fig. 3.2) that is helpful for academics trying to decide which communication tool is the most applicable.

The allocation of "high" and "low" presence in the figure does not imply a high or low value but instead a consideration for appropriateness to context and task. For example, activities asking students for high self-disclosure may create discomfort when exposing weakness or uncertainty; however, high self-disclosure is important for creating effective communities. Taking these concepts into consideration helps to select tools that ensure students are engaged and productive in their activities.

3.3.4 Providing a Narrative

Our first-year engineering course uses complex authentic tasks, and we found it necessary to scaffold students' learning with a narrative of how the activities and

Table 3.1 Tools that help content production and distribution

Focus	Examples	Advantages	Useful resources
Screen capture and webcam recording	Screencast-O-matic, Snagit, Jing, Prezi, Explain Everything, Videoscribe, Camtasia, Dahu	Device-independent solutions that play on any device	Educause: Screencasting to engage learning[a] JISC infokit:screencasting[b] Kathy Schrock's Guide to Screencasting and Screen Recording in the Classroom[c]
Video recordings from mobile devices	Phone, iPad, GoPro	Journalists are increasingly using smart devices	JISC infokit: Video Production[d] BBC Academy. Smartphone journalism: Video[e]
Open Educational Resources		Freely accessible, openly licensed resources can save time and effort	OER Commons Search[f] JISC Open Educational Resource Guide[g] National Copyright Unit: Smartcopying website[h]

[a] http://er.educause.edu/articles/2012/11/screencasting-to-engage-learning
[b] http://www.jiscdigitalmedia.ac.uk/infokit/screencasting/screencasting-home
[c] http://www.schrockguide.net/screencasting.html
[d] http://www.jiscdigitalmedia.ac.uk/infokit/video-creation/video-creation-home
[e] http://www.bbc.co.uk/academy/journalism/article/art20130702112133395
[f] https://www.oercommons.org/
[g] https://jisc.ac.uk/guides/open-educational-resources
[h] http://www.smartcopying.edu.au/open-education/open-education-resources

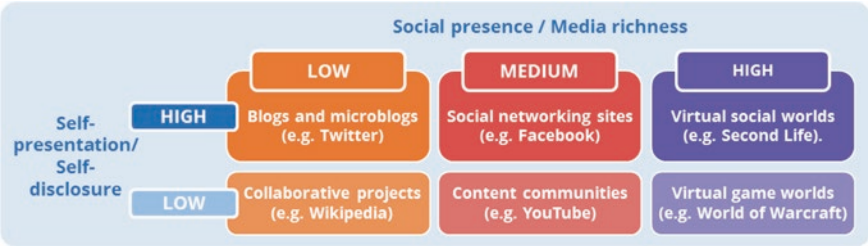

Fig. 3.2 Clarifying goals for social media. Reprinted from Kaplan and Haenlein 2010 with permission from Elsevier

Fig. 3.3 The Learning Pathway

assessment are aligned. For example, the engineering design process provides a storyline that relates back to authentic context in our courses. We could not find an existing tool that filled this function, so we developed what we now call "The Learning Pathway" (Fig. 3.3). This tool reduces confusion by signposting a "path to success" through the course.

The Learning Pathway runs like a thread through the course and breaks complex learning and sequences (e.g. podcast, online formative quiz, on-campus laboratory workshop then online summative quiz) down into manageable steps. It visualises the narrative in the form of a clickable pathway that guides users to relevant course materials and activities while showing the overall course intention. The interface connects learning activities in a blended environment to provide students with a clear outline of what they "Need to know" and "Need to do" each week to stay on track.

Since the first iteration of the Learning Pathway in 2012, the system has been successfully embraced by a variety of small and large classes (1200+ students) at

Table 3.2 Tools that help communication

Tool	Description	Advantages	Disadvantages
Discussion board (e.g. Blackboard[a])	A threaded discussion that allows ideas, Q&A, etc., to be shared	Asynchronous use Extends discussion outside of class	Can be clunky following threads Limited search and tagging function
Virtual room (e.g. Adobe Connect[b], Google Hangouts[c])	An online portal for communication	User choice of place Integration of video, screen sharing, resources and text	May require specific software
Casper Q&A[d]	A Q&A forum styled on Reddit and Stack that allows reputation points to be earned	Questions can be tagged/upvoted Editable email settings	No file upload Not suitable for conversational dialogue
YouTube[e]	A video-sharing platform	Easy upload/sharing Videos can be 11 h Scheduled uploads Analytics of usage	Videos public; access difficult to restrict Only Google + users can leave comments
Facebook Groups[f]	A social platform for text, photographs, or documents sharing	Editable post settings Users can comment/reply to posts Administrators can police posts	All posts have same privacy level Content structured by date/popularity Requests to join need administrators
Piazza[g]	A student-driven, instructor-controlled Q&A forum that supports questions, announcements, polls	Instructors can endorse Q&A Posts to class or instructor Folders used Statistics on activity	Free Integrated Learning Management System Maths (LaTeX) editor Not suitable for conversation
TodaysMeet, Braincloud, Top Hat	Communications tools enabling students to respond and discuss on mass in class including creating a backchannel discussion	Enables all students to respond and discuss Supports analytics of student activity	Requires students to have devices in class which may have some equity issues and require excellent networks
Slack[h]	A messaging app for team collaboration. Chat rooms organised by topic	Suitable for chat Public or private Users can be tagged Notifications based on keywords	Free use limited to 10,000 messages Messages can get lost in discussion No LTI integration

[a]https://en-us.help.blackboard.com/Learn/9.1_2014_04/Instructor/080_Collaboration/010_Discussions/010_About_Forums_Threads
[b]http://www.adobe.com/au/products/adobeconnect.html
[c]https://hangouts.google.com/
[d]https://www.eait.uq.edu.au/teaching-learning-projects
[e]https://support.google.com/youtube#topic=4355266
[f]https://www.facebook.com/help/162866443847527/
[g]https://piazza.com/
[h]https://slack.com/

different levels across faculties and institutions. Interested readers can explore the tool in our demo CourseSite, and you are more than welcome to use it—we have made it freely available.

3.3.5 Facilitating Collaboration

Collaboration, where students have to negotiate meaning and tasks, is another key feature of the flipped classroom. Most of our courses use project-based learning and hence require students to work in teams. Much of what we do to facilitate collaboration does not require technology:

- we design on-campus tasks to encourage learning in a team environment that requires students to support each other;
- assessment tasks are designed to develop the ability to independently judge the work and capacities of others; and
- physical spaces are provided for students to collaborate on campus (e.g. large flat floor spaces where students work assisted by a teaching team circulating the room, rooms where students can sit in pods to collaborate, and outdoor spaces where students can build prototypes).

But we also use online technology:

- modules to challenge students to reflect on personal strengths and preferences;
- chat rooms to allow students to discuss difficult concepts;
- systems to allocate students to teams based on a team skills inventory and/or prior knowledge of student attributes; and
- peer evaluation to measure the work of the individual in a team, and to identify teams that require targeted mentoring (Kavanagh et al. 2011).

Table 3.3 shows the comparison of the readily available tools for collaboration.

3.3.6 Assessment

The flipped classroom is characterised by increased opportunities for formative assessment and feedback that allow students and educators to evaluate whether key content is being understood as the course progresses, rather than at the end when it is too late. For example, online quizzes before class can be a diagnostic tool and allow the facilitator to adjust the lecture and calibrate in-class activities to suit students' needs (Novak et al. 1999). In much the same way, "clickstream" data (i.e. how many students watched a podcast, and how many watched it to the end) can be used to measure class engagement.

If the clickstream data are showing low engagement, then frequent low stakes assessment can be used to help motivate and guide student towards key

Table 3.3 Tools that help Collaboration

Tool	Description	Advantages	Disadvantages
WebPA[a]	Peer assessment of team work/input	Automatically calculates peer assessment factors Assists students/mentors review team functionality	Students can skew results; instructor moderation essential Does not work with groups of 2
iCAS[b] (Interactive Chemistry Assessment System)	Team collaboration and peer marking of submissions	Easy to monitor/control Central platform for assignment submissions/peer evaluation	Tailored specifically for chemistry assignments Can be difficult to set up
Dropbox[c]	File share service that allows multiple people to share files	Easy to set up Easy to access and use	Document version control is difficult Synchronous editing not available
Google Docs[d]	A service for writing collaborative documents	Easy to set up and use Allows multiple people to work on a document simultaneously	Not suitable for complex or large documents Difficult to monitor and control usage
Facebook[f]	A way to share files and comment on group work	Ubiquitous use Provides notifications of updates	Poor version control for documents Difficult to monitor

[a]http://webpa.ac.uk/
[b]https://espace.library.uq.edu.au/view/UQ:243051/ISIT_Final_Report.pdf
[c]https://www.dropbox.com/
[d]https://www.google.com.au/docs/about/
[e]https://www.facebook.com/

goals. Exploring your institutional learning management system (LMS, e.g. Blackboard, Moodle) will usually reveal that there are many assessment tools that support submission, marking, and grade management of assignments available to you for which you have institutional support and that students are familiar with.

Technologies also provide opportunities to explore innovative assessment tasks with students developing portfolios, videos, and virtual and real products. We recommend the Transforming Assessment website (http://transformingassessment.com/) and the Office for Learning and Teaching (http://www.olt.gov.au) for a great collection of resources and cases in technology enhanced learning and assessment.

Between your institution's LMS and the above websites, you may need to look no further but in case you are interested Table 3.4 shows the comparison of other common tools used for assessment.

Table 3.4 Tools that help assessment

Tool	Description	Advantages	Disadvantages
Semant[a]	Rapid identification of problematic concepts through semantic analysis of short-answer questions	Student responses can be used in class to focus discussion Used in LMS	Currently runs only in Blackboard
Google Sheets[b]	Collaborative online spreadsheet tool which can be used to manage marking with rubrics and mark collation	Enables a full history of changes to marking Collaborative marking—data can be entered simultaneously	Requires Google account Customisation can be time intensive and difficult
Turnitin[c]	Plagiarism detection software with built-in online grading tools for annotation and criterion-based marking	Accepts variety of document types Discourages plagiarism Marker can comment Templates/frequently used comments	Not suitable for diagrams, computer code, etc. Proprietary system
Electronic management of assessment[d]	Electronic submission of assignments, as well as marking and feedback	Increased flexibility Traceable assessment records New opportunities for peer review	Problematic submission of equations, drawings, and music Potential technical issues/disruptions

[a]https://www.elipse.uq.edu.au/projects
[b]https://www.google.com.au/sheets/about/
[c]http://turnitin.com/
[d]https://www.jisc.ac.uk/guides/transforming-assessment-and-feedback

3.3.7 Understanding What Students Are Doing in Your Flipped Classroom

Through the use of Learning Analytics, flipped classrooms provide many opportunities for you to assess student understanding and gather data to help you understand what's going on. We have already covered some tools that will help you understand what your students are doing, for example:

- assessment tools can identify key concepts that students are struggling with (e.g. Semant), individual contributions to team work (e.g. WebPA);
- communication tools enable students to tell you what they are doing; and
- social media tools can help you keep a finger on the pulse of the course.

Other tools that may help you evaluate your flipped classroom are detailed in Table 3.5.

Table 3.5 Tools that help course evaluation

Tool	Description	Advantages	Disadvantages
LMS Dashboard	Institutional LMS have associated dashboards that can show student engagement	Part of the institutional system Students familiar with system	Can be difficult to tailor/customise
Survey Monkey[a]	A proprietary system (with free trial) used to create, implement, and evaluate online surveys	Easy to set up All question types supported	An individual can take a survey multiple times Not free
Brightspace[b]	Advanced analytics to monitor and predict student performance	Can highlight problem areas	Experience needed Not free
Social media surveys/polls (e.g. Facebook, Twitter[c])	If you already use social media in your class, polls can help elicit student feedback and comments	Polls spark conversation and showcase results Backchannels enable real-time comments in class Build community	Student identity management Potential unprofessional interactions

[a]https://www.surveymonkey.com
[b]http://www.brightspace.com/solutions/higher-education/advanced-analytics/
[c]https://twitter.com

3.4 Conclusion

This chapter has explored both the affordances and challenges that technology brings to implementing a flipped classroom, peppered with examples from our engineering course. Technology has removed, and continues to remove, constraints from teaching and learning enabling exciting innovations. It can serve to alleviate the administrative burden of managing classes, especially large classes, and also to enhance and augment intended learning outcomes by fostering collaborative learning and allowing innovative assessment.

But technology must be purposefully linked to technology for intended learning outcomes, active learning, and engagement. Therefore, much like an architect or engineer conceptualises a vision and then sets out to turn it into reality, flipped classroom development should follow a design process and the selection of technology is one small part of this. We've focused on Conole's 7C framework in this chapter as we found it to be a very useful method for ensuring that technology is purposefully integrated with the design.

In choosing technology for your flipped classroom, consideration must be given to available resources and support. Some technologies are expensive to purchase and maintain, while others are freely available on the Internet. We've given you a range of tools to consider (Tables 3.1, 3.2, 3.3, 3.4, 3.5), but it may be that you find other learning design models more appropriate, and/or a different suite of tools especially given rapid obsoletism and development cycles. The key message here is to design the learning experience with students in mind and implement purposeful integration of technologies to suit intended learning outcomes and activities.

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Chapter 4
Assessing Flipped Classrooms

Renee M. Clark and Mary Besterfield-Sacre

Abstract We discuss a mixed methods approach for assessing the flipped classroom, which we applied to a school-wide initiative starting in the fall of 2013. Assessment of a flipped classroom is, in many ways, no different than rigorous assessment of any good pedagogy. Assessment planning must first consider the objectives of the pedagogical initiative. The critical question we asked was "What educational gains or advantages should students experience as a result of course flipping?" We then focused on the selection of instruments and protocols for measurement. To study student learning and achievement, we analysed pre-flip versus flip exam and homework results and formally interviewed instructors. To investigate in-class engagement and active learning, we conducted classroom observation using a validated protocol. Using web analytics video access data, we investigated preparation with the flipped classroom and its relationship to achievement. Finally, to assess student perceptions, we used an evaluation survey tailored to the flipped classroom and a research-based classroom environment instrument. A comprehensive and thorough assessment plan provides the advantage of both formative and summative data for an initiative and can guide future directions with it.

Keywords Flipped classroom · Assessment · Evaluation · Educational objectives · Learning outcomes

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4.1 Introduction and Literature Review

A comprehensive plan for assessing an educational initiative or intervention can provide both summative and formative information and enable faculty to measure and influence ultimate attainment of the objectives. Our school of engineering formally began a flipped classroom initiative in the fall of 2013 to drive active learning, student engagement and ultimately enhanced learning. The flipped courses consisted of freshman through senior-level courses in introductory programming, statics/mechanics, mechanical design, bio-thermodynamics, facilities layout/material handling, and chemical engineering dynamics and modelling. In our flipped classrooms, students demonstrated and practiced their skills during class after having received the foundational knowledge via instructor-created video lectures. To thoroughly assess the initiative, we developed a mixed methods plan involving both direct and indirect measurements, which we successfully applied over the course of multiple semesters.

Good assessment first considers the educational objectives and goals of the pedagogical initiative or particular course and then aligns the assessment methods with the objectives and intended outcomes, as discussed in the literature (Wiggins and McTighe 2005; Suskie 2008; Gray 2010; Streveler et al. 2012; Kober 2015). Thus, when we began our assessment planning, we asked the important question "What educational gains or advantages do we want students to experience as a result of course flipping?" In particular, are there certain higher-order skills in Bloom's taxonomy, such as synthesis, that are of interest? (Wiggins and McTighe 2005). Or, are the primary goals retention and integration of knowledge or mastery of difficult concepts? We additionally aimed to increase student engagement and active learning in the classroom with flipped instruction. Once the specific objectives are identified for a school-wide initiative or individual courses, instruments and protocols for measurement can be selected or developed. Although the specific objectives will drive the particular instruments and protocols selected, our objectives were consistent with many other flipped STEM classroom studies in the literature; therefore, our assessment plan may serve as a model for other STEM classrooms that are flipped.

4.1.1 Assessment Methods

4.1.1.1 Learning and Achievement

To study student learning and achievement, we analysed pre-flip versus flip direct assessment results, such as particular exams or homework scores, using an analysis of covariance with the pre-course GPA as a control variable. A pre- versus post-measurement approach is useful for showing programme improvement and course effectiveness in the light of specific changes or interventions (Hake 1998; Spurlin 2008). The direct assessments that we used were chosen carefully to ensure fair comparisons pre-flip to flip and to address the instructor's particular learning objectives with the course. We also formally interviewed instructors after the course using a semi-structured protocol to assess student gains that may not have been evident in exam or homework results. To investigate student preparation, we used video access data collected via web analytics software. We further correlated these data with achievement in the course to understand the relationship between preparation and achievement in the flipped classroom.

4.1.1.2 Classroom Observation

To investigate in-class engagement and active learning, structured observation was used. Validated protocols such as the Teaching Dimensions Observation Protocol (TDOP) or the Classroom Observation Protocol for Undergraduate STEM (COPUS) are available to structure and guide the observation (Hora and Ferrare 2013; Smith et al. 2013). These protocols enable a determination of the frequency of activities and practices such as problem solving, clicker questions, instructor circulation among students, small group work, lecturing, and peer discussion. They also provide a means to authentically assess many of the professional skills that may be intended learning outcomes for students. The TDOP was developed in 2009 by researchers at the University of Wisconsin's Center for Educational Research as part of an NSF-funded study. It was designed to capture practices in the classroom, such as student-centred learning activities, student interactions and dialogue, and technology use by instructors. The TDOP dimensions that describe these practices and activities are as follows: (1) teaching methods, or how information is disseminated and learning occurs in the classroom; (2) pedagogical moves, pertaining to teaching style and strategies; (3) questioning between instructors and students; (4) cognitive engagement by students, such as problem solving or discussing; and (5) instructional technology use. The TDOP can be used to assess classroom practices in response to instructional interventions; it does not assess teaching quality per se (Hora and Ferrare 2014). For these reasons, it is well suited to assess a flipped classroom as well as its non-flipped counterpart.

The developers of the TDOP have used both five-minute and two-minute observation windows, or segments, for recording the specific practices observed, and they have reported inter-rater reliability using the five-minute window (Hora and Ferrare 2013; Hora et al. 2012). Based on personal communication with the developer of the TDOP, the two-minute window provides more granular data, as more happens during a five-minute versus a two-minute period. However, the two-minute window places more demands on the observer and may decrease his/her ability to record notes and casually assess classroom happenings and the environment (Personal Communication with Hora 2014).

Due to difficulties in achieving inter-reliability, researchers at the Universities of Maine and British Columbia modified the TDOP. They developed the COPUS, which contains fewer codes than the TDOP and examines just two main categories—(1) what students are doing and (2) what the instructor is doing (Smith et al. 2013). Upon review of the COPUS, we believe it would also work well for assessing the flipped classroom. Since the COPUS was based upon the TDOP, it is similar but appears to be a simpler protocol. The inter-rater reliability scores achieved by the developers of the COPUS were quite good (Smith et al. 2013).

The TDOP and the COPUS are examples of structured or closed-system protocols, which provide a set of codes or a predetermined response format, such as a rating scale, by which the observer describes the classroom practices. Alternatively, with open-ended protocols, observers record narratives or notes that may be judgment-based and/or used for teacher evaluation (Boulmetis and Dutwin 2011; Stodolsky 1990). Although open-ended protocols can provide a rich description of the classroom, it is not always possible to compare classrooms (e.g. pre-flipped vs. flipped) or otherwise standardise the data (Smith et al. 2013). For these reasons, structured observation protocols may be best for evaluating flipped classroom initiatives. Prior to the development of the TDOP, examples of other structured protocols in existence included the Reformed Teaching Observation Protocol (RTOP) and the *Inside the Classroom* analytic protocol. However, both of these protocols require observers to make judgments about the lesson, its content, and/or the instructor, including the quality of each of these (Sawada et al. 2002; Pasley et al. 2004). As such, for our initiative, these protocols would not have been entirely applicable to our goal of describing student engagement and involvement in the flipped classroom. The TDOP was developed in response to such issues and was therefore was very suitable for our observational assessment needs with the flipped classroom (Hora et al. 2013).

4.1.1.3 Flipped Classroom Evaluation Survey

To study student perceptions of the flipped classroom, we employed a research-based classroom environment instrument and an evaluation survey specifically geared to the flipped classroom experience. The evaluation survey allowed students to describe their preferences, behaviours, and feelings regarding the flipped classroom, providing both formative and summative feedback. Student perceptions of the benefits and drawbacks were gathered in an open-ended fashion and analysed via a content analysis with trained coders having inter-rater reliability. Our evaluation survey was modelled upon perception instruments implemented in a flipped course at Penn State with engineering undergraduates (Leicht et al. 2012; Zappe et al. 2009).

4.1.1.4 Classroom Environment Survey

Although direct assessment of student achievement is very important, it does not give a complete picture of a student's educational experience. It is also important to understand what happens in the classroom, students' perceptions of these experiences, and the psychosocial environment they learn within (Fraser 2012). For our flipped classroom research, we employed the College and University Classroom Environment Inventory (CUCEI) for this indirect type of assessment. The CUCEI

Table 4.1 CUCEI dimensions

Dimension	Definition
Student cohesiveness	Students know and help one another
Individualisation	Students can make decisions; treated individually or differentially
Innovation	New or unusual class activities or techniques
Involvement	Students participate actively in class
Personalisation	Student interaction/instructor
Satisfaction	Enjoyment of classes
Task orientation	Organisation of class activities

reliably evaluates student perceptions of seven psychosocial dimensions of the classroom (Fraser and Treagust 1986), several of which are particularly relevant to the goals of the flipped classroom, as described in Table 4.1. In addition, this is one of the few instruments specifically suited to higher education (Fraser 2012). The CUCEI has been used previously in flipped STEM classroom research (Strayer 2012). It has also been used to assess tutorial-type STEM courses, which have a similar format to the flipped classroom (Coll et al. 2002).

As with the observation data, our classroom environment data were analysed in a pre-flip versus flip manner (when possible) or in comparison with other studies in the literature. There are additional classroom learning environment instruments available from the literature, and an examination of their dimensions should be done to guide proper selection. These additional instruments include the Learning Environment Inventory (LEI), the Individualised Classroom Environment Questionnaire (ICEQ), and 'What is Happening in this Class?' (WIHIC) (Fraser 2012). A recent book chapter by the developer of the CUCEI reviewed over 40 years of research on the learning environments of STEM classrooms (Fraser 2012). Fraser points out in this chapter that classroom environment instruments can be used as process indicators for educational innovations and initiatives. He noted a study in which classroom environment variables had differentiated between curricula even though the various outcome measures had not.

In summary, an upfront, comprehensive assessment plan can provide formative and summative evidence regarding an initiative and foster opportunities for the collection of baseline or pre-flip data for meaningful comparisons. For these reasons, a proactive assessment plan is important to the success of a flipped classroom initiative, including an ability to guide future directions with it. In the following sections, we will describe our proactive and comprehensive approach to assessing the flipped classroom, starting with our planning stage. We then describe in detail the implementation of the various methods we used, including classroom observation, measurement of achievement and student preparation, instructor interviews, and student perception instruments. We also provide recommendations and suggestions based on our experience in implementing this assessment plan. The approach we describe has been successful in building, sustaining and growing our flipped classroom initiative within our school of engineering.

4.2 Assessment Planning

Thorough and upfront assessment planning can enhance the quality, quantity, and usefulness of the information that an educational institution has about its interventions and initiatives, including pre-flip or baseline data for comparison purposes. As discussed in the introduction, those planning for the assessment of an initiative or course within a school must first consider the objectives or goals of the initiative (for example, flipped instruction) and subsequently focus on methods for optimal assessment. Thus, when we (as the assessment analysts within our school) began planning for the flipped classroom prior to its actual implementation, we utilised the planning template shown in Fig. 4.1. We recommend that assessment planning be done by a team consisting of the instructor(s) and the assessment analyst or specialist. The template in Fig. 4.1 is similar in nature to the logic model used by project managers and evaluators to describe a project in terms of its inputs, activities, outputs, outcomes, and effectiveness (Brent 2012; McCawley 2001). The framework we used has columns for the educational objectives of the intervention or initiative; a definition or description of the objectives; instruments, tests, and methods to be used to measure the intended results and outcomes; and details of the methods.

As a means of identifying the specific objectives, the following question can be asked: "What should students achieve, embody, display, or gain as a result of flipping the course(s)?" Additionally, "What information is desired or needed by the instructor, researcher, assessment analyst, or other administrator?" It may be advantageous to further define or describe the objectives, as it may help in choosing or designing optimal assessments. For example, if you want to improve student learning, is it certain higher-order skills in Bloom's taxonomy, retention of knowledge, mastery of concepts, or possibly several of these, that you are targeting?

	Objective	Definition	Instruments/ Methods	Details
1	Improve student learning	• Increase deep thinking (e.g., analysis, synthesis, and problem formulation) • Improve computational ability, modeling, and problem solving • Improve application of knowledge in future courses and beyond • Increase mastery of key concepts and minimize muddiest points	• Course-specific learning assessments (e.g., test, homework, projects)	• Non-flipped vs. flipped
			• Faculty interviews and reflections	• Post-course questions about learning gains, including deep learning
2	Improve student engagement	• Create excitement about the class and content • Improve student confidence in problem solving • Increase active learning	• Classroom Environment Inventory (Fraser & Treagust, 1986) • Flipped Classroom Evaluation Survey (Zappe et al., 2009) • Teaching Dimensions Observation Protocol (Hora & Ferrare, 2013)	• Non-flipped vs. flipped Administer at 2/3 mark of term • Administer at 2/3 mark of term • Non-flipped vs. flipped Observe at 1/3 & 2/3 marks of term

Fig. 4.1 Assessment planning template

In Fig. 4.1 for example, our objective of improving student engagement, and in particular in-class active learning and excitement among the students, led us to pursue structured classroom observation with the TDOP and Fraser's CUCEI to investigate these objectives. We recommend such a template when beginning assessment planning for an educational initiative such as the flipped classroom because of its ability to guide and direct the planning.

As shown in Fig. 4.1, we used both direct and indirect assessments to assess our initiative. Direct assessments measure student work, such as projects, exams, or homework assignments. In addition, our structured classroom observation based upon the TDOP was a form of direct assessment of the intended activities and behaviours in the flipped classroom. Indirect assessments measure students' self-reported perceptions of their learning or experiences, oftentimes through a survey, interview, or focus group (Spurlin 2008; Olds and Miller 2008). We conducted both types of assessment in a pre-flip versus flip fashion (when possible) and at particular points in the semester. The use of this mixed methods approach enabled us to triangulate our findings, which is an important component of good assessment practice. Triangulation provides an overall view of the progress on an objective by taking into consideration and comparing multiple types of assessments, including both direct and indirect measures (Spurlin 2008). In this way, validation of the results is facilitated, since various measures and sources can be used to provide corroborating evidence regarding the project (Creswell 2013; Fitzpatrick et al. 2011).

4.3 Implementation of Assessment Methods for the Flipped Classroom

4.3.1 Structured Classroom Observation

Structured classroom observation using a protocol such as the TDOP or COPUS enables the direct assessment of student activity and interaction in the flipped classroom setting, as described in the introduction. In addition, classroom observation provides a means of authentically assessing particular student behaviours and practices of interest, such as active questioning by students, teamwork, and student discussions to resolve problems, which we as educators may not often formally assess. In addition, in our experience, observation provides the assessment analyst with a much-needed and important understanding and perspective concerning the particular implementation of the flipped classroom and a solid basis for writing or otherwise reporting on it.

We have used the TDOP during six semesters of observation of the flipped classroom in our engineering school (Hora and Ferrare 2013). It has enabled us to assess many of the practices of interest related to flipped instruction, such as active learning and engagement in the form of problem solving and interactions. To perform the observation, the class period was divided into consecutive five-minute segments. In each segment, the various activities and practices within the protocol were recorded when observed. For example, we assessed the frequency of team-based problem solving, accountability quizzes, and student discussions to resolve challenging clicker questions. We also assessed the frequency of faculty and student interaction in the classroom, instructor circulation among students to coach and assist, and active student requests for help and guidance.

As with any structured observation method, observers must be trained to ensure consistency and reliability (Fitzpatrick et al. 2011; Hora and Ferrare 2013). For our flipped classroom assessment, either one or two trained observers performed the observation using the TDOP. They initially trained together using video recordings of classroom sessions available on the internet, as suggested in the literature (Smith et al. 2013). The two observers also trained together during an actual classroom session prior to calculating an inter-rater reliability statistic. One observer was the assessment analyst for the initiative, and the other was a faculty member and a university teaching and learning consultant. After observing, they discussed differences in assigned codes until a consensus was reached. Our inter-rater reliability statistics for use of the TDOP are shown in Table 4.2. They are based on a total of 80 five-minute observation segments from four different courses in our school-wide initiative. Values of Cohen's kappa above 0.75 suggest strong agreement beyond chance; values between 0.40 and 0.75 indicate fair levels of agreement above chance (Norusis 2005).

We generally observed two full class sessions per semester at approximately the one-third and two-thirds points in the term. However, this was not based on any pre-established standards but was rather a feasible and practical choice given our school-wide initiative. Observing additional class sessions would most certainly have increased the information in our data set. Our class sessions were between 50 and 110 min. In conjunction with the instructor, we chose sessions that were representative of the instructor's flipped classroom implementation, for example non-exam days.

In those cases in which the course could be observed before it is flipped, pre-flip data were collected. In that way, a pre-flip versus flip comparison could be done to measure desired changes, using a test such as a z-test of proportions or Fisher's exact test. In those cases in which pre-flip data could not be collected, our observational results were compared to those of a benchmark study. For example, in a recent TDOP study of 58 STEM classrooms, the observed percentages of the various practices based on a two-minute window were reported (Hora et al. 2012). We used Fisher's exact test to assess differences between the practices in our classrooms and those of the classrooms in this benchmark study.

Table 4.2 Inter-rater reliability statistics with TDOP

TDOP dimension	Description	Cohen's kappa
1	Teaching methods	0.90
2	Pedagogical moves	0.70
3	Instructor/student interactions	0.83
4	Cognitive engagement	0.86
5	Instructional technology	0.92
Overall		0.86

4.3.2 Assessment of Learning and Preparation

For each of the courses that we flipped in our school of engineering, we did a comparison of students' performance in the course before it was flipped versus when it was flipped. This direct assessment was based on an exercise such as an exam, homework, or project. An exercise that remained the same or was very similar across the various semesters considered was chosen by the instructor so that the comparison was fair and meaningful. Another factor that may be important is the instructor or grader over the semesters considered, with the optimal condition being no changes in this factor. However, if there are important changes, the factor can be included as a covariate, or control variable, in an analysis of covariance (ANCOVA).

In the analyses of covariance that we (i.e. the assessment analysts) performed, we included the beginning-of-the-semester cumulative GPA as the covariate to assess whether there was a change in achievement given the existing academic achievement level (Norusis 2005). For courses taken by first-term freshmen, the SAT score may serve as a pre-course control variable, since these students will not have a college-level GPA prior to the course. For small samples, there are nonparametric versions of the *t*-test and analysis of covariance, namely the Mann–Whitney test and Quade's Test, respectively (Norusis 2005; Quade 1967; Lawson 1983). Effect sizes based on Cohen's *d* can also be calculated. The effect size represents the extent of the difference between two groups (Salkind 2010).

Another way in which we used direct assessment data was a Pearson correlation of student achievement with the use of the videos. We did this to assess the relationship between student preparation with the video lectures and their achievement in the course. We utilised the final course grade (i.e. grade points) as our measure of achievement; however, exam or other results could have been used. To determine students' use of the videos, we downloaded video usage data from Sharepoint Analytics, the platform used to house our videos. These data indicated the number of times each video had been accessed by each student. With the analytics data, however, we identified a potential bias in that students may have watched the videos in groups, particularly in the dormitories. Therefore, not every student may have officially logged into watch a particular video. In addition, these data only indicated that a video had been launched or loaded by a student and not necessarily that it had been watched in whole or even in part. For this reason, we also asked the students to self-report the percentage of the videos they watched in our flipped classroom evaluation survey. Example results from this web analytics data use can be found in a previously published article (Clark et al. 2017).

4.3.3 Interviews and Focus Groups

As with structured classroom observation, we have found post-course interviews or focus groups with instructors to be useful to obtain an overall assessment of student learning and achievement in the flipped classroom. Interviews are a central part of qualitative evaluation, as they allow the analyst to learn the various realities and perspectives of the situation being studied (Fitzpatrick et al. 2011). Although there were several courses in our initiative in which exam or homework scores were not significantly different in the flipped version of the course, we (i.e. the assessment analysts) uncovered important findings in the post-course, semi-structured interview or focus group with the instructor or the teaching assistants. We used a set of questions aligned with our research goals, which are shown in Appendix 1 (Boulmetis and Dutwin 2011).

For example, one instructor reflected that the students were "more sophisticated, confident, and proficient CAD users" in the flipped classroom environment, as described in our case study in this book (Clark et al. 2017). This was despite a lack of significant change in the CAD take-home assignment scores (pre-flipped vs. flipped). Another instructor reflected that students in the flipped course were much better problem solvers than in previous semesters. In this course, students were assigned higher-level problems in the flipped version and solved them or made great strides in doing so. Based on these reflections, this instructor planned to provide more challenging problems going forward. In the instructor's assessment, he also benefitted from the flipped classroom because it gave him insight into the types of problems he should be posing to students.

4.3.4 Classroom Environment Instrument

As discussed in the introduction, it is important to understand students' perceptions of their classroom environment and the psychosocial environment in which they learn to give a complete picture of their educational experience (Fraser 2012). To this end, we administered the CUCEI at approximately the two-thirds point in the semester. We (as the assessment analysts) implemented the CUCEI using our survey software, Qualtrics, for ease and efficiency of data collection. The instructor distributed the survey link to the students and asked them to take the survey as desired, after explaining the nature of the study.

For those courses in which we were able to collect pre-flip environment data, we measured changes in the classroom environment in the flipped course using a *t*-test or the nonparametric Mann–Whitney test and Cohen's *d* effect size calculations. For those courses in which we did not have pre-flip environment data, we had the objective of benchmarking our flipped classroom environments against a larger-scale study. However, based on a literature search and personal communication with the developer of the CUCEI, we were unable to identify such a study (Personal Communication with Fraser 2014). However, we did find two smaller-scale CUCEI studies with classroom formats similar to ours, as discussed previously (Strayer 2012; Coll et al. 2002). Although the CUCEI instrument in Strayer's study differed somewhat from Fraser's original instrument, we determined Strayer's instrument to be similar and suitable for comparison (Strayer 2007). Two of the dimensions in Fraser's instrument—satisfaction and involvement—were not measured in Strayer's study. Several published articles contain classroom environment results from our flipped classroom implementation (Clark et al. 2014a, b). In addition, at the time of this writing, we submitted an article on our school-wide initiative with comprehensive classroom environment results (Clark et al. 2016).

4.3.5 Flipped Classroom Evaluation Survey

At the same point in the semester that we administered the CUCEI, we asked the students to also take the flipped classroom evaluation survey, using the same approach with Qualtrics. This perception survey was tailored to the flipped classroom experience and designed to provide both formative and summative indirect measures, including the benefits and drawbacks perceived. Throughout the timeframe of implementing the flipped classroom initiative in our school, this evaluation survey evolved based upon input and feedback gathered from our own faculty. The questions used within our survey are shown in Appendix 2.

In two open-ended questions on the evaluation survey, we asked the students what they liked about the flipped classroom and its benefits as well as the perceived drawbacks and suggestions for improvement. We performed a content analysis of the responses, in which codes were assigned to each response using the frameworks in Appendices 3 and 4. More than one code could be applied to a single response. These frameworks were established prior to the coding based on a grounded, emergent qualitative analysis by the assessment analyst using all student responses in our school-wide initiative (Neuendorf 2002).

After a brief training period, a single analyst coded all of the responses, which numbered approximately 400 for each of the benefits and drawbacks questions. A second analyst coded 30% of the responses to provide a measure of inter-rater reliability. We achieved an inter-rater reliability score based on Cohen's Kappa of $\kappa = 0.75$ for the benefits analysis, which suggests good agreement beyond chance (Norusis 2005). For the drawbacks analysis, the inter-rater reliability based on Cohen's Kappa was $\kappa = 0.83$, which suggests strong agreement beyond chance. These coding frameworks are provided in Appendix so that other flipped classroom researchers and analysts can similarly code the benefits and drawbacks of their own flipped classroom initiatives as perceived by the students.

4.4 Summary and Conclusions

A thorough and proactive assessment plan can enhance the collection of both formative and summative data to support an educational initiative, including baseline or pre-flip data for measurement of change. As discussed in the literature, good assessment planning begins with the identification of the objectives of the educational programme or initiative. Refinement of these objectives to specific goals, such as enhancement of certain higher-order skills in Bloom's taxonomy or increased student problem solving during class, can enhance the selection of particular instruments, methods, or protocols for measurement. Based on a review of the literature, the objectives associated with the flipped classroom initiative in our school were consistent with those at other schools; therefore, our assessment methods can serve as a model for others.

We analysed pre-flip versus flip direct assessment data, such as particular exams or homework assignments, to study student learning and achievement in the flipped classroom, using an analysis of covariance with pre-course GPA as a control variable. We also interviewed instructors using a semi-structured protocol after the course to assess learning gains that may not have been exposed through exam or homework results. We used web analytics data to examine students' preparation with the videos and its correlation to their achievement. To assess student engagement and active learning, we utilised a structured observation protocol—the TDOP—to determine the frequency of desired activities such as problem solving, instructor circulation to assist students, small group work, and peer discussions. Our structured observation showed there to be increases in these desirable practices with the flipped classroom, and we have found structured observation to be a very powerful tool in assessing flipped classrooms. To measure student perceptions, we administered a research-based classroom environment instrument as well as an evaluation survey specifically tailored to the flipped classroom experience that allowed students to describe their preferences, behaviours, and feelings in relation to the experience.

Based on our own experiences as well as the direction provided in the literature, we believe in first considering the reasons for flipping the course and the desired learning objectives. This should be the first step of the assessment planning process for a flipped classroom. To formally structure the planning, we recommend the use of a planning template, in which the objectives can be further defined and the instruments and methods best suited to each objective can be specified. We feel this is best accomplished as a joint effort by the assessment analyst and the instructor(s) of the course. If this is done early enough in the planning process, it may be possible to collect pre-flip or baseline data for comparison or change measurement purposes. We used a mixture of direct and indirect assessments so that we could triangulate our results and obtain a comprehensive picture of the flipped classroom experience.

In executing a comprehensive assessment plan such as ours, we recommend developing an implementation plan in conjunction with the instructor that captures the logistics for carrying out the assessment. The logistics should include selecting target dates for any surveys and classroom observation that do not interfere with course priorities, such as exams or project due dates for students. Instructor involvement in the assessment process was critical, including in the selection or development of surveys, in the selection of direct assessments to compare pre-flip to flip, in reflections about the impact of flipped instruction on learning, in a willingness to participate with classroom observation, and in the encouragement of their students to provide feedback via the surveys. As the assessment analysts, meeting with the instructors periodically to obtain informal or formative feedback was also valuable. Finally, in executing our plan, we would recommend the use of at least two trained analysts to complete the subjective or qualitative work, such as the classroom observation or the coding of open-ended responses. The establishment of inter-rater reliability among them is important and necessary for quality purposes.

In summary, a proactive, mixed methods plan is important in the assessment of a flipped classroom initiative for both formative and summative assessment purposes. The approach we discussed in this chapter has worked well in growing and illustrating our flipped classroom initiative within our school of engineering.

Appendix 1

Faculty/instructor interview or focus group questions

	Interview/focus group questions
1	You had an objective of "particular objective" with the flipped classroom. Did you reach this objective? If not, why do you think this was so?
2	With the flipped classroom, what benefits could you provide to the students?
3	With the flipped classroom, did students have time to do more active learning or practice during class and/or could you provide more individualised help to students during class? Please expound on
4	With the flipped classroom, did you notice that the students experienced fewer software execution problems or less frustration with the software? (for software-based courses)
5	With the flipped classroom, were there benefits to you as an instructor?
6	With the flipped classroom, what drawbacks existed for you or the students, including any drawbacks the students may have mentioned to you?
7	With the flipped classroom, did you notice improvements in problem solving ability, deep learning, quality of the students' work, or student engagement?
8	With the flipped classroom, did you notice any other good outcomes or improvements compared to previous semesters?
9	Do you plan to flip additional courses or continue to flip this course?
10	What advice would you give to a faculty member who is contemplating flipping?

Appendix 2

Course flipping evaluation survey

	Evaluation survey question	Response options or type
1	Do you prefer a "flipped" classroom over a traditional lecture class?	Yes No Not sure yet
2	What percentage of the videos did you watch? (approximate as needed, and use 0 or 100 as appropriate)	0–100%
3	When did you primarily view the videos?	Before the class period for which they were assigned After the class period for which they were assigned

(continued)

	Evaluation survey question	Response options or type
4	How often did you re-watch the videos or any portions of them?	Never Rarely Sometimes Often Almost always or Always
5	Why did you re-watch videos or portions of them? (select all that apply)	The topic was difficult or challenging to grasp The instructor's explanation or lecture was not clear (please provide specifics) To reinforce my understanding as I was learning new material To review or study course material prior to an exam or homework problem Poor audio or visual quality of the video or other technical difficulty (please provide specifics) Other (please provide specifics)
6	Did you experience any technical difficulties with the videos? (e.g. clarity/volume of speech, text size, visual quality, availability, etc.)	Yes (please provide specifics) No
7	How did you primarily use the videos?	To learn new material To review or reinforce material after it was demonstrated or presented in class
8	With the "flipped" classroom, how would you rate the overall time required of you (both in and out of class), compared to a traditional lecture class?	Less than regular lecture About the same More than regular lecture
9	I prefer using class time for problem solving or active learning exercises (with the instructor or TAs present for assistance) rather than listening to a lecture	Strongly disagree Disagree Neutral Agree Strongly agree
10	I am NOT able to learn from a video	Strongly disagree Disagree Neutral Agree Strongly agree
11	More time needed to be spent at the beginning of class reviewing the video content	Strongly disagree Disagree Neutral Agree Strongly agree
12	I understand the reasons or rationale for the "flipped" classroom style in this course	Strongly disagree Disagree Neutral Agree Strongly agree

(continued)

(continued)

	Evaluation survey question	Response options or type
13	Was there any important course content that was missing from the videos?	Yes (please provide specifics) _______ No
14	Please describe the length of each of the videos	Too short Just right Too long
15	What did you like most about this "flipped" class, and what benefits did you perceive?	Open ended
16	What suggestions do you have for improving this "flipped" class, and what drawbacks did you perceive?	Open ended

Modelled upon Zappe et al. (2009)

Appendix 3

Framework for coding of open-ended responses to benefits

Category	Benefit description/examples
Video/online learning	Re-watch videos Work at one's own pace; pause video Flexibility, convenience, own preferences Modularisation of topics
Enhanced learning or learning process	Better understanding; less confusion Enhanced learning/effectiveness/depth/ability Subject matter retention Multiple sources/resources for understanding Reinforcement and review Multiple attempts
Alternative use of class time	In-class active learning, problem solving, clickers In-class support and questions In-class group time for projects Student interactivity and peer support
Specific to course or course's videos	Videos concise or had a good pace Overall work time less Videos had relevant content (e.g. demo or examples) or were of high quality
Preparation, engagement and professional behaviours	Engaged during class; paid attention; not bored Enjoyed class Arrived to class prepared Ability to learn on one's own; independence Drove motivation and accountability
No benefit or neutral result	No benefits perceived Did not like flipped instruction Videos not used Instructional differences not noticed

Appendix 4

Framework for coding of open-ended responses to suggestions/drawbacks

Category	Suggestion and drawback description/examples
Specific to course or course's videos	Include more examples or problems in the videos Videos needed editing or bug/technical fixes Videos were too long Videos were not sufficiently described Videos were dry or boring Videos did not have an appropriate pace Videos repeated information Video material was too complex
In-class time	Increase time for active learning or problem solving Increase effectiveness or relevancy of problems; grade them Provide appropriate amount of lecture or content review Have more instructor-types during class to assist Synchronize class activity and video content
Prepare, Equip & incentivize students to flip	Prepare students for the flipped learning style Incentivize students, including video quizzes Clarify/emphasize expectations, including video watching Provide video "lecture" notes Ensure videos available in advance for students
No drawbacks or neutral result	No drawbacks or suggestions
Load, burden, stressors	Insufficient time to complete out-of-class activities Increased work load Increased time burden Concerns over grades or impacts to the grade Accountability quizzes (including surprise)
Approach differently	Do not flip courses in general; use traditional teaching Do not flip this course in particular Provide students with a choice on flipping Flip only a portion of the class periods
Video/online learning	Students unable to ask questions during a video Instructor unable to sense student understanding in a video Distractors to viewing videos in a non-classroom setting Less motivation to attend class
Student learning	Lesser understanding or learning Difficulty learning from a video

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Chapter 5
Reflective and Reflexive Practices in the Flipped Classroom

Geoff Greenfield and Paul Hibbert

Abstract This chapter explores what we are asking students to do in flipped classroom context. We show how we are asking students to independently (but with facilitation) engage with practical and theoretical problems, and how engaging in this independent learning process challenges students to understand *themselves* differently. This requires the development of two distinct yet overlapping kinds of practices—namely *reflective* (problem-oriented) and *reflexive* (self-oriented) practices (Hibbert in J Manage Edu 37:803–827, 2013; Cunliffe in J Manage Edu 28:407–426, 2004; Cunliffe in The Sage handbook of management learning, education and development. Sage, London, pp 405–418, 2009a). We use Knowles et al.'s (The adult learner. Butterworth-Heinemann, Oxford, 2011) six andragogic principles that characterise adult learners and show how reflective and reflexive practices are involved in helping students to live out these principles in university contexts. In doing so, we outline a developmental trajectory for students, moving from a transactional learning mindset to an exploratory framing of the learning process. This characterisation of the learning process provides an initial overview for educators who seek to develop their approach to reflective teaching, in the context of flipped classrooms. This overview naturally leaves some questions unanswered. So we conclude by offering some suggestions to the most likely three such questions: 1. *Application*: where might I get more specific, implementable ideas?; 2. *Alternatives*: is Knowles et al.'s (The adult learner. Butterworth-Heinemann, Oxford, 2011) framework the only or best way to frame the application of reflective/reflexive practice?; and 3. *Adaptation*: what might I do to operationalise these ideas in my own classroom contexts?

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Keywords Reflective practice · Reflexive practice · Flipped classroom · Adult learners · Application · Alternatives · Adaptation

5.1 Introduction

This chapter is concerned with exploring two particular aspects of what we are asking students to do in flipped classroom contexts. The first aspect is that we are asking students to independently (but with facilitation) engage with practical and theoretical problems in order to develop their own discipline-focussed understanding. The second aspect is that, through engaging in this independent learning process, we are asking students to understand *themselves* differently, that is, to see themselves as adult learners (Knowles et al. 2011) capable of developing their knowledge further through individual *self-directed* learning, and through engaging with other adult learners in team processes. These things that we thereby ask of students—to learn in a more independent mode and to understand themselves differently—are two distinct yet overlapping challenges. Addressing these challenges also requires the development of two distinct yet overlapping kinds of practices—namely *reflective* (problem-oriented) and *reflexive* (self-oriented) practices (Hibbert 2013; Cunliffe 2004, 2009a).

In this chapter, both kinds of practice are outlined and the issues that may arise are considered. To provide a structure for this engagement, the remainder of the text proceeds in three parts. First, reflective and reflexive practices are briefly defined and contrasted. Second, using Knowles et al.'s (2011) six adult learner principles as an organising framework, example approaches to support student engagement in these practices are described. Finally, issues related to variations in learner engagement and developmental trajectories are considered in order to stimulate further generative reflection for educators.

5.2 Reflective and Reflexive Practices

As we will argue later in this chapter, reflective and reflexive practices can often overlap, especially in relation to reflection in a critical mode (Dehler 2009; Hibbert 2013). But before the overlaps and their implications are considered, it is helpful to try to first highlight the distinctive differences between the two kinds of practices. Reflective practice, in professional contexts and the vocational education programmes that support such contexts, is most easily approached through the work of Schön (1991). From his conceptualisation, reflective practice is concerned with the operation of two related modes of thought, *reflection in action* and *reflection on action*.

Reflection on action is the simplest practice to understand—it is a retrospective examination of events, to determine what we have learnt from our experience and how we might therefore act differently in the future. It is thus a practice centred on developing the capacity for solving *future problems*. Authors have discussed various ways of supporting this kind of reflection; some of these approaches are highly structured and involve frameworks or tools for engaging with experience or "training problems" (see Gray 2007, whose examples include some "tools" of this kind). Such approaches lead to relatively predictable learning outcomes, as they focus thinking within the terms that the framework offers.

Other approaches to reflection on action are less structured and concentrate on the role of writing (i.e. conversation with oneself) and/or speaking (i.e. conversation with others), in a flexible pattern of (re)-engagement with experience (Bolton 2014). This kind of reflective practice is creative and rather unpredictable in its outcomes—and therefore *potentially* leads to more substantial learning gains, albeit in unexpected directions. However, in the case of "conversation with oneself", the scope of learning can still be somewhat constrained by the individual's mental models, developed from repeated and confirmatory experiences that shape their ways of seeing and understanding (Hibbert et al. 2014; Knowles et al. 2011).

Reflection in action has a similar feel to the "conversation with oneself" that can be one way of conducting retrospective reflective practice, and uses the individual's existing mental models productively. It is a rather intuitive and unstructured process, focussed on solving *current problems*. Schön (1991) provides a good example in his account of an architect's conversation, in which he considers the terrain of a construction site for a school and the ways in which children might relate to and interact with an imagined structure. This kind of intuitive reflection is built upon professional learning that has been embedded through earlier reflection on action, in formal training and prior professional projects.

To go beyond the utility of existing frames and mental models effectively depends on finding ways of exploring problems differently, through challenging our usual ways of thinking. This is where we step into *reflexive* practice (Cunliffe 2004; Hibbert et al. 2010; Myers 2010). Instead of using mental tools to solve problems, reflexive practice focuses on ourselves as problem solvers, asking such questions as follows:

- How do I recognise problems, and do my assumptions and usual frameworks for thinking mean that there are (aspects of) problems that I miss?
- Are there other way(s) of understanding the nature of the problems I encounter, and my own role in solving them?
- How might I learn to change *myself* in order to have a richer (or different) understanding, and see things differently?

Such questions can lead individuals to transformational learning outcomes, outcomes that lead to changes in action as well as changes in thinking (Hibbert and Cunliffe 2015). Making this kind of outcome possible requires encounters with different paradigms and/or individuals with different perspectives, which we engage with in dialogue. Going back to our example from Schön (1991), we might ask how an architect's ideas about the construction of a school might work out differently if he talked with children, parents or teachers—and tried to "think with" their points of view. Taking others viewpoints as seriously as our own opens us up to the surprising recognition that our knowledge is always imperfect and that the learning we gain from any problem, situation or encounter is intrinsically linked to our belief that the other person (or text, or unfamiliar idea) can always reveal something we cannot see from our usual point of view (Grondin 2011). This recognition helps learners to move from a relatively acquisitional, exchange view of learning (in which knowledge is given and received) to a view of learning as a process of shared exploration and creation (Hibbert et al. 2014).

In students first encounters with flipped classrooms, we require both kinds of practices to be developed. We require them not only to be effective "problem solvers", but also to undergo an effective transformation into independent "adult learners" (Knowles et al. 2011) who can reflectively and reflexively engage with learning experiences, as sites of both acquisition and exploration. We now turn to Knowles et al.'s (2011) principles in more depth, as a framework for considering the application of reflective and reflexive practices in more detail.

5.3 Using *Adult Learner* Principles as a Way to Approach Reflective and Reflexive Practices

In this section, we connect in depth with Knowles et al.'s (2011) six andragogic principles that characterise adult learners and show how reflective and reflexive practices are involved in helping students to live out these principles in university contexts.

5.3.1 Motivation to Learn

The first principle we wish to consider is students' motivation to learn and how that might be enhanced—or not—through reflective and reflexive practices. Knowles et al. (2011) connect with the basic understandings of motivation as either intrinsic (in learning contexts, focussed on personal development) or extrinsic (oriented towards some desired outcome). In the classroom context, both kinds of motivation can be in play, but they are complicated by whether the student has a present orientation or a future orientation. In a present orientation, students are motivated by factors within the educational context, whilst in a future orientation they are considering what the expected qualification will allow them to be or become after the completion of their formal studies. Extrinsic and intrinsic motivational factors can apply in either orientation, and reflective and reflexive practices can helpfully connect with these motivations in each case (c.f. Archer 2007). We shall illustrate this in connection with the remaining five principles in the adult learner framework, moving first to the closely related principle of a "need to know".

5.3.2 Need to Know

We could summarise this principle by stating that *adult learners don't undergo instruction just because they are instructed to do so!* Instead, there needs to be some clear understanding of why they need to learn that works within their (evolving) perspective. This is important since there are different motivational factors in play, in part related to the present and future orientations discussed above; the reasons for needing to learn will have an impact on the potential learning outcomes that might be hoped for; and the perceived need to learn will be different in conventional and flipped classroom contexts. These kinds of reflective and reflexive practices involved in establishing and connecting with, or building usefully on, a student's need to know are indicated in Table 5.1.

It is important to note that there will be a mixture of needs from a student's perspective, both because of mixed motivations and because some simple present outcomes (grades, passing the course) are nevertheless essential for more complex, deferred outcomes (future professional practice). The degree to which the student can be helped to connect with the reality of future deferred outcomes, the more likely they will be able to engage in reflexive practices that change their approach to learning more radically (c.f. Hibbert 2013). Essentially, this is connected to the next of the six principles that we consider, the individual's *readiness to learn*.

5.3.3 Readiness to Learn

> The use of computer-based simulations such as those based on "The balanced scorecard" (Kaplan and Norton 1992) in a capstone course provides students the opportunity to make decisions and apply knowledge as if they were in the roles.

Supporting student's readiness to learn involves imaginative work. Knowles et al. (2011) emphasise that a student's readiness to learn is linking to their life-stage, to their process of becoming and give the example of parenting—a subject which becomes the focus of intense learning and reflection for adults who become parents, but not so much for those who have not (or will not) arrived at this stage. We might draw similar conclusions about professional practice in student's chosen field and readiness to learn what is really required in that field. For these reasons, there is a need for stimulation readiness to learn by helping students to imaginatively occupy future roles. This stimulation of readiness to learn might be enacted through, for example, dialogue with experienced professionals to explore the field from within; or simulations that require students to act "as if" they were in demanding professional roles (or situations which require similar capabilities—see Nichols and Wright 2015). Examples might also be used to generate connections

Table 5.1 Working *with* and *on* students' need to know

Classroom/learning context and student orientation	Most important aspect of "need to know"	Facilitation considerations	Reflective and reflexive practices
Conventional/present orientation	Obtaining grades/passing the course	Structure all student engagement to feed into grades: do not expect participation otherwise	Reflective: directed application of predesigned frameworks, tools and concepts
Flipped (1)/present orientation	Confidence in, and mastery of, the subject	Structure engagement and feedback to foreground students' (awareness of) capabilities within activities	Reflective: self-selection and application of predesigned frameworks, tools and concepts
Flipped (2)/future orientation	Understanding of future professional practice	Connect classroom activity with professional practice cases, simulations and examples; where possible, have students work on "real" problems	Reflexive: student imaginatively projects themselves in the role professional practitioner and acts within that framework

to this future orientation, when they can also bridge the gap by connecting with students' frames of reference in the here-and-now, for example, by connecting with contemporary culture. All of these ways of "bridging the gap" have a common feature—they relate to concrete (or otherwise graspable) problems instead of abstract frameworks and generally combine reflective practice (problem-solving) with the process of developing readiness through the reflexive practice of role play. This leads us to consider the next of Knowles et al.'s (2011) principles, which is that adults relate to learning as a means of solving *problems*.

5.3.4 Problem-Solving

> In a flipped classroom environment, the creation of a "management team meeting" structure for the seminars allows students to apply what they know. However, it also encourages them to consider themselves as future professionals and the implications of this.

Knowles et al. (2011) argue that adults engage in learning in order to solve problems. They are generally not concerned with learning that is about filling in the gaps of a particular subject or academic discipline. On the surface, academics devoted to their subjects we might be tempted to refer to themselves as the exceptions that prove the rule—but even within academia learning is applied to our teaching practice and content and/or to forms of written output—thus learning, even for the academic, serves a functional purpose. But it also serves to address a more fundamental problem—the question of who we are to be. Reflective practice oriented towards solving problems that are located in field blends into reflexive practice that solves or at least addresses the question of our academic identities (Ashwin 2015). In contrast, for students undertaking classes in vocational subjects the connection with practical problems does not require so much elasticity of thought; but it nevertheless still leads into reflexive practice. We still expect students to be ready for entry to professions at the conclusion of their studies, and therefore as we have discussed earlier, stimulating their readiness to learn before they have gained experience of the reality of professional life is important.

5.3.5 The Role of Experience

Experience is the next of the principles that we address. Knowles et al. (2011) argue that for adult learners this is the most useful learning resource. This principle seems to be well supported in professional practice; and there are numerous approaches to learning from experience, especially through group processes, in organisational contexts (see Raelin 2008 for a useful overview). Flipped classroom contexts can help students develop useful reflective practices that can help them maximise their leaning from experience in the future. A good example of this relates to how student groups approach “real” problems that are set by external “clients” in practically oriented classes; students can be encouraged to use Schön’s (1991) ideas of reflecting *in* action and reflecting *on* action to consider how they an develop:

- *Adaptive skills* through flexing working styles to suit the dynamics of the group,
- *Anticipatory skills* in relating to client interests in exchanges of communication, and
- *Analytical skills* in deciding how to selectively apply concepts, tools and frameworks to the problem at hand.

Keeping reflection on the three skills above in play during (simulated) experiential learning, perhaps through the use of credit-bearing reflective diaries,[1] students may be able to develop the aggregate reflexive practice of considering how to change their modus operandi in relation to the demands and possibilities of the problems with which they are presented (c.f. Hibbert 2013). In doing so, they may potentially escape limiting the learning potential of future experiences that come from fixed mental models (Knowles et al. 2011); and this might help them to also transition to understand themselves as self-directed learners. But it also places them at risk of focussing on ends and accepting (almost) any means to “get the job done”, with the result that adaptation of oneself and exploitation of experience might become cynically instrumental; so there is a need for more attention to the individual’s self-concept, and how they question the effects of their future practice.

5.3.6 Learner’s Self-concept

The final principle that Knowles et al. (2011) argued for was that adult learners develop a concept of themselves as autonomous and self-directed. Adult learners regard themselves as *responsible for their own decisions*, and this particularly includes their decisions in relation to learning. However, Taylor (2006) has argued that development for self-directed learning can be a complex process that is not *just* a matter of acquiring a requisite set of skills; we agree and suggest that supporting this transition actually requires ongoing reflexive practice during (and indeed after) the years of adult higher education. We argue this because Hibbert and Cunliffe (2015) have shown that reflexive practice is important for *really* understanding the basic concept of responsibility and that acculturation to organisational

[1]See Hyland-Russell 2014, for an innovative approach that uses a portfolio of text and images.

life and one's situation in the workplace can lead to forgetfulness in this regard: there is focus purely on ends and means (and their effects on others) are given little thought. Individuals can fall in with a new community and allow themselves to be guided by it, for good or ill (Hibbert et al. 2010); and this may lead to an abandonment of habits of reflexive practice or even of critical reflection. For that reason, one of the most helpful things that we can do for our students—and flipped classroom contexts that build up independent action and responsibility are especially constructive in this regard—is to help them maintain their reflexive self-awareness, so that they can avoid becoming the kinds of people that they might otherwise dislike (c.f. Hibbert 2013). Doing this means asking critical and imaginative questions (c.f. Duarte 2009) within their reflexive practice, such as "What is important? What if we think about organizations […] in this way rather than that? Where will it take us?" (Cunliffe 2009b: 99). Above all, our students need to be encouraged to ask who they are becoming and whether this is who they really want to be. There is a moral dimension to all professional practice, and we need to include an awareness of this, and a means of grasping it, in the patterns of reflection and reflexivity that we help students to develop. This does not prevent students *choosing* to be immoral/amoral; but it means they cannot become so *accidentally*.

5.3.7 Conclusion and Suggestion for Further Reflection the Role of Experience

In our discussion above, we have outlined a series of related principles that can be used to reframe reflective and reflexive practices in higher education contexts. In doing so, we have outlined a developmental trajectory for students, moving from a transactional learning mindset to an exploratory framing of the learning process. We have also emphasised that becoming a self-directed learner in this way inevitably leads to questions of responsibility (especially related to future professional practice). In addressing these main points, we have not sought to be directive (by prescribing particular practices) nor exhaustive (by considering how the ideas we have engaged with may play out differently within different disciplinary and interdisciplinary contexts). This characterisation of the learning process provides an initial overview for educators who seek to develop their approach to reflective teaching, in the context of flipped classrooms. This overview naturally leaves some questions unanswered, and we could like to conclude by offering some suggestions to the most likely three such questions:

- Application: where might I get more specific, implementable ideas?
- Alternatives: is Knowles et al.'s (2011) framework the only or best way to frame the application of reflective/reflexive practice?
- Adaptation: what might I do to operationalise these ideas in my own classroom contexts?

We address each of these points in turn below.

5.4 Application

There are many resources that provide ideas that are suited to supporting reflective and reflexive practices in higher education contexts. We would like to highlight three resources—some of which we have alluded to earlier—as good, recent examples of their type. The first is Ashwin's (2015) *Reflective Teaching in Higher Education*. Ashwin's book offers a substantial, highly structured theoretical review and includes some reflective exercises; it is very much focussed on the educator's own reflective development as a teacher, but its structure and examples lead naturally to ideas for working with students. Hibbert (2013) provides some ideas in a similar vein, although in the brief format of a journal article there is less room for exploration of the concepts. Ashwin's (2015) ideas can be adopted by educators working within any discipline, but might perhaps find more traction amongst those working in social and applied sciences and the humanities.

The second resource we would like to highlight is Bolton's (2014) *Reflective Practice*: *Writing and Professional Development*. Bolton's text focuses on reflective writing and narrative and poetic forms in particular; it may be particularly useful in the education of healthcare professionals and social science disciplines, but could potentially be applied more widely.

The third and final resource is Raelin's (2008) *Work-Based Learning*. In his own words, Raelin (2008: 7) regards his book in this way: "If there is recipe to be afforded here, it is one that merely prescribes how to set up various experiences that make use of the organic and reflective processes embedded in work-based learning". The "organic and reflective processes" that are described in the text are easily applied to collaborative, project-based learning in higher education (which may include "real" projects or simulations). Raelin's (2008) ideas also have the benefit that students can carry the practices and approaches he advocates with them, into their professional lives. The book is grounded in the disciplines of management and organisational studies, but the ideas apply to any organisational context and thus to any educational programme that seeks to prepare students for professional practice in their discipline.

5.5 Alternatives

We have used Knowles et al.'s (2011) six adult learning principles to frame our discussion of reflective and reflexive practices, but there are other ways of thinking about framing such practices. Indeed, the three resources we highlighted above (Ashwin 2015; Bolton 2014; Raelin 2008) each have their own "take" on the matter. But another common framework for understanding learning processes that may be useful to consider here is Bloom's taxonomy, "a six-level classification system that uses observed student behaviour to infer the level of cognitive achievement" (Athanassiou et al. 2003). The six progressive levels of cognitive development in the framework are as follows: knowledge, comprehension, application, analysis, synthesis and evaluation. Athanassiou et al.'s (2003) research on the use of the taxonomy was focussed on management students, but Bloom's taxonomy is applicable to a wide range of disciplines and so their conclusions are of general relevance. They concluded that "…students can be encouraged to think at higher levels of cognition using the taxonomy […] This study also suggests that use of the taxonomy provides students with a practical tool by which to evaluate their own performance and understand what behaviours indicate that higher order cognition is occurring. In these ways, our use of Bloom's taxonomy supports the development of student responsibility and a student-centered classroom" (Athanassiou et al. 2003: 551). Their conclusions thus support further development of the application of Bloom's taxonomy, in relation to the framing of reflective practice in the classroom.

5.6 Adaptation

We wish to conclude by offering a closing thought on how educators may adapt (some of) the ideas on reflective and reflexive practices to their own contexts. Our thoughts here are relatively concise: this can best be achieved through your own reflective practice. You will know your students, your resources and constraints best, and for that reason we would find it inappropriate to be too directive about how you might implement some of the approaches we have touched on. But there are at least two sources of further guidance that we can recommend. One source of guidance is Ashwin (2015), which is principally focused on educators' reflective self-development and may help you to think about how you engage with the particularities of your context. The second source of guidance is to work with like-minded colleagues. As Hibbert (2013: 821) puts it: "invest in building a network of similarly minded academic colleagues. Developing this kind of approach to teaching is always going to be harder work than "standard" approaches, and supportive connections and conversations might not always be available in your own institution. Furthermore, conversations with sympathetic colleagues can better address the particular practical concerns of each educator's precise context…"

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Chapter 6
Case Study Framework

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Abstract The case studies in Part 2 of this book are intended to showcase different contexts and highlight the diversity of flipped classroom approaches in practice. They are included to provide you with ideas to develop your own flip classroom practice, serve as a source of encouragement, and foreground the challenges that you may face.

Keywords Case studies · Case study framework · Big ideas · Common framework · Theoretical concepts

6.1 Introduction

The case studies in Part 2 of this book are intended to showcase different contexts and highlight the diversity of flipped classroom (FC) approaches in practice. They are included to provide you with ideas to develop your own FC practice, serve as a source of encouragement, and foreground the challenges that you may face.

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6.2 Case Studies

6.2.1 Methodology

It was our intention to provide a coherent book that provided firstly the considerations of the flipped classroom (FC) and secondly case studies as to how this might look like in the practical sense. These case studies would feature relevant teaching philosophies, strategies, and resources utilised along with academic and student experiences. Most importantly, the authors would be asked to include how they implemented their FC within the context of their institution and discipline, and using available resources.

The case studies in this section of the book are therefore based upon a common rationale and provide a consistent thread in terms of:

1. why the FC was necessary and its overall purpose;
2. how the FC was designed and implemented in response to 1; and
3. the evidence of FC success (or not) in terms of:
   (a) student grades,
   (b) utilisation of technology,
   (c) efficiencies in teaching,
   (d) cultural shifts or changes,
   (e) application to other teaching areas,
   (f) academic satisfaction, and
   (g) student satisfaction.

In order to maintain this thread, a common framework that linked the 'big ideas' from Part 1 to the case studies was disseminated to the case study authors. The framework was divided into eight components or thematic concepts (as detailed below) intended to bridge the gap between FC theory and practice across the breadth and depth of discipline practices taught within higher education. The case studies do not necessarily include all the components, but they are listed here as a reminder of what has gone before.

6.2.2 Component 1: A Purpose for Flipping the Classroom

The drivers for academics to consider changing approaches are exerted both outside the institution and within as universities compete with alternative curriculum programs such as MOOCs (Hollands and Tirthali 2014; Long 2013), struggle to match industry requirements for graduates, and require new value propositions for student presence on campus. Underpinning these pressures are the consistent concerns around student attrition rates, funding, increased numbers, and student disengagement. Explicit FC design can address most if not all of these concerns but fundamentally the approach needs to be adopted purposefully in response to a need for improvement in learning.

> …the visibly higher levels of student 'engagement', collaboration and self-directed learning align well with the stated intent of the university to integrate technology, pedagogy and curriculum and thereby promote a 're-imagining' of the learning narrative (Chap. 15).

6.2.3 Component 2: The FC Within the Curriculum

The FC should be integrated with the degree program curriculum. A spine of FC offerings across a program can provide an iconic experience for a student and be a showpiece for a school, discipline, or faculty.

Effective FC integration enables students to:

- understand threshold concepts through approaches that determine students' understanding and respond as necessary (Reidsema et al. 2014);
- achieve learning at higher levels as per Bloom's taxonomy (Clark et al. 2014); and
- increase engagement with their studies.

> …during the lecture we can ask questions, it builds up our critical thinking…how we engage with people, how we engage with our peers as well… (Chap. 11).

6.2.4 Component 3: Design and Implementation

A successful FC integrates many elements including:

- a course narrative that provides structure, links learning activities, and demonstrates relevance of the activities;
- pre-learning that usually involves some sort of online exercise and that may or may not have associated assessment;
- in-class activities that are linked with pre-learning, allow student collaboration and peer learning, and are engaging;
- assessment that fits the nature of the FC; and
- many different methods of communication with students.

Implementation, as with all new teaching innovations, will require continuous evaluation and flexibility/openness to change when the need for improvement is identified.

> Conversations in focus groups and written student feedback have indicated that carefully-structured, practically-oriented, collaborative workshops that complement the online mini-lectures have been key to the success of the flipped classroom approach in the course (Chap. 19).

6.2.5 Component 4: Students

Learning aims and expectations must be matched between facilitator and student. This is important for any offerings as students may demonstrate resistance to the FC, especially if it is their first experience. It is therefore necessary to address expectations at a meta-level (i.e. students should be made aware of the pedagogy and reasons behind its use).

The importance of ownership of learning must be conveyed, and it is therefore recommended that this be embedded in the FC design.

> … my attitude and application towards this course has been much higher… I believe this is due to the hands on learning approach where we are expected to learn the material ourselves rather than just listening to a lecturer talk (Chap. 9).

6.2.6 Component 5: Academics

The role of the teaching academic must move from instructor to facilitator to support the shift from information transmission (i.e. lecturing) to assisting and guiding student learners to own their learning and thus become information gatherers, analytical and critical thinkers, and problem solvers (i.e. facilitation).

> I also really enjoyed the flipped class room approach; it wasted less time compared to other courses where the instructor would just regurgitate material that the student could figure out on their own (Chap. 16).

6.2.7 Component 6: Online

Ubiquitous access to online resources has negated the need for the classroom to be a place for information transfer and has therefore facilitated the rise in interest and implementation of the FC. Online learning environments can be used to:

- provide opportunities for discourse between students and teaching staff;
- develop online learning communities;
- provide a gateway to existing content and content creation tools; and
- host many applications to design and deploy active learning strategies.

> Informal feedback from students revealed that they valued the video recordings and formative assessment and appreciated the level of feedback provided by the online dashboard and the positive effect it had in their preparation of the material (Chap. 13).

6.2.8 Component 7: Resources

FC teaching requires consideration of resources and they might include:

- teaching and learning spaces which can cater for various activities and numbers of students;

- podcasting, screencast, and video tools;
- wikis and other social communication/collaborative learning platforms; and
- digital assignment tools.

An oft-forgotten resource are the students themselves who can be asked to develop, research, and/or compile material as part of their learning activities.

> “The bus tour (Virtual) is a good interactive way to explore design trends of subdivisions from different years”, and “the major assignment (subdivision) was a lot of fun and really meaningful (Chap. 17).

6.2.9 Component 8: Evaluation

Learning Analytics, used to measure student online learning behaviour and knowledge acquisition, student observational tools, such as the Teaching Dimensions Observational Protocol (Clark et al. 2014), and design-based research methodological approaches can be used to measure the success of a FC (Reidsema et al. 2014). It may be that a combination of these tools is used, but it is important that evaluation of the FC be factored into any undertaking to use the approach.

> As the semester went on, we got better at doing the flipped tutorial activity and we really started to enjoy working as a team and pushing each other to think of ways theory could apply to the case study (Chap. 20).

6.3 What Might You Look for in the Case Studies?

There are a number of different aspects that you might purposefully search for in each of the case studies other than the above components. For example, depending on your need or interest, you may be interested to know:

- what the value proposition to entice and engage students on campus was;
- how the various FC components were interlocked;
- how the alignment between activities on and off campus and the intended student learning objectives was managed;
- if a purposeful learning partnership (Baxter Magolda 2012) was developed;
- what course narrative was used and how it was delivered;
- whether a ‘metacognitive’ approach to instruction was used to help students take ownership of their learning;
- if the FC allowed the more challenging tasks of analysis, evaluation, and creation with others to be conducted in class time (Krathwohl 2010);
- if pre- and/or post-class activities were used to maximise learning from in-class work (Abeysekera and Dawson 2014); and
- whether there was evident transformation in teacher and student practices.

Alternatively, you might like to consult Table 6.1, to explore the various contexts that are covered by the chapters.

Table 6.1 Case study matrix

Chapter: title	Discipline/ institution	Cohort size/level	Salient points
7: Using a flipped classroom framework to design an authentic, active learning environment for developing first-year student engineers	Engineering University of Queensland Australia	Approximately 1100 First year	Large-scale flipped classroom Active learning and teamwork strategies 'The Learning Pathway'—an online learning organisation tool
8: Experiences with "flipping" an introductory mechanical design course	Engineering University of Pittsburgh USA	Approximately 200 First year	The teaching dimensions observation protocol (TDOP) Problem solving with SolidWorks Recorded lectures in modules using Camtasia with IT staff assistance
9: Inclusive STEM: closing the learning loop	Medicine RMIT University Australia	Approximately 100 Third year and postgraduate	Collaborative tutorial 'Lectorial' (combined lecture and collaborative student groups) Online quiz as optional formative assessment
10: Flipping on a shoestring—a case study of Engineering Mechanics at the University of Technology Sydney	Engineering University of Technology Sydney Australia	Approximately 100 First year	Collaborative learning framework Two types of online pre-work: narrated PowerPoint and instructor demonstration Weekly concept quizzes
11: Design, deployment and evaluation of a flipped learning 1st year course	Engineering University of Sydney Australia	Approximately 300 First year	Scaffolded and sequenced learning Formative and summative assessment A variety of modalities, devices, and temporal options
12: Flipped classes: drivers for change, transition and implementation	Engineering Edith Cowan University Australia	Approximately 190 Third year	Transitions academics and students to the flipped classroom Qualitative questionnaire to gain student perspective Modest resource requirements
13: A technology enabled flipped classroom model	Engineering Medicine Nanyang University Singapore	Approximately 100 (Medicine). 70 (Engineering) First and second year	A learning framework to integrate digital and physical environments Highly mobile, team-based learning (TBL) curricular experience Dissemination and applicability
14: Flipping a postgraduate classroom: Griffith University	Engineering Griffith University Australia	Approximately 120 Postgraduate	Effective utilisation of time and resources Postgraduate study Gamification

(continued)

Table 6.1 (continued)

Chapter: title	Discipline/ institution	Cohort size/level	Salient points
15: Flipping the learning of subdivision design for surveying students	Surveying RMIT University Australia	Approximately 60 Second year	Virtual bus tour: online material including maps, photographs, and text The CES Good teaching score Combined formative and summative assessment model
16: Flipping a collaborative classroom to gain deeper understanding of the health system	Health Sciences University of Queensland Australia	Approximately 300 First year	Collaborative classroom Semester-long tutorial teams Team teaching
17: Implications for pedagogy: flipping the classroom to engage pre-service teachers	Education University of Queensland Australia	Approximately 40 Fourth year and Grad Diploma	Course redevelopment Teaching reflections on community of practice, ethics, and habitus Enabled teacher self-critical reflections
18: Flipped tutorials in business courses	Business University of Queensland Australia	Approximately 1200 First year	Transformation of academic and student Low-stakes assessment to enable extrinsic motivation of grade Intrinsic drivers: students care about success in overall degree

We hope that you enjoy reading and learning about others' experiences as much as we did.

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Part II
Practices

Chapter 7
Designing an Active Learning Environment Architecture Within a Flipped Classroom for Developing First Year Student Engineers

Julie McCredden, Carl Reidsema and Lydia Kavanagh

Abstract This case study presents the flipped classroom (FC) as a framework for a large first-year fundamental engineering practice course (ENGG1200). The aim was to develop student engineers who would leave the course with both the required academic knowledge of materials engineering and the practitioner skills required to apply this knowledge to real-world practices including design, problem-solving, modelling, and professional skills. Using a design approach and drawing on relevant research, a learning environment was constructed whose architecture comprised an integrated set of learning components that would develop within our students the internal mechanisms required for demonstrating these skills. A central component of the learning environment was an authentic open-ended design project that was completed by multidisciplinary teams. Implementation of the course using a FC framework allowed contact time with students to be used for hands-on workshops that developed and scaffolded many of the practitioner skills necessary for the design project. Out-of-class hours were used by students for acquiring the necessary academic knowledge required for the projects, supported by the online learning environment that included modules and quizzes, an organisational tool (the Learning Pathway), reflections, and extensive additional resources. The course design process, the design solution, and the evaluation of the course architecture are described in this chapter along with the characteristics that enabled the learning goals to be achieved. Evaluation revealed two main clusters of associated activities: one around the online learning activities

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and the other around the hands-on teamwork activities. These clusters were consistent with the design aim of using the course activities to develop a set of internal mechanisms within students such as materials knowledge, self-management, teamwork, and hands-on skills. Furthermore, evaluation of student reflections indicates that students did indeed develop knowledge and skills in these areas as well as modelling, problem-solving, and communication and that they linked concepts with practice. Many aspects of the course design process described here are transferrable to other disciplines aiming to facilitate authentic learning activities using FC approaches.

Keywords Practitioner skills · Situated cognition · Course design · Distributed scaffolding

7.1 Introduction

Engineering education is actively exploring new paradigms for equipping student engineers with skills that enable them to work in a world that is becoming more complex and interdisciplinary. To facilitate this change in educational practice, lists of graduate competencies have been developed by Engineers Australia (Bradley 2007) and the US Accreditation Board for Engineering and Technology (ABET 2008). These graduate competencies include ‘hard’ and ‘soft’ skills, such as possessing theoretical and technical knowledge along with the ability to apply these to solve problems within real-world contexts, to be systems thinkers, to be able to work in interdisciplinary teams and across cultural settings, and to be able to communicate effectively with a range of stakeholders.

Flipped classroom (FC) methods free up contact time with students and thus allow instructors to move their focus to activities and experiences that allow students to achieve the ABET graduate competencies as well as course learning goals. As engineers ourselves, the decision to use a FC for our new, first-year engineering (FYE) foundation course (ENGG1200 Engineering Problem Solving and Modelling) was a considered one, as per the process outlined in Chap. 2. In addition, we knew that the use of a formal design approach has been helpful in the past for bringing about curriculum change (e.g. Pauley et al. 2005). We consulted with instructors from all disciplines and also used evidence from the engineering education literature to make design decisions, thus helping to bridge the gap between research and design approaches to engineering education (Turns et al. 2007; Crismond and Adams 2012).

For the purposes of this case study, we have the following design process:

1. **Specifying** the internal mechanisms within students as outcomes, specifying the methods and processes that will promote these learning goals (the learning environment mechanisms), and the context for the course (resources and constraints);
2. **Comparing** the methods available (from the literature) with the given context;

3. **Creating** the design solution including the Learning Environment Architecture (LEA), its components, and their interactions that would produce the specified outcomes; and
4. **Evaluating** the LEA in terms of:
   – whether it created the specified mechanisms and
   – the effects of the LEA on students.

The first section of this chapter works through the design process for ENGG1200, the second-semester fundamental engineering course taken by all engineering disciplines at the University of Queensland (UQ). The course design and implementation are detailed in the second section, and this chapter culminates with the presentation of evidence around the effectiveness of the FC implementation.

7.2 Design Step I: Specification

7.2.1 Student Learning Mechanisms

In ENGG1200, we were aiming to develop the following fundamental skills and knowledge within our student engineers (i.e. our learning objectives):

- Individual knowledge: introductory-level understanding of engineering materials.
- In-depth (hands-on) experience in the process of engineering design.
- Fundamental understanding of how engineers solve problems using modelling and simulation.
- Graduate competencies: teamwork, project management, and professional communication.

The inclusion of design, modelling, report writing, and teamwork are the aspects of this course that give students experiences similar to a real-world engineering apprenticeship. However, as expertise cannot be developed through one course alone (Crismond and Adams 2012), so our end goal was that the students gain 'expert-like novice' abilities in each of these areas (Bereiter and Scardamalia 1993).

Underlying the learning objectives were the more specific 'situated cognitions' (Brown et al. 1989) needed for engineering, (see Dym et al. (2005) and Walther and Radcliffe (2006)):

- **Thinking skills**: systems thinking, reasoning with uncertainty, making estimates, conducting experiments, agility, pragmatism, and indeterminism;
- **Practical skills**: modelling and simulation tools, team player, professional skills, and project management tools; and
- **Design skills**: specific design cognitions (DCs) and habits of mind required for proficient design thinking.

7.2.2 Learning Environment Architecture (LEA) Mechanisms

The FC course design was based on Schoenfield's (2014) essential learning environment components for promoting successful active learning. These are described fully in Chap. 2 (Table 2.2) and are given again in summary form below:

1. Knowledge and Skills
   1.1 Includes facts, procedures, frameworks, models, and principles.
   1.2 Uses real-world practices.
   1.3 Fosters discipline-specific habits.
2. Cognitive Demand
   2.1 Creates intellectual challenge.
   2.2 Facilitates student understanding; does not direct.
3. Access to Content
   3.1 Engages with other disciplinary content.
   3.2 Involves all students.
4. Agency, Authority, and Identity
   4.1 Collaborative at all stages.
   4.2 Recognises contributions.
   4.3 Builds practitioner identity.
5. Use of Assessment
   5.1 Reveals current thinking.
   5.2 Gives constructive feedback.
   5.3 Moves students forward.

7.3 Design Step II: Method Selection and Architecture

7.3.1 Overview

Given the Design Step I specifications, the next two steps in the design process were to consider the teaching and learning frameworks that have been successful for facilitating active learning (Chap. 3) and to make an informed choice. Design-based learning (DBL), a particularly suitable method for engineering, had been successfully used for the partially-flipped preparatory course (ENGG1100 Engineering Design) run in Semester 1, and hence, this method was chosen to underpin ENGG1200. The main focus of ENGG1200 was therefore a design–test–build project that was open-ended and worked on in multidisciplinary teams, henceforth called the 'DOEM' project.

It should be noted that the course design solution had to be enacted for over 1000 students. The usual method for ensuring cognitive apprenticeship for active learning includes the 'teacher as coach' as an essential resource. This requires an intimate and open-ended interaction between students and teachers that allows for personalised feedback and guidance, which is not possible at the scale of ENGG1200. However, the FC allowed us to negate the high student-to-staff ratio through the utilisation of collaborative learning and peer support. Furthermore, ENGG1200 builds on preliminary engineering competencies and skills learned in ENGG1100. For example, in the preliminary course, students are introduced to a comprehensive peer assessment tool and a well-structured set of resources for supporting teamwork, team management, and team processes (Kavanagh et al., in press). In ENGG1200, students are expected to utilise this experience, and hence, only rudimentary team support is offered. Similarly, students are expected to build on their knowledge of engineering design, project management, and communication. On a meta-level, the partial flip of ENGG1100 introduces students to an 'ownership of learning' mindset, and in ENGG1200, this experience allows us to replace the 'teacher as coach' method with online resources and help tools, collaborative learning using online chats, and learning from tutors and peers in hands-on workshops and in design–test–build sessions.

Distributed scaffolding (Puntambekar and Kolodner 2005) underpinned the course as evidenced by multiple scaffolding activities such as workshops, hands-on modelling, and build laboratories overseen by tutors and experts, and scheduled peer support sessions. An important part of the scaffolding was an extensive set of online resources aimed at guiding each student through individual preparation for the other activities, in terms of:

- organisation (via the 'Learning Pathway', described below),
- any content needed as background knowledge,
- just-in-time help via online help tools,
- formative and summative assessment, and
- reflective practice.

Figure 7.1 depicts the course LEA, including the main activities of the DOEM project and individual learning, as well as the scaffolding and supports that fed into the main project. The figure also shows the knowledge and skill mechanisms to be acquired by the students as a result of these activities and scaffolds plus the assessment activities designed to measure how well students had developed these mechanisms. Compulsory activities are outlined in bold in this diagram, and online activities are shaded. All of these elements are explained in more detail in the following sections.

7.3.2 The DOEM Project

Each team was set the task of designing and creating an artefact that was to be demonstrated both virtually and physically at the end of the semester. This required the application of relevant science, technical skills, and industry-based

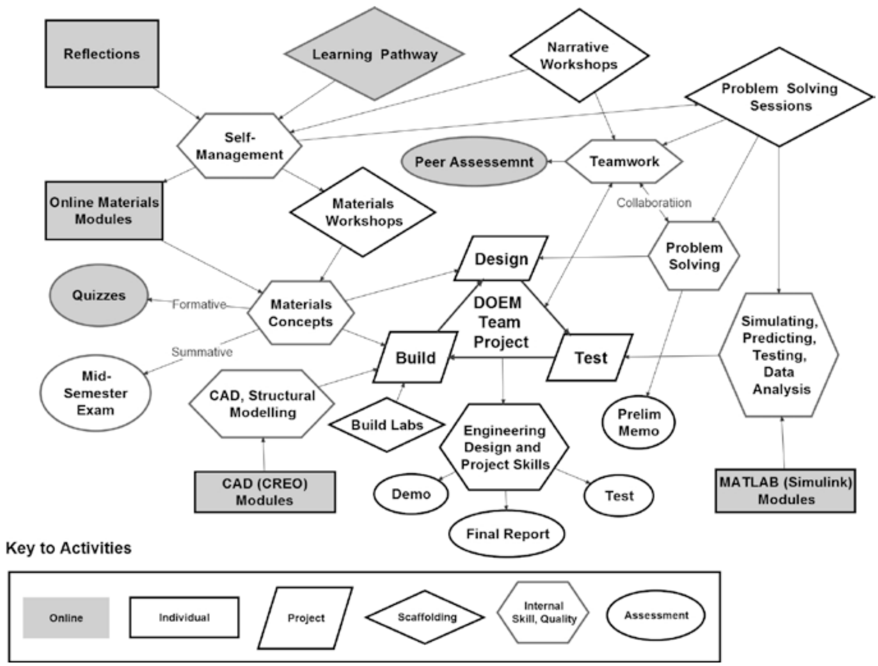

Fig. 7.1 ENGG1200 LEA

tools from various disciplines as well as data collection, analysis, and professional communication.

To cater for the many different disciplinary preferences present in the course, four projects such as the design of a drill-bit plus Arduino-coded controller were created. Thus students could select a project that was appealing but not necessarily aligned with their engineering discipline. The projects were designed to allow for:

- the translation of theory into practice in line with course learning objectives;
- production of both physical and virtual artefacts;
- multidisciplinary input; and
- a collaborative team of six students.

A main goal for students was that by participation in the DOEM projects, they would learn a set of Design Cogntitions (DCs) that would teach mindsets useful for design aspects of future engineering projects. The strategies that have been shown to facilitate specific DCs (Crismond and Adams 2012) and the methods for enacting them that were included within the ENGG1200 course LEA are described in Table 7.1.

There were four deliverables required for each DOEM project: a preliminary memo detailing the project scope and a plan for completion, a scaffolded milestone test, a demonstration of both the virtual and physical artefacts, and a report on the process. The DOEM project thus incorporated the LEA

Table 7.1 Design cognitions and corresponding LEA components (Crismond and Adams 2012)

Design cognition (DC) goals	Learning environment component
DC 1 Understand the design problem before design (including functional description, problem framing, and scoping)	Create a design brief in the initial phase of the project
DC 2 Build knowledge through research before solution	Require critical literature review of prior art; provide reverse engineering workshops
DC 3 Generate more than one idea; overcome functional fixedness	Facilitate collaborative brainstorming sessions; change design specifications after initial solution; specify creativity as an outcome
DC 4 Represent design with detail and substance	Require design sketches and modelling prior to building
DC 5 Use design constraints and balance systems of benefits and trade-offs	Facilitate discussions with experts (i.e. project leaders, mentors, and laboratory technicians)
DC 6 Conduct tests and experiments	Schedule test and demonstration sessions with design advice from experts
DC 7 Troubleshoot: Focus attention on potential problematic areas while designing	Facilitate an 'observe, diagnose, explain, and remedy' cycle: embed test/demonstration with experts
DC 8 Revise and iterate	Use test and demonstration sessions as milestone check and reflection points. Provide a visual timeline showing what needs to be done and when it needs to be done
DC 9 Practice reflective thinking on own and others' design solutions and strategies	Embed computer-supported structured reflections with triggers around the different stages of the project design and teamwork

mechanisms: (1) 'Knowledge and Skills' (1.2 and 1.3), (2) 'Cognitive Demand' (2.2 and 2.3), (3) 'Access to Content' (3.1), and (4) 'Agency, Authority, and Identity' (4.1–4.3) plus all of the DCs (Table 7.1).

7.3.3 Hands-on Activities

Figure 7.1 shows how the designing, testing, and building of the DOEM artefacts required knowledge of materials and manufacturing, as well as the use of problem-solving strategies and an ability to use engineering software (e.g. CREO and MATLAB). The applied knowledge and skills that students had to acquire for successful completion of their DOEM project were developed with the help of online tutorials plus intensive hands-on workshops designed to teach modelling, materials processing, software tools, and problem-solving. These workshops were designed to provide a cognitive apprenticeship type of active learning using hands-on experiences, feedback, and interactions with discipline experts, tutors, and peers. The workshops that were run were as follows:

- **Materials workshops**: Interactive, hands-on workshops were used to develop the applied materials and manufacturing skills for success in the projects (e.g. tensile testing). These 2-h sessions were run for the first 6 weeks for large groups of up to 14 teams of 6 students.
- **Problem-Solving Workshops**: For the first 6 weeks, 2-h sessions were used to deepen students' understandings of the principles and practices that engineers use to design, solve problems, and manage projects. Again, students worked in teams of 6.
- **Modelling workshops**: In weeks 6–9 of semester, each team was divided into two groups. One group worked through online modules that allowed them to use CREO to manufacture a component of their artefact. The other group took online modules that allowed them to simulate the behaviour of their artefact using MATLAB's Simulink.
- **Narrative workshops**: Each week, two consecutive groups of 500–600 students worked collaboratively at tables of 9, through the 'course narrative' in a 1-hour flipped classroom face-to-face session.
- **Troubleshooting sessions**: Extra sessions were scheduled for students to test their artefacts and receive feedback and assistance with problem-solving.

Project coordinators, project leaders, and tutors ran the above sessions interactively. In addition, a technical support team based in the laboratories guided student teams as they manufactured (using CREO) and constructed (using hand tools) their artefacts.

7.3.4 Individual Learning

A significant portion of the course content was delivered online. In the first 6 weeks, students worked through a set of online learning modules designed to help them acquire the academic components of materials engineering. Each module was comprised of teaching texts, videos, workshop briefs, practice quizzes, and final weekly quizzes. Completion of the weekly modules was left up to the student, with the final quizzes being assessed. Furthermore, it was impressed upon students that mastery of the materials concepts would help with their team project, as well as their performance in the mid-semester examination. The online learning environment incorporated LEA mechanisms: (1) 'Knowledge and Skills' (1.1), (3) 'Access to Content' (3.1 and 3.2), and (5) 'Use of Assessment' (5.1–5.3).

In addition, students completed fortnightly online reflections to assist them with learning to think about their own behaviours and achievements and to set their own goals. These reflections were graded, and students were given feedback by their peers and tutors in order to develop their ability to become reflective practitioners and for self-management (DC goal 9 from Table 7.1).

7.3.5 Support Systems

The disparate online and on-campus learning activities required students to be organised. To support students with self-organisation, the online ‘Learning Pathway’ tool (Fig. 7.2) was created and embedded into the course Learning Management System (Blackboard). The Learning Pathway helped students to manage themselves and their group by indicating:

- a timeline for the whole semester that connected learning activities to course objectives and the design phase of their project;
- a weekly checklist of what students ‘needed to know’ and what they ‘needed to do’; and
- an overview of assessment due dates.

Additional support for required concepts, skills (both technical and practical), and design–test–build activities was provided online via:

- a set of online tutorials/links to tutorials for learning CREO, MATLAB, and ARDUINO code;
- an online question-and-answer tool: CASPER (Herbert et al., 2013);
- needs-based project leader or tutor-created videos;
- mentoring for teams as necessary; and
- inclusion of extra online learning resources (e.g. links to videos and text) for enhancing individual learning of the academic components of materials engineering.

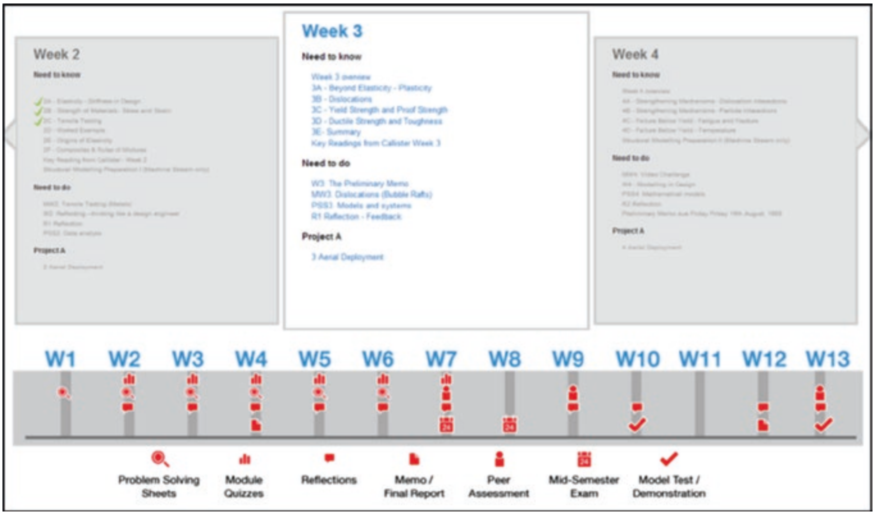

Fig. 7.2 The Learning Pathway (LP) online support tool

These supports provided further distributed scaffolding for LEA mechanism (1) Knowledge and Skills (1.1–1.3) and promoted (3) Access to Content (3.1 and 3.2) so that all students had the opportunity to be engaged with content. This was made possible by ensuring that the supporting online components were available, engaging, and interactive.

7.4 Design Step III: Course Creation

Table 7.2 details ENGG1200 learning objectives and assessment. Assessment was designed to be formative and summative, and individual and team-based. This allowed the LEA 5 (Use of Assessment) mechanisms to be incorporated into the course, so as to develop both academic and practitioner skills, as follows:

Table 7.2 ENGG1200 course objectives and associated assessment activities

Element	
Learning objectives	Materials I: describe atomic/micro-structural characteristics of materials; explain elastic modulus/composite moduli; describe mechanisms for plastic flow in metals/strength enhanced microstructure Materials II: describe/analyse stress-strain response, determine effect of temperature and time under load, choose materials based on properties Problem Solving: solve engineering problems using framework; sketch, define scope; propose model, incl. variables/constants/assumptions/sensitivities Modelling: Produce model/simulation flow chart; use MATLAB to solve developed model; verify model; validate simulation; use CREO to design/develop structural model; create CNC tool path; produce 2D working drawings Design: Use design thinking/reflexive practice to plan/implement/design engineering solution Manufacturing: Use knowledge of manufacturing/materials to build prototype Communication: build on ENGG1100; writing coherence/rationale; master graphics/data/word processing Team Work: devise/implement strategies based on critical personal reflections to improve team performance and fast track team development
Assessment	Online material quizzes (6x)—10%, individual hurdle assessment, Weeks 1–6 Problem solving book (6x)—5%, team submission, Weeks 1–6 Reflections (5x)—15%, individual submission, Weeks 2, 4, 6, 9, and 13 Preliminary memo (Scope, Problem, Prior Art, and Project Management)—15%, team submission, Week 4 Mid-semester concept exam—20%, individual hurdle assessment, Week 8 Prototype demonstration—20%, team submission, Week 10 (Test), Week 13 (Demonstration) Final Report (Virtual and physical model details, Construction process, Team reflection, Key lessons learnt)—15%, team submission, Week 13 Peer Assessment Factor (PAF)—Week 7 and 13, Applied to team submissions

- To develop academic concepts and problem-solving skills in materials science: formative practice using weekly quizzes and mid-semester examinations (LEA 5.1–5.3);
- To develop practitioner teamwork skills: peer assessment, providing feedback to team members regarding their teamwork early on, and also providing individualisation of marks according to the quality of teamwork as measured by a Peer Assessment Factor (PAF) later in the semester (LEA 5.2 and 5.3);
- To develop writing skills and DCs and to give early feedback on these: an initial project memo and final report (LEA 4.2, 4.3, 5.1, and 6.1); and
- To promote DC goals 6–8: milestone test sessions to give feedback on the quality of the project artefact and simulation prior to submission (LEA 4.2, 4.3, and 5.1).

There were four deliverables required for each DOEM project: a preliminary memo detailing the project scope and a plan for completion, a scaffolded milestone test, a demonstration of both the virtual and physical artefacts, and a report containing the finalised design and reflections on the process. The DOEM project thus incorporated LEA mechanisms: (1) 'Knowledge and Skills' (1.2 and 1.3), (2) 'Cognitive Demand' (2.2 and 2.3), (3) 'Access to Content' (3.1), and (4) 'Agency, Authority, and Identity' (4.1–4.3) and all of the DCs (Table 7.1).

Table 7.3 details the activities that were designed using the project-based learning approach. The activities were scheduled to allow for:

- time to learn materials science and materials manufacturing (academic skills phase) before the end of the design period and before the build commenced (practitioner skill phase);
- workshops for developing skills in teamwork, problem-solving, design thinking, structural and behavioural modelling, project management, research, and data analysis to be experienced in a timely manner relative to the DOEM project activities;
- a preliminary project memo early on that demonstrated students' understanding of both course and DOEM project objectives; and
- a prototype test session with time for refinement prior to the demonstration and report deadlines for submission.

7.5 Design Step IV: Evaluating the Flipped Classroom LEA

7.5.1 Assessing the Architecture

The ENGG1200 Learning Environment Architecture (LEA) is comprised of the activities designed to teach students materials concepts and engineering competencies as they actively engage in online modules, workshops, and the DOEM project. The LEA was evaluated in two parts:

Table 7.3 ENGG1200 implementation details

Activity	Session type	Objectives (Table 7.2)	Resources	Space	Assessment
Team-based workshops (90 students, weeks 1–6)	Team-based laboratory (1 h/w) + problem-based workshop (1 h/w)	1, 2, 8	Worksheets; tutors; laboratory equipment	Flat floor; round tables; 6 students/table; computers	End-of-session tutor marking
Online learning (weeks 1–6)	Online	1, 2	Podcasts, readings, quiz tool	NA	Online quizzes; midterm concept examination
'Community' workshop (600 students, weeks 1–10)	Collaborative active learning	3, 4, 5, 7, 8	Paper worksheets; facilitators	Flat floor; round tables; 9 students/table	Worksheets submitted with major reports
Software workshops (90 students, weeks 7–9)	Team-based computer laboratory sessions	3, 4, 5	Tutors; CAD/MATLAB; worksheets	Computer laboratories	Virtual model; manufacturing code
Team-based build/test (weeks 7–12)	Student-booked machine shop/electrical laboratory	6, 7, 8	Hand tools; CNC; test rigs; tutors	Laboratories; undercover outdoor areas	Physical prototype

1. The ability of the LEA to exhibit the mechanisms of active learning as anticipated by the course design and
2. The effects of the LEA on the students:

   (a) achievements such as gains in learning, hands-on engagement, teamwork, and project skills and
   (b) experiences with the LEA: what helped, what hindered, and the lessons learned.

The mechanisms of the course that were specified in Design Step I (above) were grouped into internal mechanisms to be developed within students and the learning environment mechanisms designed to promote these. It was an outcome of the design process that the architecture of ENGG1200 contained the required learning environment mechanisms. Table 7.4 summarises how the five LEA mechanisms were encapsulated within the components of ENGG1200. These mechanisms were scheduled to interact with one another in a timely way and to create the desired learning and support for other activities. Thus, the learning environment mechanisms were built into the course design. We now need to demonstrate how these mechanisms were visible during the lifetime of the course. Some preliminary results are available, as follows.

7.5.2 Student Interaction with Online Materials Modules

The online interaction data (Fig. 7.3) shows the cumulative percentage of students interacting with the online resources over the first 6 weeks and the week prior to the mid-semester examination. By the end of most weeks, 70% had completed the readings, 60% had watched the videos, and 80% had completed the summative quizzes.

The online resources were in high use prior to weekly quizzes due dates and the mid-semester exam. For students who utilised the weekly modules, the online resources were successful in developing the required materials concepts, as evidenced by the significant correlations between time spent watching videos and examination marks ($r = 0.27$) and between time spent on practice quizzes and examination marks ($r = 0.17$). That these activities improve marks suggests that the practitioner skill of self-management is important for improving academic outcomes.

Evidence for the active learning of the desired practitioner mechanisms is less visible because these mechanisms are theoretical constructs and not directly measurable. The available evidence is based on the active learning components of the course that were measured (i.e. the quantifiable activities and deliverables), as well as independent observer and tutor observations, as described below.

Table 7.4 ENGG1200 course structure (13-week teaching semester)

Learning goals, engineering skills	Learning mechanisms	Framework	Architectural component (delivery method)	Details, scaffolding	Assessment/outputs	Weeks
Individual skills						
Core knowledge/ concepts	LEA 1.1, 1.3 (Knowledge) LEA 3.1,3.2 (Access) LEA 5.1,5.2,5.3 (Assessment)	Online formative assessment, distributed scaffolding, collaborative learning	Fortnightly online modules: vodcasts, factual/conceptual questions, practice quizzes	Designing with materials: elasticity, plasticity, strengthening, polymers, etc.	Online quizzes	1–6
Self-management	LEA 3.1, 3.2 (Access) LEA 4.2, 4.3 (Agency)	Visible course narrative	Integrated workshops, Learning Pathway	Participation in workshops, laboratories, teamwork, online modules/quizzes, collaborative writing	Completed all tasks on time	1–11
Self-development	LEA 1.2, 1.3 (Knowledge) LEA 4.2, 4.3 (Agency) DC 9 (Reflection)	Reflective practice	Fortnightly online structured reflection	Reflection on self-management, teamwork, project work, and changes made	Self-reported changes in behaviour, attitudes, understandings	2,4,6,9
Thinking skills	LEA 1.1, 1.2, 1.3 (Knowledge) LEA 4.1, 4.2, 4.3 (Agency) DC 9 (Reflection)	Distributed scaffolding, collaborative learning, reflective practice	Group workshops, teamwork, laboratories, online structured reflection	Generate and adapt, identify and solve, define and analyse, evaluate and reflect, critical reasoning	Reflections Design reports (2x)	2, 4, 6, 9, 12

(continued)

Table 7.4 (continued)

Learning goals, engineering skills	Learning mechanisms	Framework	Architectural component (delivery method)	Details, scaffolding	Assessment/outputs	Weeks
Engineering technical skills						
Problem-solving techniques	LEA 1.1, 1.2, 1.3 (Skills)	Active learning, collaborative learning, distributed scaffolding	Integrated workshops using worksheets, group discussions	SOLVEM, data analysis, models/systems, mathematical models, programming	Worksheets	1–6
Materials laboratories	LEA 1.2, 1.3 (Skills)		Workshops, podcasts	Various material tests	Worksheets	1–6
Modelling tools	LEA 1.2, 1.3 (Skills)		Workshops, hands-on learning	Online modules for MATLAB, ARDUINO, and CREO	Structural/behavioural models	7–10
Professional competencies						
Team dynamics	LEA 1.1, 1.3 (Skills) LEA 4.1, 4.2, 4.3 (Agency)	Collaborative learning, teamwork, distributed scaffolding	Integrated workshops using worksheets, group discussions	Sharing of tasks, distributing workloads, team communication, interpersonal issues	Peer assessments	1–11
Project management	LEA 1.2, 1.3 (Skills) LEA 4.1, 4.3 (Agency)			Gantt charts	Meeting project milestones and task requirements	3, 10
Professional communication	LEA 1.2, 1.3 (Skills) LEA 4.3 (Agency)			Collaborative writing	Design reports: preliminary memo and final report	4,10,12

(continued)

Table 7.4 (continued)

Learning goals, engineering skills	Learning mechanisms	Framework	Architectural component (delivery method)	Details, scaffolding	Assessment/outputs	Weeks
Design cognitions/design–test–build process skills						
Design	DC 1 to 5, LEA 4.1 to 4.3, LEA 1.1 to 1.3	Design-based learning, active learning, distributed scaffolding, collaborative learning	Team design	Generate design assisted by lessons from materials, problem-solving and modelling workshops, vodcasts, CASPER	Preliminary memo, test session, artefact quality	1–10
Test	DC 6 to 9, LEA 5.1 to 5.3		Prototyping laboratories (teams)	Build prototype, test, refine, overseen by project leaders and tutors, CASPER	Test session	7–10
Build	DC 9, LEA 1.1 to 1.3		Virtual and physical laboratories (groups)	Laboratory technicians, vodcasts, CASPER	Artefact quality: virtual and physical prototypes	7–10
Integrate	LEA 1.1 (Knowledge)		Integrate design concepts, hardware constraints, apply theory	Hands-on problem-solving, group discussion, tutor guidance, vodcasts, CASPER	Preliminary memo, final report, virtual and physical prototypes	1–13

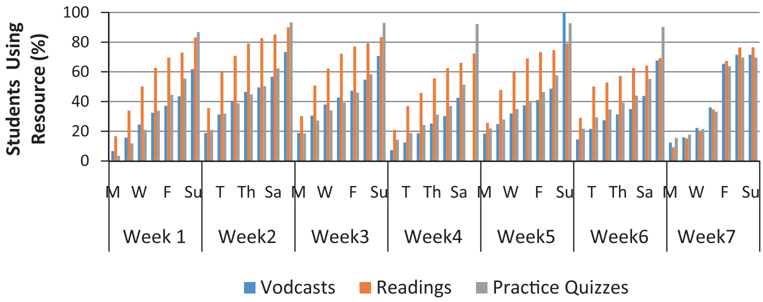

Fig. 7.3 Interaction with online resources

7.5.3 Participation in Problem-Solving and Narrative Workshops

Student teams received 5% for the quality of the problem-solving worksheets. Generally, all teams scored well, as the sessions were tutor-facilitated. Queries were thus quickly addressed and corrected. The distribution of these marks (Fig. 7.4a) shows that most students attended and engaged in these sessions: 97.5% of the class received 4.5% or more, and 55% of the class received full marks. These results show high levels of student engagement with the active problem-solving sessions.

Students received 4% for completing all narrative workshop templates. The distribution of these marks (Fig. 7.4b) shows that while a small group of about 40 students handed in only half of the templates, most students handed in all templates with 84.5% of the class receiving 3.5% or more. These results indicate high levels of student engagement in the narrative workshop sessions.

In order to further evaluate engagement, tutors were given a voluntary survey at the end of the semester, that asked questions about how well student teams worked within workshops. A total of 13 tutors completed the survey in 2014. Figure 7.5

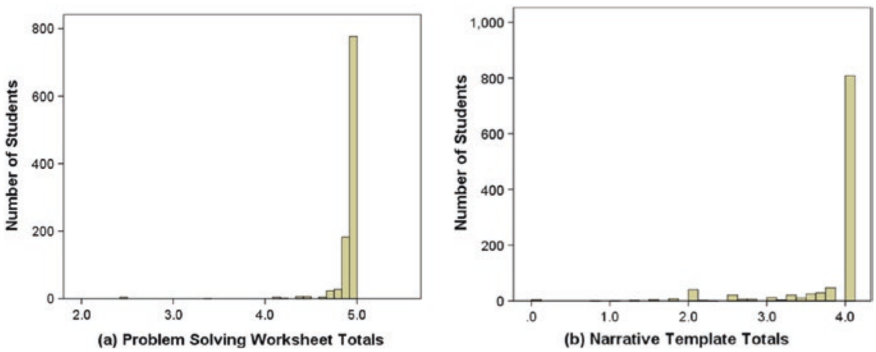

Fig. 7.4 Marks for (a) problem-solving and (b) narrative workshop worksheets

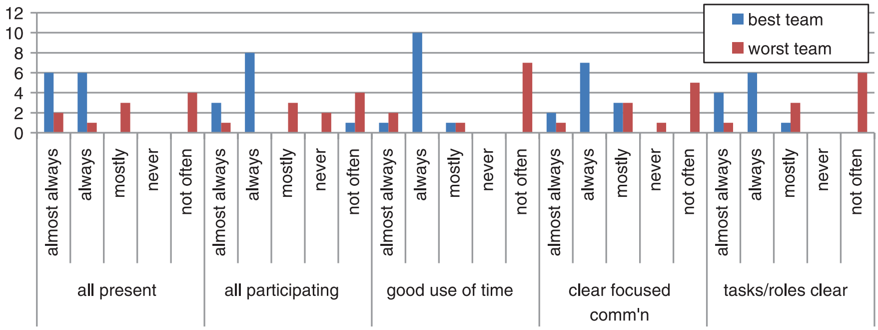

Fig. 7.5 Tutor observations of best and worst teams ($N = 13$)

shows that the best teams, as judged by final marks, were rated ‘almost always’ or ‘always’ on all the dimensions, while the worst teams were more likely to be rated ‘not often’. Tutors commented that the best teams were highly engaged: they made good use of the online tutorials and information, turned up to the sessions, and stayed back late if necessary. Tutors noted that these teams needed only prompts or questions to help guide them back on track and were able to solve problems themselves.

Teams that did not perform so well (i.e. the worst teams) were less able to make use of the online tutorials and information (some just did not understand what they needed to do) and had members who were less engaged and did not participate or who turn up to the sessions. Tutors noted that these teams needed direct help and were not able to solve problems themselves.

7.5.4 Participation in Build Workshops

Students booked building workshops according to their needs. Independent observations showed differing levels of engagement:

- a team that had not planned before coming, that had a poor sense of purpose and roles of each team member, and that did not make full use of the time available;
- a team that came with plans and equations, had components marked out for construction, and conferred with one another on decisions that needed to be made; and
- a team that had come with some design plans, but had agreed to work some decisions out as they went.

The observations above give an indication of the range of engagement that teams had made with the available learning activities.

7.5.5 Assessing Course Component Interaction

The mechanisms that we wanted to develop within the students as a result of course participation are depicted by the hexagons in Fig. 7.1. They can be grouped into the main academic mechanism promoted by the ENGG1200 course (i.e. materials concepts) and into practitioner mechanisms required by ABET and by industry (i.e. self-management, teamwork, materials concepts, problem-solving, engineering design and project skills, research and data analysis, and report writing).

To give a broad overview of how the course components relate to one another, and to look for evidence for the underlying mechanism of academic and practitioner learning, all measurable variables were subject to a correlation analysis as below.

1. All the variables used for assessing student progress and abilities were correlated.
2. The correlations that were statistically significant ($p < 0.05$) were considered further in order to create a model of how the students' interactions with each of the course components related to their interactions with other course components (Fig. 7.6).
3. Construction of the model used the following principles:

   – Components of ENGG1200 that were correlated and that preceded each another chronologically were used to suggest influence by the first component on the second (as shown by the directional arrows in Fig. 7.6).
   – The correlations of the Peer Assessment Factors (PAF1 and PAF2) with the test, demo, memo, and final report were omitted as PAF1 and PAF2 were used to scale these components, and therefore, significant correlations were to be expected.
   – Stronger correlations ($r > 0.2$) were considered first (darker lines in Fig 7.6). Then, weaker (but still statistically significant) correlations were added so as to complete the picture (lighter lines in Fig 7.6).

Figure 7.6 shows a cluster of personal activity, incorporating the marks for quizzes and reflections, that correlates with both mid-semester examination marks and PAF scores. That is, the student's academic preparation and ability to reflect on their progress influenced how well they did on the mid-semester examination and how their peers rated their team contribution. This is a further example of academic and practitioner skills working together to give positive outcomes for both academic learning (mid-semester marks) and practitioner learning (PAF scores).

There is a second cluster of components around the hands-on, teamwork components of ENGG1200 that are the deliverables of the DOEM project: preliminary memo, test, demo, and final report. The first three items had strong correlations with the final report, while the test session, which focuses on the prototype build progress, also correlated strongly with the previous deliverable (memo) and with the final demonstration of the prototypes (demo). This is not surprising as the deliverables were designed so that earlier deliverables would offer formative learning opportunities that could be demonstrated in the later deliverables.

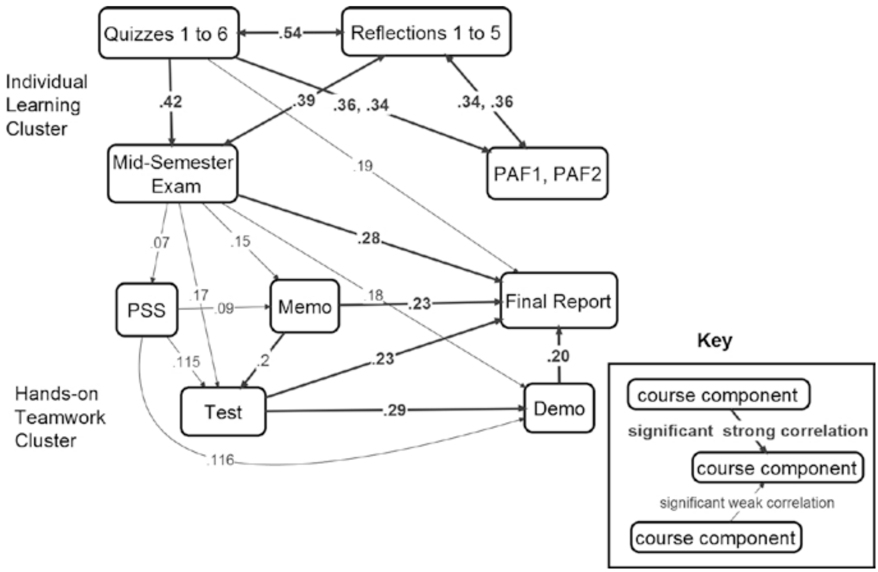

Fig. 7.6 Emergent achievement clusters

The emergent achievement clusters suggest that some students were better at online individual activities, while some were better at on-campus teamwork activities. However, the mid-semester examination was the mediating factor between the individual learning cluster and the teamwork cluster. That is, mid-semester results, which were correlated with reflections and quiz marks, were also weakly correlated with the subsequent team-based assessment items: the memo, test, demo, and final report. These weaker correlations may have been more due to examination marks and project activities being correlated with a third (hidden) variable rather than to direct influence. For example, all of these relationships could be influenced by students with good self-management skills doing better than others at all three of these tasks. This possibility will be explored more fully later on.

The mid-semester examination was broken down into its materials and problem-solving subsections to see whether either section was related to the other course components. The correlations of these sections with all other course components revealed that the materials subsection had stronger correlations with online quizzes (0.34), the memo (0.15), and the final report (0.14) than the problem-solving part (online quizzes 0.22, memo 0.09, and final report 0.07). This result could have been due to the fact that students' level of understanding of the material content, as indicated by examination marks, was more visible within the written project deliverables. Future versions of ENGG1200 will investigate the impact of the problem-solving lessons more fully.

7.5.6 Assessment of Learning Mechanisms and Outcomes

The expected learning outcomes from the course architecture (Fig. 7.1) were combined with the emergent clusters of achievements (Fig. 7.6) to obtain a merged model (Fig. 7.7). This model assumes that the links between observable items (Fig. 7.6) are good evidence for the existence of the underlying internal mechanisms acting as mediators to produce the leaning clusters. For example, 'self-management' was required to ensure that a student had completed both the online quizzes and the online reflections and that they performed well within their team. Therefore, 'self-management' is a mediating mechanism placed within the individual learning cluster.

The justification for selecting the chosen mechanisms as being the true underlying mediator mechanisms for promoting the observable skills is as follows.

- students commented on the importance of the development of these mechanisms within themselves in order to achieve their personal goals for the course (Sect. 7.6);
- course facilitators expected that those particular mechanisms would be developed due to the course activities; and
- chosen mechanisms contribute to the entire cluster of activities. For example, although an alternative mechanism of 'academic ability' could be placed inside the individual learning cluster as it contributes to quizzes and to some

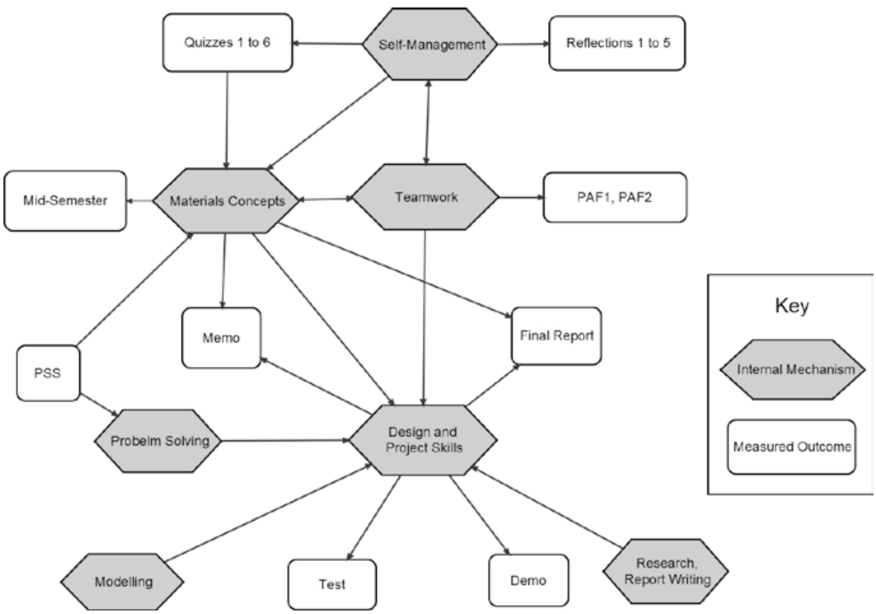

Fig. 7.7 LEA components and the underlying internal mechanisms acting as mediators

extent reflections, it does not necessarily contribute to PAF scores, as students with high general academic ability may not necessarily be good team members. However, 'self-management' is a mechanism that contributes to all three correlated activities within the individual learning cluster, and so it is the mechanism that has the best fit.

This logic resulted in the following internal mechanisms shown in Fig. 7.7 being postulated:

- a 'materials concepts' mechanism within the individual learning cluster with a link to 'teamwork';
- a 'teamwork' mechanism as a mediator of the PAF scores;
- a 'self-management' mechanism as a precursor for 'materials concepts' and 'teamwork; and
- a 'design and project skills' mechanism for the observable team-based deliverables ('memo', 'test', 'demo', and 'final report').

Altogether, the merged model of mediating mechanisms points to an important understanding that 'self-management' is crucial to student success. The results suggest that this mechanism mediates learning of materials concepts that then lead to better mid-semester marks and also mediates teamwork, which then leads to better PAF scores. Teamwork then mediates project work, which leads to better memos and reports. However, given that 'self-management' is not specifically taught in ENGG1200, it is not clear whether this mechanism was developed as a result of participating in the course activities or whether it was a pre-existing ability that students brought to the course. Given the demonstrated importance of 'self-management' to success, future work will need to investigate what aspects of this practitioner skill are brought to the course and what aspects the course help it to develop. These questions can be investigated more fully by future inclusion of methods for measuring self-management more directly, thus enabling the use of more sophisticated statistical techniques such as structural equation modelling for validating the existence of mediating mechanisms.

It does appear that performance on course deliverables indicates the development of differing groups of skills. To investigate this further, various groups of variables were placed into three stepwise hierarchical linear regressions to see how they predicted three outcomes of interest: academic skills (indicated by marks on the examination), teamwork (indicated by PAF scores), and project skills (indicated by project marks). In each regression, a student's grade point average (GPA) was used as a measure of academic ability for the first step and the other variables entered in the second step. This method revealed any additional variances after the effect of academic ability had been taken into account. The results were as follows.

- **Mid-semester marks**:

Quiz, reflection, narrative template, and problem-solving workshop marks were included to see how each variable contributed towards the mid-semester examination mark. The resultant regression equation (7.1) accounted for 27% of the variance in examination marks ($R^2 = 0.27; F_{3,1037} = 125; p < 0.001$) and showed that performance on quizzes and reflections improved student performance over and above that which would be predicted by academic ability alone.

$$\text{MidSem} = 0.37\text{GPA} + 0.15\text{Quiz} + 0.13\text{Reflection} \quad (7.1)$$

where

MidSem	Mid-semester examination mark
GPA	Grade point average (range: 1–7, 7 = high distinction, 4 = pass)
Quiz	Combined mark for all six online quizzes (range: 0–10)
Reflection	Combined mark for all five reflections (range: 0–15)

This result is fairly typical for any FC course in that students who do well on the formative exercises do better on the examination. However, participation in the problem-solving sessions and the narrative sessions did not contribute significantly to the examination results, but this may have been to the small variance in the scores. It is instructive to note the significant contribution of student reflections to the mid-semester result. This finding is supports the suggestion that underlying student characteristics such as self-monitoring may help with student achievement. This possibility needs to be explored in future versions of the course.

- **PAF scores**:

The effects of GPA and performance on the mid-semester examination, quizzes, reflections, narrative templates, and problem-solving workshops were analysed to see whether they predicted peer assessment (PAF1 and PAF2) scores. The resultant regressions (7.2 and 7.3) accounted for 11% of the variance in the PAF1 scores ($R^2 = 0.11; F_{3,1037} = 43.5; p < 0.001$) and 12% of the variance in the PAF2 scores ($R^2 = 0.12; F_{4,1036} = 37.3; p < 0.001$).

$$\text{PAF1} = 0.07\text{GPA} + 0.21\text{Reflection} + 0.14\text{MidSem} \quad (7.2)$$

$$\text{PAF2} = 0.15\text{GPA} + 0.20\text{Reflection} + 0.07\text{MidSem} + 0.06\text{NarrTempTot} \quad (7.3)$$

where

PAF1	Peer Assessment Factor (Week 7)
PAF2	Peer Assessment Factor (Week 13)
NarrTempTot	Total for the narrative workshop worksheets (range: 0–4)

Together these results suggest that the way in which a student was judged by their peers was influenced by that student's general academic ability and their ability to reflect on their own behaviour. In Week 7 (PAF1), it was also influenced by the student's examination mark, but by Week 13 (PAF2), this was no longer important. Participation in the weekly narrative workshops was also a minor factor at the end of the semester, and this may be evidence that the narrative workshops were operating as intended and enhancing team progress.

- **Project report**:

All measured outcome variables except for PAF scores were included in a regression analysis to see which were most important in predicting the project report marks. The resultant equation (7.4) revealed the important variables that together accounted for 9% of the variance in the report marks ($R^2 = 0.09$; $F_{6,1034} = 18.2$; $p < 0.001$).

$$\text{Report} = 0.17\text{Memo} + .14\text{Test} + 0.09\text{MidSem} + 0.08\text{NarrTempTot} + 0.02\text{PSS} \quad (7.4)$$

where

Report	Mark for the final design report (scaled from a team-based mark)
PSS	Mark for the problem-solving sessions (scaled from a team-based mark)
Memo	Mark for the initial memo (scaled from a team-based mark)
Test	Virtual and physical test session mark (scaled from a team-based mark)

These results suggest that project activities and team management are paramount for the project outcomes. That is, the team's ability to prepare a good plan and design for their project, as indicated by the memo mark, and how on track the team are by the testing session are the most important indicators of how well the team will do on the final report. The amount of engagement that the team had in the narrative and problem-solving workshops seems to have had a slight influence as did the knowledge that team members had of materials, as indicated by examination marks. It is of note that GPA is not a significant factor, suggesting that project work develops situated learning skills (i.e. design, modelling, problem-solving, and teamwork) rather than general academic skills.

The above results appear to indicate that the course activities are working together as planned to develop skills in the areas of materials engineering, teamwork, and engineering design.

7.6 Student Reflections of Learning Processes

In addition to the objective analyses conducted in Sect. 7.5, we examined students' perceptions about how course activities assisted their learning and development of skills. This was done through the analysis of two of the five written reflections that formed part of the individual learning cluster (Fig. 7.6). The two reflections were those where students were asked specifically to reflect on their learning at the beginning (R1) and end of the semester (R2) as follows:

> R1: Consider ENGG1200 and what it means to own your own learning. Do you have particular expectations for ENGG1200 and can you see anything that particularly interests you? Consider your strengths and how they may be utilised within your team and don't forget to address areas of competency that you wish to improve on. What personal goals do you intend to set for yourself?

R5: Critically review your involvement in ENGG1200. Did you meet all of your goals and if not why not? Consider what your key lessons were and what helped you during the process?

For the purposes of the FC evaluation, a sample of 150 students was randomly selected and their reflections analysed using thematic analysis with NVIVO.

Figure 7.8 shows the main goals set by the students as well as their perceived levels of achievement over the semester. The figure reveals two interesting findings. Firstly, the main goals set by the students were not the course deliverables (e.g. quizzes or final report), but rather the underlying mechanisms that had been specified within the course design (Figs. 7.1 and 7.7). Secondly, students were much more focused on professional skills. That is, out of the 150 student reflections analysed, 56% nominated teamwork, team communication, or team management as their first or second goal and 37% nominated self-management as their first or second goal. As previously discussed, 'teamwork' and 'self-management' seems to be necessary mechanisms for success in both the individual learning and teamwork activity clusters; therefore, this finding shows students' awareness of how important these competencies are to course outcomes. Interestingly, students thought they had been more able to develop teamwork skills than self-management skills. This finding will be considered within our future lines of enquiry.

Students also mentioned course supports being instrumental in achieving their goals. Figure 7.9 shows the main supports mentioned as helpful by the sample of 150 students.

As previously mentioned, cognitive apprenticeship is an integral part of active learning but is difficult to achieve with large classes. In ENGG1200, the LEA components and associated scaffolds were designed to ensure that this aspect was present, in particular for learning practitioner skills. Figure 7.9 reveals that the design may have been successful in this respect because scaffolds such as 'Workshop Leaders', 'Tutors', 'Learning Pathway' and 'Online Modules' were

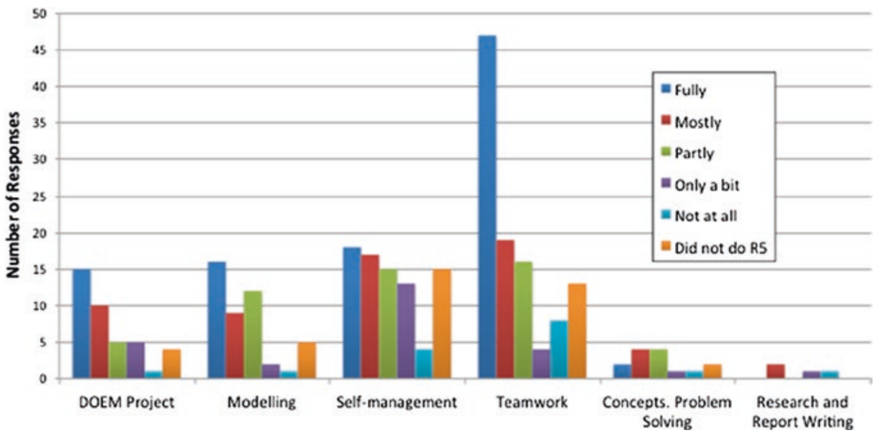

Fig. 7.8 Perceived attainment of goals ($N = 150$)

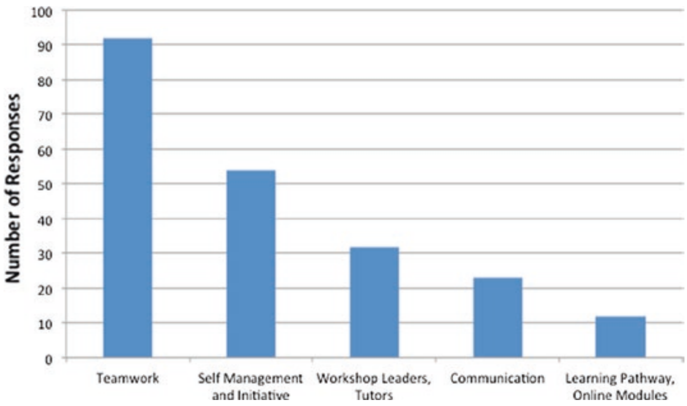

Fig. 7.9 LEA components helpful in achieving goals ($N = 150$)

frequently mentioned as helpful. Specific comments also attest to the fact that tutors and instructors were helpful guides in a master–apprentice-like role:

> What really helped me this semester was the support of our tutors and project leaders by always providing resources, answers to our questions and a determined belief that despite our adversities or doubts we would be able to complete this project, and to do so well if we applied ourselves.
>
> I have never done any CAD modelling and it was fantastic to learn first-hand from the tutors in the CREO session.

Figure 7.9 also reveals that the most significant sources of help were thought to be students' own professional abilities (i.e. 'teamwork', and 'self-management and initiative'). This implies that the professional skills that the course was designed to develop were owned by students as necessary for their success (Table 7.5) gives examples of students describing internal mechanisms that they experienced during the course as suggested by both the objective analysis shown in Fig. 7.7 and students' subjective experiences. The table contains a single representative quote for each component, but in each case, there were other similar quotes lending credence to this claim.

Student reflections also provided evidence that students perceived that internal mechanisms such as 'materials concepts', 'self-management', and 'teamwork' (Fig. 7.7) had developed within themselves as a result of the course architecture. Table 7.6 gives examples of student reflections describing the learning mechanisms developing due to the deliberate scaffolding of course components. Furthermore, evidence was found for interactions among these mechanisms, such as 'self-management' mediating 'teamwork'.

The final analysis question regarding specific skills obtained by students as a result of the course LEA was also answered through the analysis of the final reflections (Table 7.7).

Table 7.5 Internal mechanisms experienced by students

Element	Student comment
Teamwork: Teamwork was both a scaffold for the team project and a skill to be developed	
Sharing of load	Being paired with a good team meant that the heavy workload of this course was shared between us and made manageable for everyone
Support	What helped me throughout the process was the other team members in my group, as they knew exactly what I was going through at any point in time and we could help each other get through each piece of assessment
Motivation	As a team we pushed each other to our limits. We helped each other meet our deadlines whilst providing both moral support and assistance whenever it was needed
Communication	Learning to communicate effectively within the team is another key lesson. Since we separated into two groups [for software workshops], it was hard to pass on information. We were able to adapt to this by using Facebook as well as weekly meetings
Collaborative learning: Collaborative learning underpins any FC	
Course concepts	… by discussion and collaboration of ideas with other team members, I have been able to meet my goals of better understanding the ENGG1200 concepts
Problem-solving	… the knowing that teamwork would allow easier problem solving, tasks to finish earlier and allow everyone to share their diverse talent [for] each task …
Design	Especially for design, it is much easier to be creative as a team than as an individual. This is very new to me as I normally study on my own, but have now realised that working in groups is more beneficial
Writing	It was great in the way our group would have all our work uploaded often a week before a due date. This allowed [us] to go through and critique our work, also seeing it from different angles. For the report this really helped as I was a little unsure on my work, but using my team members as peer markers kept me at ease
Peripheral participation	… although I did not partake in the construction, I attended our construction sessions and this enabled me to learn about the process
Self-management: Self-management is a foundational mechanism for all aspects of ENGG1200. It is not explicitly addressed, but a mechanism already internal to the students or developed from participation	
Managing study	The key lesson that resonated with me was the importance of time management. The use and learning of this lesson allowed me to effectively study for the midsem and organise myself and my team for the major project
Planning	I decided to follow the planning steps recommended by the lecturers. Having a plan ensured that time wastage was minimised and resulted in the project being executed in a structured manner. Personally, planning also ensured that I had a purposeful schedule, without the 'what do I do next?' dilemma, and low stress levels, as I was always aware of the current project status and my responsibilities within it
Gantt charts	We initially disregarded planning and assumed it was not important, but found that it wasn't until we created the Gantt chart that we began to gain control over the project

(continued)

Table 7.5 (continued)

Element	Student comment
Preparing for meetings	Another lesson I learnt was to write up what needs to be done in the meeting beforehand, and to check up on our progress each week. I believe that this helped me stay on track, being the essential tool to help my team complete any goals we set
Developing skills	I applied the lessons I learned from ENGG1100 (Communication, Planning, Teamwork, and Preparation)… Because of this I believe the Final Report and Demonstration will be successful and comply with my goals
Engaging with own learning	… my attitude and application towards this course has been much higher which has resulted in the knowledge gained from this course far exceeding that I gained from ENGG1100. I believe this is due to the hands on learning approach where we are expected to learn the material ourselves rather than just listening to a lecturer talk
Reflecting	Another key lesson was that knowing [that] how you fell about work issues as well as your particular thoughts on different aspects of your work can better prepare you for tackling different problems with less effort and more efficiency I hated [reflecting] and saw [reflections] as one of the worst possible chores known to engineering students but now I can see their importance. Being able to critically analyse your thoughts is a weapon every successful engineer possesses

The example quotes in Table 7.7 are grounded in the course content and details of the students' projects. Taken together with the quotes in Table 7.6, there is clear evidence for the development of practitioner skills, with an emphasis on teamwork skills such as collaborative learning and communication and on self-management skills including reflective practice. Design and modelling were also highly mentioned; even though these were not visible within the analysis of the skills that had objective measures available in the current study. Further versions of the course will investigate the development of design and modelling skills more closely. It is also of note that research and report writing skills were not mentioned as being supported, suggesting that scaffolding of report writing may need to be included in future versions of the course.

Table 7.6 ENGG1200 scaffolding experienced by students

Scaffold	Facilitating	Student comment
Online modules/ quizzes	Materials concepts	In terms of learning more about materials … I definitely achieved this goal (having not much prior knowledge in this area) and it will be very useful moving forward in my engineering studies and career. The online modules were a huge help in this area in particular
	Self-management	At first I found [the weekly quizzes] to be time consuming, tedious tasks for a relatively miniscule grade. That opinion changed when I put them to good use [in] the mid-semester exam. Further, my newfound understanding of materials has been of assistance at my work place when I reference technical drawings or am trying to comprehend a concept explained to me by an engineer
Problem-solving sessions	Materials concepts	Attending all materials and problem solving sessions enhanced my performance and knowledge for the mid-semester exam and all group assessment
	Engineering design and project skills	These sessions were very useful in understanding how engineers need to apply different problem solving techniques to different questions. SOLVEM provided our group with a structured and formal way to approach a problem, which greatly assisted our team project
Self-management	Individual learning and teamwork	For the [individual assessments] I feel like I met my learning goals of being self-motivated and learning all the material. This individual work was essential in being an active group member with knowledge that could assist the build and design of the project
Materials workshops	Materials concepts	The material selection process and the critical [analysis] of materials are linked together. I wanted to learn these topics since professional engineers must have [this] knowledge and I wanted to be able to understand this concept earlier in my degree. The material sessions in ENGG1200 helped me to achieve these goals…
The learning pathway	Self-management	I have learned to manage my time more effectively. Keeping on top of a large workload is an important skill to have in this course and the Learning Pathway has really helped me with structuring my study …

Table 7.7 Skills and knowledge development experienced by students

Skills/knowledge	Student comment
Materials concepts and skills	The key lesson … is the material part, I learnt a lot out of it, such as stress and strain, plastic and elastic deformation, especially the dislocation, that gave me a clear definition for the problems [that] confused me before, also helping me understand the concept I used in CREO prototype design
Design cognitions	This course has changed my mentality of testing being the only method of making sure a design works. I now have the tools to predict how a design will behave before it is actually tested One of my key lessons was learning to visualise … Our team developed a design early, however only in week 8 did we discuss it with tutors and realise frustrating flaws. I realised the need for professional engineers to communicate well and regularly with clients Another key lesson was experiencing how complicated it can be to design different parts or systems and then integrating them into a single product
Modelling tools and processes	I have discovered the practicality of using Computer Aided Drawing to design and simulate projects before they are fabricated I learned that computer modelling and simulation is a great time saving tool. It allows for the rapid design and evaluation of multiple designs within a short period of time Using MATLAB and CREO taught me that engineers can use technology as not only a way to speed up the design process but also to check design and ensure it will function
Problem-solving	… at first a solution might not be overly obvious [but] once broken down and examined from a few different angles it is easier to brainstorm how a solution could be achieved … we were able to learn about solving complex problems and how to break them up into simpler ones through the use of diagrams, flow charts, SOLVEM and more I learnt … the importance of methodical, logical process, efficient data sorting as well as a framework for visually representing problems
Teamwork	I assumed that I work best individually, and that team members would hold me back. However, after seeing potential in other team members, my perception shifted. I realised that working as a group towards a common goal results is a much better outcome. Since then, I have been more willing to work as a team [and] my ability to work within a team has greatly improved Early in the project, I noticed several of my team members devoting significant time to our project. Seeing this motivated me to try and contribute in a similar way. I felt that if they valued our team highly, I should also
Multidisciplinary	The key lessons I've learned is that the various engineering disciplines can be present in one project, even though it is quite small and relatively simple. This has helped broaden my view, and help emphasise how important it is to at least be a little knowledgeable about things outside your exact field so that you can help in the facilitation process Being jointly responsible for the electrical component of the project with two other team members, I was both required to and able to undergo a learning experience with them in a branch of engineering which we all were relatively new to

(continued)

Table 7.7 (continued)

Skills/knowledge	Student comment
Collaborative learning	… we faced problems with our code and although I was not involved in developing this, I was able to support my team by discussing and brainstorming to find possible causes and solutions to the problem even if I did not fully understand all the details I had to change this learning approach when using MATLAB Simulink to model our project. I discovered the importance of using and relying on organisational support; in the real world of engineering you cannot do everything on your own
Self-management	The other key lesson I have learnt is the importance of planning. Ever since high school days, I have never been one to plan ahead. However, I decided to follow the planning steps recommended by lecturers. Having a plan of action ensured that time wastage was minimised and resulted in the project being executed in a structured manner I became a better scheduled person… I would miss some deadlines because I didn't organise time well, or simply didn't check [the] learning pathway… Now I check my email and [the] learning pathway's 'what to do' every week, and organise my time so I can finish the assignment on time in order to achieve a good result in the subject
General	Personally, I have learned how to: assemble rigid and flexible piping system recognise the fundamentals of how electrical systems work build a clamping system to hold our valves and servos in place use CREO and Visio … all of these skills will be very useful later on in this degree and may be a great asset in future… I feel that these project subjects, although they sometimes expect a lot, are like building blocks of everything I need to know to become a fully-qualified engineer Reflecting on this subject, really highlights the speed at which we are learning in these project subjects. I feel like I have gained knowledge equivalent to that of 2–3 years of high school

7.7 Conclusions and Recommendations

The ENGG1200 case study presented here reveals how the process of designing a FC LEA is much like the design of an engineering artefact: it is a complex undertaking, requiring design specifications, consideration of constraints and available resources, background research, and evaluation of effectiveness. Firstly, the mechanisms required for successful active learning were embedded into the course LEA, and secondly, the course was designed to develop a set of specific academic and practitioner mechanisms within our student engineers.

The results of investigating the course using both objective analysis (correlations and modelling) and subjective analysis (investigations of student reflections) are that:

- The internal mechanisms of self-management, teamwork, materials concepts, problem-solving, design, and project skills were evidenced as being important mediators of success in the course activities. These components emerged both from the quantitative analysis of measured outcomes and from the subjective experiences of students as reported in their reflections. These mechanisms were perceived by students both as being important to success and as being promoted by the activities and scaffolds of the course. In addition, students recognised collaborative learning and communication as important aspects of teamwork and modelling skills as an important aspect of project work, all of which were supported by the course activities and scaffolds. However, the mechanisms of research and report writing were perceived by students as being important but not developed by the course LEA;

- The exact mechanisms whereby the problem-solving sessions helped to develop problem-solving, design, and project skills are unclear. The measurement of how involved students were in these sessions and what they learned from them was not sufficient to allow any insights to be made. Future research will address this as well as how the workshops helped to help connect theory with practice;
- Self-management was a key skill that students needed to draw upon in order to succeed. Within a FC framework, self-management is essential to student success, but we do not yet understand whether students who bring good time management are more able to succeed in a FC course or whether the FC helps to develop these skills.

The success of the course has been shown by the explicit mention in student reflections of the various bespoke methods of delivery and resources that were designed alongside the delivery methods, as being helpful in acquiring the important learning mechanisms. From these mentions, and the correlations between assessment items, the distributed scaffolds that provided active learning and apprenticeship experiences can be seen to have been successful in producing the learning goals and design cognitions DCs that were set as objectives for the course.

In summary, we can conclude that a well-considered FC course design has been able to realise both ABET criteria and the ENGG1200 course objectives. That is, both academic skills via online modules and hands-on workshops and practitioner skills via real-world hands-on teamwork activities and design projects have been developed within our student engineers on a large scale (i.e. with over 1000 students).

Future work on the role of self-management towards both academic and practitioner skills and on tracking the development of design and modelling skills will be of interest to teaching and industry professionals.

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Chapter 8
Experiences with "Flipping" an Introductory Mechanical Design Course

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Abstract We formally incorporated the "flipped classroom" into our undergraduate mechanical engineering curriculum during the fall of 2013. In addition to a second-year course in mechanics and statics, we also flipped the laboratory portion of a required second-year course in introductory mechanical design taken by over 200 students annually. The CAD modelling portion of the course was delivered in a flipped fashion, in which students applied their SolidWorks knowledge during the weekly two-hour laboratory session. In the "flipped classroom", face-to-face time is used for application of skills versus the conveyance of facts. To enable this approach, students watched video lectures before class. This course was part of a school-wide initiative to drive active learning, engagement, and deeper learning. We obtained positive results with flipping this course, as perceived by the students, teaching assistants, and instructor. Structured classroom observation revealed many of the ideals of the flipped classroom, including teamwork, peer discussions, active questioning, and problem-solving. Using the Teaching Dimensions Observation Protocol (TDOP), we observed that nearly 100% of the observation segments contained problem-solving with SolidWorks as the TAs circulated and assisted students. This interactive environment aligned with our finding from the College and University Classroom Environment Inventory (CUCEI), in which students rated the Personalization dimension, which assesses student-to-teacher interaction, highest. We benchmarked our CUCEI results against those of STEM classrooms at two other schools. Our direct assessment of learning based on SolidWorks take-home assignments showed statistically equivalent results

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when comparing the pre-flipped to the flipped course, as have other mechanical engineering studies in the literature. However, during a semi-structured interview, the instructor reflected that students in the flipped class were more sophisticated, proficient SolidWorks users, attributing this to more practice time available with the flipped classroom. Based on student survey data, nearly 60% of respondents preferred using class time for active learning versus listening to a lecture; thus, the majority realized the value of the flipped approach. A content analysis showed the most frequently perceived benefit to be the flexibility associated with video or online learning, as noted by 46% of respondents. The instructor noted that students in the flipped classes displayed greater confidence and interest in SolidWorks compared to students in previous classes. However, the TAs noticed that students were not watching the videos in all cases, necessitating the use of accountability quizzes. Despite some challenges and a lack of statistical significance of the homework results, we considered this to be a successful implementation of the flipped classroom given the level of student engagement. Going forward, flipped instruction will be the teaching and learning format that we plan to use with this course as well as others in the mechanical engineering department.

Keywords Flipped classroom · Mechanical engineering design · Assessment

8.1 Introduction

Our flipped classroom was included as part of a school-wide initiative within Pitt's Swanson School of Engineering beginning in the fall 2013. This initiative was supported in part by the school's Engineering Education Research Center (EERC) and consisted of freshman through senior courses across multiple engineering disciplines. The school-wide objectives were to (1) enhance in-depth learning and achievement of the higher-order skills in Bloom's taxonomy, (2) enhance student engagement and involvement, and (3) better utilize the school's state-of-the-art instructional facilities and technology to support active learning. The instructor's primary goals in flipping this course were to better support design activities during face-to-face class time, including increased teaming, group discussions, and oversight and guidance of the design process used by the students.

This required second-year course (MEMS-0024: Introduction to Mechanical Engineering Design) is taken by approximately 200 students per year and covers fundamentals of the mechanical design process, including concept generation, graphical communication, use of CAD software (i.e. SolidWorks) to create working drawings and dimensioning and tolerancing. The laboratory aspect of the course involving student use of SolidWorks was the portion flipped. There were three laboratory sections per semester given the total number of students. Each section was led by two undergraduate TAs who supported the students in their in-class SolidWorks assignments, which consisted of problems such as creating an assembly from part files or developing dimensional drawings.

To assess progress in relation to the school’s objectives, the EERC developed a comprehensive assessment plan consisting of direct and indirect measures. These assessments included course-specific examinations and projects, interviews and discussions with instructors, perception instruments, structured classroom observation, and analysis of video usage data to determine preparation and engagement with the videos. The instruments included a classroom environment index and a formative evaluation survey tailored to the flipped classroom.

The classroom environment index, formally known as the College and University Classroom Environment Inventory (CUCEI), measured student perceptions of the learning environment as well as their engagement in the course (Fraser and Treagust 1986). This reliable inventory evaluates perceptions of seven psychosocial dimensions of the classroom and was used previously in flipped classroom research (Strayer 2012). Several of the dimensions are particularly relevant to the flipped classroom, including involvement, student Cohesiveness, Individualization, Personalization, and innovation. Our evaluation survey was modelled upon another survey used in flipped classroom research (Leicht et al. 2012; Zappe et al. 2009). We expanded upon this survey slightly given the interests and insights of our own faculty. Classroom observation was conducted using the validated Teaching Dimensions Observation Protocol (TDOP). This protocol involves a series of small observation windows and a set of codes related to teaching and learning practices. The dimensions covered in this protocol are (1) teaching methods, or how information is disseminated and learning is accomplished during class; (2) pedagogical moves, pertaining in part to teaching style and strategy; (3) questioning between instructors and students; (4) cognitive engagement by students, such as problem-solving; and (5) instructional technology use (Hora and Ferrare 2013). The developers of the TDOP have used both a five- and a two-minute observation window and initially reported inter-rater reliability using the five-minute window (Hora and Ferrare 2013). Based on personal discussion with the developer of the TDOP, the two-minute window provides more granular data, since more occurs in five minutes versus in two minutes. However, the two-minute window places more demands on the observer and may decrease his/her ability to record notes and informally assess classroom happenings and the environment (Hora 2014).

8.2 Methods

In this section, we discuss course and faculty development for the flipped classroom and our mixed methods assessment approach. This approach included both direct and indirect assessments and allowed us to triangulate our results. Our assessment methods consisted of statistical analysis of SolidWorks results, instructor interviews, structured classroom observation, and student perception surveys. Our methods aligned with our school-wide objectives with the flipped classroom as described in the introduction.

8.2.1 Course and Faculty Development

Preparations for the flipped classroom began approximately six months before implementation. The school-wide preparations included the formation of a learning community in the spring 2013 by the EERC (Baxter Magolda and King 2004). In addition to the instructor, other engineering instructors who were flipping courses participated in this community. The assessment analyst and the IT staff doing the video creation and editing were also part of the community. During the meetings, various topics were discussed by this community, including challenges related to students and video development, assessment plans, classroom logistics, active learning techniques, and the instructors' goals. The EERC also sponsored a flipped classroom one-day seminar in the spring of 2013 for the instructors of the inaugural flipped courses in the school. Engineering faculty from another institution with teaching and assessment experience with the flipped classroom led the seminar.

The instructor began creating his video lectures in the summer of 2013 prior to the fall semester. The instructor recorded his lectures in small modules using the Camtasia software with the assistance of the IT staff. He recorded 51 modules having an average length of 9.3 min, which according to 68% of survey respondents was "just right". Example module titles are shown in Table 8.1.

The classroom used for the laboratory portion of the course was conducive to active learning; it contained desks with computers that accommodated groups of students for teaming.

8.2.2 Assessment Methods

To directly assess learning and achievement in the flipped classroom, we compared SolidWorks results from the pre-flipped versus flipped versions of the course. This was done using an analysis of covariance with the pre-course GPA as the control variable. The instructors were also interviewed after the course to uncover gains and outcomes that were not evident in the direct assessment results.

Table 8.1 Example video module titles

Getting started with SolidWorks	Adding dimensions to a drawing
Sketching	Creating a bill of materials
Putting part files into an assembly	Using the revolve tool
Editing an existing assembly	Using the loft tool
Using the hole wizard	An example of the loft tool
Creating a drawing	Creating a motion study animation

Finally, to assess the relationship between preparation and achievement in the flipped classroom, we performed a correlation analysis of the number of videos accessed versus the final course grade.

To directly assess engagement, active learning, and classroom dynamics and usage, two class sessions per semester were generally observed at approximately the one-third and two-thirds points in the term. A total of five 110-min sessions were observed between fall 2013 and fall 2014. To measure the relative degree of active and interactive learning in our classroom, we compared the observational results to those of a recent TDOP study of 58 STEM classrooms using Fisher's exact test. Fisher's test can be used in lieu of a z-test of proportions when the numerators are small. Either one or two trained observers performed the observation using the TDOP. When two observers performed the observation, they discussed any differences in assigned codes afterwards until a consensus was reached. The overall inter-rater reliability statistic achieved by these two observers was a Cohen's kappa of 0.86. The individual protocol dimensions ranged from 0.70 to 0.92. These values are based on 80 five-minute observation segments from four different courses. Values of Cohen's kappa above 0.75 suggest strong agreement beyond chance; values between 0.40 and 0.75 indicate fair levels of agreement above chance (Norusis 2005).

To indirectly assess student engagement, we distributed the CUCEI and the flipped classroom evaluation survey at approximately the two-thirds point in the term. The evaluation survey assessed students' feelings about and perceptions of the flipped classroom, including benefits and drawbacks perceived. A trained coder, who was a junior engineering student, conducted a content analysis of the perceived benefits and drawbacks, and a second coder (i.e. the assessment analyst) coded a sample (i.e. approximately 35%) of the responses to assess inter-rater reliability. The inter-rater reliability scores achieved based on Cohen's kappa were $\kappa = 0.73$ for the benefits analysis and $\kappa = 0.85$ for the drawbacks analysis. The coding framework for the content analysis was developed by the assessment analyst using a grounded, emergent approach upon reviewing student responses for all flipped courses in the school-wide initiative (Neuendorf 2002).

8.3 Results

Based on a variety of assessments performed, we found favourable outcomes with the flipped classroom. The results of the activities—direct assessment of SolidWorks assignments, instructor interviews, correlational analysis of video usage with SolidWorks performance, structured classroom observation, and the classroom environment and flipped evaluation surveys—are discussed next, in the context of our school-wide objectives with the flipped classroom.

8.3.1 Direct Assessment of Learning and Instructor Interviews

We compared students' achievement on their SolidWorks take-home assignments using one semester of pre-flip and two semesters of flip performance data. Using pre-course cumulative GPA as a covariate or control variable, we did *not* find a significant difference pre-flip to flip ($p = 0.41$). The pre-flip SolidWorks percentage was 94% ($n = 177$); the flipped percentage was 93% ($n = 394$). The SolidWorks take-home assignments were generally the same across the semesters. The average cumulative GPA for the pre-flip group was just slightly higher, although not significantly so.

Despite the statistical equivalence of the two sets of SolidWorks scores, the instructor reflected in a post-course interview that the students in the flipped section were more "sophisticated" and proficient CAD users. He attributed this to the time available in the flipped classroom for active learning, which allowed for more practice with SolidWorks in a guided environment. Students had to solve twice as many problems versus in the non-flipped course. In addition, the instructor also noted in both a post-course interview and a focus group that students likewise felt more proficient and confident with SolidWorks versus in previous years. For the first time in teaching this course, his students identified SolidWorks as the best part of the course.

8.3.2 Video Access Analysis

In addition, we utilized web analytics data to determine the videos accessed by each student. However, these data only indicate that a video was launched or accessed and not necessarily that the video was watched in whole or even in part. In addition, students might have watched the videos in groups in the dormitories; therefore, not all students might have officially logged into watch a particular video. Thus, we present both web analytics as well as self-reported data to portray video usage. The self-reported data will be discussed in a subsequent section. The data in Table 8.2 encompass the fall 2013 and fall 2014 semesters.

Examining the relationship between preparation via the videos and performance on SolidWorks assignments, we found a weak to moderate correlation of 0.33 between the number of unique videos accessed and the percentage on SolidWorks assignments ($p < 0.0005$). The scatter plot of the number of unique videos accessed (out of a possible 51) versus the SolidWorks percentage is shown

Table 8.2 Web analytics percentage of videos accessed

	Average number of videos accessed	Available videos	Average % accessed	Students
MEMS-0024	27	51	53	418

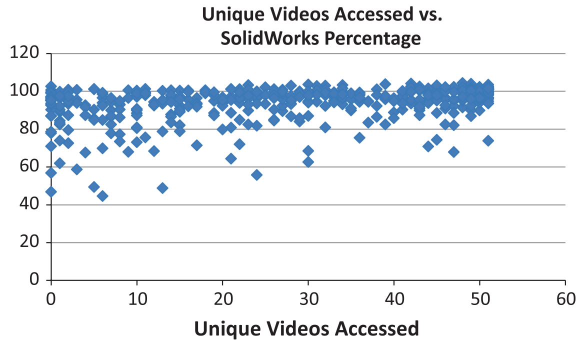

Fig. 8.1 Unique videos accessed versus SolidWorks percentage

in Fig. 8.1. This plot shows that some students did "fit" the expected relationship between videos accessed and performance. However, many who accessed 30 or fewer videos earned SolidWorks percentages of 80% or more, as indicated by the large number of points in the upper left quadrant.

In addition, we also analysed the total number of times the videos were accessed versus the SolidWorks percentage and found the correlation to be similar at 0.31 ($p < 0.0005$). The latter analysis accounted for the case in which a video was accessed multiple times by a student, for example for reinforcement or study purposes. We defined a "distinct" access of a video as the one that occurred at least ten minutes after the last access of the video by the student. For example, if a student accessed a particular video at both 2:03 PM and 2:05 PM on a given day, these would *not* be counted as two distinct accesses. We considered ten minutes to be reasonable since the average length of each video was between nine and ten minutes.

8.3.3 Classroom Observation

Using the TDOP, structured classroom observation was conducted to directly assess student engagement and involvement based upon the practices and activities of both the students and the instructors. In this case, undergraduate TAs served as the instructors in the laboratory portion of the course that was flipped. The 110-min class period was observed in five-minute segments, in which various activities and practices contained within our protocol were recorded as observed.

Observation of the five class sessions revealed an outstanding implementation of the flipped classroom. The teaching assistants were in nearly constant demand during class and provided as-needed support to the students' use of SolidWorks. Specifically, in 97% of the segments, the TAs circulated (MOV) to provide support and answer the students' questions (SCQ), as shown in Table 8.3a. During nearly the entire class period, students actively worked with SolidWorks at their desks (DW) to solve the design problem (PS) posed to them. These problem assignments

Table 8.3 (a) Comparison to 2012 National STEM TDOP study (two-minute window) (b) Comparison to 2010 TDOP study (five-minute window)

Classroom element	Description	STEM comparison study (%)	Mechanical engineering design (%)
(a)			
MOV	Instructor circulates in classroom	7	97*
ART	Student articulation/discussion	9	86*
PS	Problem-solving	12	97*
SCQ	Students ask question or request assistance	9	97*
DW	Students actively work at desk/PC	6	98*
(b)			
PS	Problem-solving	31	97*
DW	Students actively work at desk/PC	5	98*

were generally due at the end of the two-hour period. At the same time, the students discussed the work, interacted, and assisted one another (ART). In short, the flipped portion of this mechanical engineering course was characterized by a high degree of active student learning supported upon demand by the TAs.

Using our five-minute observation window, we benchmarked our results against a national 2012 TDOP study, as shown in Table 8.3a. This study used a two-minute observation window and involved 58 math and science faculty in three public research universities. The courses taught by these instructors consisted of 38% upper and 62% lower division courses (Hora et al. 2012). Our flipped classroom was more active and interactive compared to the classrooms in this benchmark study, as shown in Table 8.3a. Interestingly, in another study, Finelli and Daly also noted a small number of observation segments (i.e. 9%) that involved active learning when assessed across 26 engineering courses using a variation of the TDOP (Finelli and Daly 2011). In Table 8.3a, each classroom element that was significantly higher compared to the benchmark study with $p < 0.0001$ is marked with an asterisk (*). Thus, all of the classroom elements of interest were significantly higher in our flipped classroom compared to other courses nationally and would remain significant after correcting for multiple comparisons using Bonferroni's adjustment. The comparisons were made using Fisher's exact test.

In personal conversation with one of the TDOP's developers, he pointed out that in certain cases, a five-minute observation window could result in higher proportions compared to a two-minute window (Hora 2014). For example, if problem-solving (PS) was recorded just once in ten minutes using the two-minute window, its frequency of occurrence would be 20%. However, using the five-minute window, the frequency would be 50%. Granted, in this case, problem-solving

(PS) occurred rather sparsely during the ten minutes. If PS had occurred continuously, then the frequencies of occurrence would have been the same at 100%. In our flipped classroom, the students tended to work continuously on SolidWorks problem-solving, with peer discussions and student questions continuously taking place. Nonetheless, we obtained earlier benchmark data from the developer of the TDOP, in which a five-minute observation window had been used. These data were collected during the spring of 2010 and involved 57 math and science instructors at three large research universities (Hora and Ferrare 2013). We used these data as a second comparison, as shown in Table 8.3b. However, the developer cautioned that the TDOP was at a much earlier stage of development when he used the five-minute window and was a different protocol compared to the current instrument. Since several of the codes in Table 8.3a did not exist in the earlier instrument, we could only benchmark PS and DW. Comparing Tables 8.3a and 8.3b, the most notable difference was related to the frequency of problem-solving (PS) in the comparison study. However, despite this difference, our mechanical engineering design course was still significantly more active ($p < 0.0001$) in regard to problem-solving and student work at the desk.

In summary, the mechanical design sophomores were actively engaged throughout the class period, either focusing on solving the SolidWorks problem or seeking assistance from the TAs or one another. The TAs were in constant demand throughout class and were able to assist the students as questions arose. This ability to assist upon demand was an important factor in the success of this flipped class.

8.3.4 Classroom Environment Inventory

Using the CUCEI, we indirectly assessed the seven psychosocial dimensions of our flipped classroom as described in Table 8.4. There are seven questions per dimension, and each question has a scale of 1–5, with 5 being most desirable. We received 263 responses, representing a 67% response rate.

The Personalization dimension of the flipped classroom scored the highest of the seven dimensions, with a dimension mean of 3.87 on the 5-point scale. This dimension relates to the interaction between the students and their instructor. Surprisingly, the student Cohesiveness and Individualization dimensions scored lowest and below the average value of 3.00, with dimension means of 2.67 and 2.70, respectively. Thus, our mechanical design respondents did not rate their interactions with one another as particularly noteworthy nor did they perceive notable individual or differential treatment, which are two key characteristics of the flipped classroom. This was surprising since the students tended to team up and assist one another during class with the SolidWorks assignments. In addition, the TAs were in demand the entire class period, providing assistance and support to the students upon demand, as observed during five separate class periods.

Table 8.4 CUCEI comparisons

Dimension	Definition	MEMS-0024	Statistics flipped course	Chemistry tutorial course
		M	M	M
Student Cohesiveness	Students know and help one another	2.67	3.00	2.87
Individualzation	Students can make decisions; treated individually or differentially	2.70	2.58	2.59
Innovation	New or unusual class activities or techniques	3.25	3.08	2.84
Involvement	Students participate actively in class	3.30	–	3.03
Personalization	Student interaction with instructor	3.87	4.13	3.26
Satisfaction	Enjoyment of classes	3.39	–	3.40
Task Orientation	Organisation of class activities	3.75	3.51	3.31
	n	263	23	257
MEMS-0024 SD values: Cohesiveness 0.693; Individualization 0.422; Innovation 0.501; Involvement 0.552; Personalization 0.709; Satisfaction 0.822; Task Orientation 0.598				

We had the goal of benchmarking our classroom environment against a large-scale study. However, based on a search of the literature and personal communication with the developer of the CUCEI, we were not able to identify such a study (Fraser 2014). However, we did find two smaller-scale CUCEI studies with similar classroom formats. Compared to a flipped statistics course at a US university, our course compared fairly closely, as shown in Table 8.4. Although the CUCEI instrument used at the other university differed somewhat from Fraser's instrument, the questions were sufficiently similar and suitable for comparison (Strayer 2007, 2012). Also, two of the dimensions in Fraser's instrument—Satisfaction and involvement—were not measured in this other study. Interestingly, the student cohesion dimension in our flipped classroom was significantly lower than in the flipped statistics classroom ($p = 0.03$), although it would not be if corrected for multiple comparisons using Bonferroni's adjustment. All other differences were not significant at $\alpha = 0.05$; however, the sample size at the other school was small. The nonparametric Mann–Whitney test would have been preferable; however, we had only summarised (i.e. mean) data from the other study. As a takeaway, Personalization was also the highest rated dimension in the flipped statistics classroom, and Individualization was the lowest rated dimension. This may be a general result for flipped classrooms.

We found a second, larger CUCEI study that was performed with a chemistry tutorial class (Coll et al. 2002). This class at the University of the South Pacific was similar to our flipped classroom in that it was an interactive class in which students could clarify lecture content and develop problem-solving skills with instructor guidance. Our flipped classroom environment was rated significantly better on the order of $p < 0.0001$ on four dimensions—innovation, involvement, Personalization, and Task Orientation. However, the student cohesion dimension in our flipped classroom was significantly lower ($p = 0.005$), and the difference would remain significant at $\alpha = 0.05$ if corrected for multiple comparisons. Thus, overall, our course compared favourably to this chemistry course with a similar class format. The effect size, as measured by Cohen’s d, was large for the Personalization dimension ($d = 0.87$). This was a good outcome for our flipped classroom, as a large-scale study of over 20,000 students found that frequent interaction between faculty and students was extremely important to student development and Satisfaction (Astin 1993; Smith et al. 2005). The effect size represents the extent of the difference between two groups. Cohen defined effects as small ($d = 0.20$), medium ($d = 0.50$), or large ($d = 0.80$) (Salkind 2010). The involvement, innovation, and Task Orientation dimensions had medium effect sizes ($d = 0.48$, $d = 0.51$, and $d = 0.68$, respectively), and Individualization and student Cohesiveness small effect sizes ($d = 0.21$ and $d = 0.25$, respectively).

An internal consistency reliability analysis based on Cronbach’s alpha of our MEMS-0024 classroom environment data showed reliabilities above or near 0.70 for Personalization, Cohesiveness, Satisfaction, and Task Orientation. Cronbach’s alpha is an indication of how reliable a measurement scale is, with a value of 0.70 typically taken as target reliability (Nunnaly 1978). The involvement dimension had a Cronbach’s alpha of 0.49; Individualization and innovation have values of 0.17 and 0.29, respectively.

8.3.5 Flipped Classroom Evaluation Survey

The students evaluated the flipped portion of the course via a formative evaluation survey, with approximately 53% providing feedback. Our survey was modelled upon a student perception instrument used in a flipped course for undergraduates in architectural engineering (Leicht et al. 2012; Zappe et al. 2009).

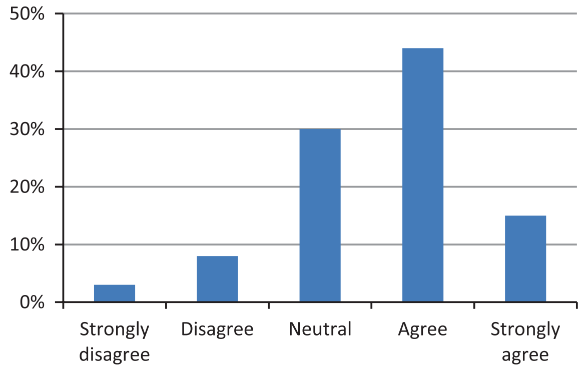

Fig. 8.2 Question: prefer using class time for problem-solving?

8.3.5.1 Student Preferences and Behaviours

Nearly one-third of respondents (30%) preferred the flipped classroom versus traditional lecture, with another 37% being unsure of their preference. One-third (33%) did not prefer flipped instruction. Ninety-three percentage (93%) of respondents reported watching the videos before the class for which they were assigned; however, they reported watching only 70% of the available videos. Therefore, the respondents seemed to demonstrate partial acceptance of responsibility for the self-directed portion of the flipped classroom. This was corroborated by 93% of the respondents also indicating that they primarily used the videos to learn new material versus review or reinforce it. When asked to compare the use of class time for problem-solving with the TAs present versus listening to a lecture, 59% preferred the former, as shown in Fig. 8.2. Thus, the students do recognise value in the flipped method of instruction. In comparison, Zappe et al. found lower student preference for active learning in the classroom, with 48% agreeing or strongly agreeing that they preferred problem-solving versus lecture during class time (Zappe et al. 2009).

8.3.5.2 Content Analysis of Benefits and Drawbacks

In an open-ended question in the evaluation survey, we asked the students what they liked about the flipped classroom and its benefits. The frequencies associated with the categories in our coding framework are shown in Table 8.5. The most frequently mentioned benefit as perceived by 46% of student respondents related to the conveniences available through video or online learning, including the ability to re-watch videos, self-pacing, flexibility, modularisation, and accommodation of one's own preferences. This was followed by the alternative, or reformed, use of class time, as mentioned by 26% of respondents; this category included in-class problem-solving, clicker questions, group work time, peer discussions, and instructor support. There were 19% of respondents who identified enhanced or deeper learning and 10% who identified benefits such as higher engagement,

Table 8.5 Summary of open-ended responses to benefits

Frequency	% of respondents	Category	Description
79	46	Video/online learning	Re-watch videos Work at one's own pace; pause video Flexibility, convenience, own preferences Modularisation of topics
45	26	Alternative use of class time	In-class active learning and problem-solving In-class support and questions In-class group time for projects Student interactivity and peer support
32	19	Enhanced learning or learning process	Better understanding; less confusion Enhanced earning/effectiveness/depth/ability Subject matter retention Multiple sources/resources for understanding Reinforcement and review Multiple attempts
24	14	Specific to course or course's videos	Videos concise or had a good pace Overall work time less Videos had relevant content (e.g. demo or examples) or were of high quality
17	10	Preparation, engagement, and professional behaviours	Engaged during class; paid attention; not bored Enjoyed class Arrived to class prepared Ability to learn on one's own; independence Drove motivation and accountability
11	6	No benefit or neutral result	No benefits perceived Did not like flipped instruction Videos not used Instructional differences not noticed

better preparation, and the promotion of professional behaviours. Both of these were welcome findings. These results were based on a content analysis of 172 student responses by a single coder, who was a junior engineering student. A second coder, who was the assessment analyst for the project, coded 35% of the responses, corresponding to 61 responses, to provide a measure of inter-rater reliability. The inter-rater reliability score based on Cohen's kappa was $\kappa = 0.73$, which suggests good agreement beyond chance (Norusis 2005).

In a second open-ended question, we asked the perceived drawbacks with the flipped classroom and suggestions for improvement to make the flipped experience better. The most frequently mentioned drawback or suggestion as shown in Table 8.6 involved feedback specific to the particular course or the videos for the course, such as "include more examples in the video" or "videos were too long". This was followed by suggestions regarding how time should be used during class

Table 8.6 Summary of open-ended responses to suggestions/drawbacks

Frequency	% of respondents	Category	Description
59	37	Specific to course or course's videos	Include more examples or problems in the videos Videos needed editing or bug/technical fixes Videos were too long Videos were not sufficiently described Videos were dry or boring Videos did not have an appropriate pace Videos repeated information Video material was too complex
41	26	In-class time	Increase time for active learning or problem-solving Increase effectiveness or relevancy of problems; grade them Provide appropriate amount of lecture or content review Have more instructor types during class to assist Synchronise class activity and video content
31	19	No drawbacks or neutral result	No drawbacks or suggestions
17	11	Load, burden, stressors	Insufficient time to complete out-of-class activities Increased work load Increased time burden Concerns over grades or impacts to the grade Accountability quizzes (including surprise)
16	10	Prepare, equip, and incentivise Students to flip	Prepare students for the flipped learning style Incentivise students, including video quizzes Clarify/emphasise expectations, including video watching Provide video "lecture" notes Ensure videos available in advance for students
16	10	Approach differently	Do not flip courses in general; use traditional teaching Do not flip this course in particular Provide students with a choice on flipping Flip only a portion of the class periods
7	4	Video/online learning	Students unable to ask questions during a video Instructor unable to sense student understanding in a video Distractors to viewing videos in a non-classroom setting Less motivation to attend class
4	3	Student learning	Lesser understanding or learning Difficulty learning from a video

(26%) and perceived burden or stressors, such as an increased time burden (11%). Ten percentage (10%) of respondents suggested that the instructor better prepare, equip, or incentivise students for the flipped method. We were encouraged to learn that very few respondents (3%) indicated decreased student learning, and only 10% recommended a different teaching approach in the course. These results were based on a content analysis of 160 student responses by a junior engineering student. A second coder, the assessment analyst for the project, coded 38% of the responses, corresponding to 61 responses, to provide a measure of inter-rater reliability. The inter-rater reliability score based on Cohen's kappa was $\kappa = 0.85$, which suggests strong agreement beyond chance (Norusis 2005).

8.3.5.3 Self-Reported Video Use

In the evaluation survey, we asked students to report the percentage of videos they watched; however, this percentage is based only on the segment of the population that responded (~49% of students). The average reported percentage was 70%, as shown in Table 8.7. Zappe et al. found a higher percentage, with 92% reported having watched each video in their flipped architectural engineering course (Zappe et al. 2009). The MEMS-0024 average was lower than the average percentage reported in other sophomores through senior flipped courses at Pitt (89%) during the fall 2013 through fall 2014 semesters. However, it was higher than the average percentage reported by our freshmen in a flipped programming course, using data only from those freshman sections in which video watching was emphasised. Based on an ANOVA and three post hoc tests (two of which did *not* assume equal variances), a significant difference was found between each of the groups in Table 8.7 (1, 2, and 3) ($p < 0.0005$). Thus, the MEMS-0024 mechanical design students were statistically different from other student groups in our school in terms of self-reported video access. They reported accessing more of the available videos compared to the freshman but not as many as other sophomores, juniors, and seniors in our school of engineering.

Based on Tables 8.2 and 8.7, it appears that the sophomores in MEMS-0024 did not utilize the videos to the extent hoped for. This was suspected during the first semester in which the course was flipped, and accountability quizzes were then implemented to encourage pre-class video watching. Compared to the self-reported data, the web analytics data indicated a lower average percentage of videos accessed by the students of 53%, as shown in Table 8.2.

Table 8.7 Self-reported percentage of videos watched

	Average (%)	Students
MEMS-0024 (Pitt)	70	192
Other flipped courses (Pitt—Sophomore to senior)	89	129
Other flipped courses (Pitt—Freshman)	45	95
Zappe et al. (Penn State)	92	77

8.4 Discussion

8.4.1 Comparison to Other Mechanical Engineering Courses

8.4.1.1 Direct Assessments

Our results that indicate a lack of significant change between pre-flipped and flipped performances are situated among other studies in the literature that show mixed results. At the University of North Dakota (UND), a series of undergraduate mechanical engineering courses was flipped (Cavalli et al. 2014). The flipped courses included introductory mechanical engineering design (similar to MEMS-0024), introductory mechanics, and numerical methods. In numerical methods, the traditional on-campus section had the highest achievement, with 82% earning a C or better. In the on-campus flipped section, however, 72% earned a C or better. In this course, there were hands-on programming exercises to solve engineering problems following lecture and discussion (Cavalli et al. 2014). However, at the University of Puerto Rico at Mayaguez, the results were different in an inverted statics course. On an end-of-course administration of the Concept Assessment Tool in Statics (CATS), students in the inverted sections scored statistically higher than students in the traditional sections ($p = 0.0076$). On a pre-course administration of the CATS, there was no statistical difference between the inverted and traditional sections ($p = 0.43$), suggesting an equal-footing start. Although not statistically significant, likely due in part to a small sample size, students in the inverted sections who took both the pre-course and end-of-course CATS had a higher average normalised gain of 17.5, versus 14.9 for the traditional sections. The instructor overall formed a "favorable impression" of the inverted method and planned to continue using it (Papadopoulos and Roman 2010).

8.4.2 Comparison to Other Mechanical Engineering Courses—Indirect Assessments

When surveyed, 54% of the UND on-campus learners preferred the flipped format (Cavalli et al. 2014). This was higher than our finding in MEMS-0024, with just 30% of respondents preferring the flipped format. A similar percentage to the UND percentage was found in an electronics instrumentation course taken by upper-level mechanical engineers at Rensselaer, in which 56% indicated a preference for online video lectures versus traditional lectures (Connor et al. 2014).

There was some dissatisfaction on the part of the UND on-campus learners that the instructor had not given "live" lectures (Cavalli et al. 2014). This was likewise noted by our MEMS-0024 instructor in a post-course interview after the first flipped semester. Based on this, he delivered a small amount of in-person lecture on SolidWorks during the second semester, and he planned to do more in the future, as the students were appreciative. UND also learned there must be "gate checks", or assessments to ensure that students arrive to class prepared (Cavalli et al. 2014). Our MEMS-0024 instructor also noted a lack of video preparation with some students during the first semester of flipping and began administering quizzes at the semester midpoint. In Rensselaer's electronics instrumentation course, only 19% of survey respondents used the videos in a preparatory fashion, with most students using them to study for tests or clarify concepts (Connor et al. 2014). Based on both the self-reported and the web analytics data, the students in MEMS-0024 did not access the videos to the extent desired as well.

8.5 Conclusions

The Swanson School of Engineering at the University of Pittsburgh officially began promoting the flipped classroom in the fall of 2013 across its multiple programs. A required second-year course in mechanical engineering design was one of the first to be flipped. Flipped instruction allows an instructor to implement more active learning in the classroom while still imparting necessary course content. With active learning in a flipped classroom, students apply and practice various concepts and skills initially presented outside of class, oftentimes by recorded video lectures. This promotes increased involvement in one's learning, better understanding and outcomes, and a richer experience, particularly with the higher-order skills in Bloom's taxonomy (Prince 2004; Chi 2009; Hake 2001).

Structured observation revealed a very well executed implementation of the flipped classroom in the laboratory portion of this course.

In short, the TAs were in nearly constant demand during class and provided individualized support to the students' interactive problem-solving efforts, which was a large contributor to the success of the implementation. In nearly all five-minute observation segments, the students were actively engaged with a SolidWorks design problem on the PC and assisting and communicating with one another or posing questions to the TAs. Our flipped class compared favourably to a recent observational study of other STEM classrooms in terms of in-class active learning and student–teacher interactions.

Although our direct assessment results did not show a statistical difference in the SolidWorks scores pre-flip to flip after controlling for GPA, the overall outcomes in this course were positive and encouraging. The instructor noted greater "sophistication" and proficiency among students in the flipped classroom in terms of their CAD usage, attributing this to expanded in-class software practice and support. The students also expressed greater confidence and interest in SolidWorks compared to previous semesters, which the instructor likewise attributed to more practice and support. Accounts of performance outcomes related to mechanical engineering courses flipped at other universities have shown mixed results to this point.

The students rated the classroom environment highest on the Personalization dimension of the CUCEI, which assesses student-to-teacher interaction. The average score of a 3.9 on the 5.0 scale aligns with the instructor's assessment that the heightened support provided during class contributed to the positive outcomes of greater sophistication and self-confidence with SolidWorks.

In summary, we would recommend the flipped instructional format for an introductory mechanical engineering course with a CAD component. In our implementation, the students worked on SolidWorks design problems during each two-hour laboratory session as the teaching assistants circulated and supported the students in their design efforts. The students greatly interacted with each other as well as the TAs, and class time was dedicated to the active practice and application of their SolidWorks skills.

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Chapter 9
Inclusive STEM: Closing the Learning Loop

Cindy O'Malley, Patricia McLaughlin and Pauline Porcaro

Abstract The importance of STEM (Science, Technology, Engineering and Mathematics) disciplines for the future economic and social well-being of all Australians cannot be underestimated: 75% of the fastest growing global occupations require STEM skills and knowledge (Becker and Park in J STEM Edu 12(6), 2011). Increased participation in STEM-related tertiary education is fundamental to the economic and social well-being of the individual and the nation, yet the number and capacity of STEM graduates Australia produced from tertiary institutions is inadequate (OECD in Over-qualified or under-skilled: A review of existing literature. OECD, Paris, 2011). Attracting and retaining STEM tertiary students will rely upon approaches to learning and teaching that engage, motivate and inspire more diverse cohorts. As the Australian Chief Scientist notes:

> STEM disciplines are critical engines of innovation and growth. The future of the Australian economy will be underpinned by the number and calibre of STEM graduates and the academic staff leading them. We are at present falling short: something different has to be done, demanding a paradigm shift (Office of the Chief Scientist, Australia, 2012).

This chapter discusses a recent initiative The RMIT Inclusive Teaching and Assessment Practices Project which was created to address the diverse needs of all learners across the university.

Keywords STEM · Inclusive teaching · Laboratory medicine

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9.1 Introduction

Like many other universities around the world, RMIT caters to an increasingly more diverse student cohort. This is evident in STEM disciplines at RMIT and provides new challenges and problems for both the University and the students. It is particularly problematic where more traditional, didactic, teacher centred, teaching styles have prevailed. Modern learners come with different degrees of abilities and the capacity to be successful at University requires different levels of support. The RMIT Inclusive Teaching and Assessment Practices Project was initiated with these students in mind, with the aim of providing a cohesive approach to learning and teaching practices that addressed the needs of all learners across the University irrespective of their background.

9.2 Inclusive Teaching

> Inclusive curriculum design recognises that students have multiple identities shaped by previous experiences and a diverse range of personal circumstances influencing how they study (http://reforma.fen.uchile.cl/Papers/Inclusive%20curriculum%20design%20in%20HD%20-Morgan.pdf, accessed 12 January 2015).

Funded by the Federal Government's 'Higher Education Participation and Partnerships Programme' (HEPPP), the Inclusive Teaching and Assessment Practices Project commenced at RMIT in 2012. Over two and a half years, the project team outlined the Principles of Inclusive Teaching, created a website housing a host of teaching resources and conducted a range of Professional Development workshops and activities for over 1800 staff including the 'Inclusive Teaching Conversation Series', where teaching staff had the opportunity to hear from experts who had trialled a range of innovative teaching approaches centred on engaging all learners.

> An inclusive teaching approach reflects the aim of all good teaching: to develop practice and assessment which is effective for all learners (http://www1.rmit.edu.au/browse;ID=epk6c4011qg11, accessed 12 January 2015).

Much has been written about the requirements of an inclusive approach to teaching (Devlin et al. 2012; Morgan and Houghton 2011); it is student centred rather than teacher centric; requires planning to ensure there is opportunity to draw from learners' life experiences; offers collaborative activities to assist students with grasping new concepts; relates to problems in the real world; builds critical thinking in our students rather than passive listening skills; and provides choices to suit all learning styles. It requires an explicit plan to make learning accessible to a diverse group of learners with a range of learning needs.

Vignette

…during the lecture we can ask questions, it builds up our critical thinking…how we engage with people, how we engage with our peers as well… Cindy wants us to think a lot so when we go to the exam we're not really scared… we already have that practice of thinking independently. Mary, Laboratory Medicine student.

Thomas and May (2010) refer to four main dimensions of diversity: educational, dispositional, circumstantial and cultural. These dimensions indicate the importance of diversifying learning design in order to be accessible to all students. The success of the twenty-first-century student requires new approaches to teaching that address these dimensions; approaches capable of engaging all learners whilst building lifelong skills that will serve students well into their future lives and careers.

The four dimensions (see Table 9.1), centred on a diverse student cohort, acted as the foundation to the RMIT Principles of Inclusive Teaching (2012). These principles are detailed below and set the groundwork for the STEM-flipped classroom project.

Table 9.1 RMIT Principles of Inclusive Teaching

RMIT Principles of Inclusive Teaching
Principle 1: Design intentional curriculum 'Intentional curriculum design is about anticipating and responding to the multitude of backgrounds, abilities, aspirations and ways of engaging that make up the diverse student cohort'
Principle 2: Offer flexible assessment and delivery 'Offering a range of assessment formats allows students to identify and work from their strengths and may reduce the need for educators to provide individualised assessment tasks. Flexible delivery gives students a range of methods from which they can optimise their learning styles and skills and manage time constraints and helps educators cater to a range of preferred learning styles and needs'
Principle 3: Build a community of learners 'When opportunities are given to students to build strong, positive relationships and a sense of belonging, they will feel valued, listened to, and respected. To be successful, all learners must feel safe in the learning environment, feel respected for the perspectives they bring, and feel confident they will succeed' (Ibid)
Principle 4: Teach explicitly 'An explicit approach to teaching recognises that learning in the tertiary domain is culturally based and multi-dimensional: from the initial transitions into Western academic literacies through to workplace and research skills. Understanding specialised language, concepts and the underpinning cultural values used across disciplines helps students to participate in unfamiliar environments'
Principle 5: Develop a 'feedback rich' environment 'A feedback rich environment fosters learner confidence and motivation, and promotes autonomy. It tells students how well they are doing, what they can do to improve, and affirms their ideas and efforts. For educators, providing constructive feedback to students shows us how effective our teaching is and where students require help'
Principle 6: Practise reflectively 'Reflective practice acknowledges that self-examination of our beliefs, attitudes and teaching practice helps us to recognise where potential for exclusion exists. Using this knowledge, we can implement strategies to ensure our practice is inclusive'

Adapted from http://mams.rmit.edu.au/awpaynuo8w3j.pdf

Fig. 9.1 Flipped classroom method alignment with inclusive teaching principles (RMIT University 2014)

These principles subsequently directed the approach to project activities, and the Inclusive Teaching Project Team soon turned their focus onto seeing them in action by offering 'practical advice on how to develop inclusive teaching pedagogies and trial new approaches to curriculum design, learning activities and assessment tasks' (Harley, J. and Nomikoudis, M. p. 9). The professional development series that resulted from the project included a substantial investment in introducing the flipped classroom methodology to teaching staff. The methodology was identified by the project team as one that aligned closely with the inclusive teaching philosophy and, indeed, the six key principles adopted by RMIT.

The following diagram (see Fig. 9.1) demonstrates the fusion of the RMIT Inclusive Teaching Principles with the flipped classroom methodology, outlining the alignment between the principles and the learning design in the flipped classroom case study described in the following STEM case study.

Vignette
Being able to go through the content before the lectorial gives you time to consolidate your knowledge. So for me I guess it really pushed me to be a more active learner by going through the content before the class. Sarah, Laboratory Medicine student.

9.3 Closing the Learning Loop

> Flipping the classroom establishes a framework that ensures students receive a personalised education tailored to their individual needs (Bergmann and Sams 2012).

The Haematology 2 class is an optional undergraduate course selected by third-year Laboratory Medicine students who wish to major in this discipline and is preparatory for them to venture into diagnostic laboratories for professional practice placement. It is co-taught to postgraduate students who additionally have a more detailed study programme, including tutorials with significantly more in-depth studies. The undergraduate students study two hours blood film morphology laboratory, two hours wet practical laboratory and a one-hour lecture per week. The postgraduate students attend all of these classes, plus they read two current journal articles and answer questions in preparation for a 2-h tutorial. The students within the course are from diverse backgrounds—racial, socioeconomic, cultural, and have followed different routes into higher education. The course is for 12 weeks, and this first iteration of the flipped classroom was conducted in semester 1, 2014.

The reasons for considering a change in teaching approach in this course were varied. Firstly, the modern laboratory is changing significantly with the introduction of technology and is very different to that of 30 years ago. This rate of change is only likely to accelerate, so to ensure that students are better prepared for laboratories of the next decade and beyond, there is a need to prepare them for an unknown laboratory environment. Thus, rote learning the content of the course is not sufficient for graduates, and they must have the ability to analyse, synthesise and integrate knowledge from various sources. Secondly, it is commonly stated by students that they studied long and hard for an examination, but that they did not achieve the mark commensurate with the effort expended. In many cases, this relates to their inability to articulate the complex issues: students understand the content, but cannot explain it sufficiently. Finally, a significant increase in student numbers led to a change in the timetable resulting in the lecture being held after the morphology practical laboratory. As each morphology session related to the lecture material, it was vital that the lecture material was provided online prior to morphology laboratory commencing.

To prepare the students for the change in delivery of the course to a "flipped" mode, all students were sent email messages explaining the reasons for the change in approach. Notices were also placed on the internal learning system (Blackboard) with links to a 60-sec YouTube video, explaining flipped classes.

The pre-class work for the students was the Lectopia recording of the previous year's lecture. Although not ideal, the students were able to access this recording prior to the morphology session. The lecture time was thus changed into a much more interactive session and was followed on the same day by the wet practical session in the laboratory. The major change to content and delivery in this first attempt at "flipping" was in the lecture time, which was termed a lectorial to better describe the change in format.

The initial plan for the lectorials was for students to discuss aspects of the lecture within their small groups to practice articulation of the concepts and validate their explanations to then share them with the entire class. This was followed by general discussion and questioning to elicit the most important points and ensure that they had understood the pre-class work. The students were then asked whether they needed further explanation of any topics and were given the opportunity to request up to 3 screencasts of short recorded lectures with PowerPoint slides on a small topic. These screencasts were then placed on Blackboard within 48 h of the lectorial. The final part of the session was spent going through a case study using the knowledge that they had gained and applying it in a real-world fashion to supply context to their learning. The case studies were in the same format as the final examination for the course. In the final weeks of semester, these case studies were changed to essay topics and the students discussed how to structure their answer to show analysis and synthesis of the material. This also served as preparation for the final examination.

Vignette

It directly relates to not only what we are going to learn in the lab but what we are going to get in the examinations…I feel it's a really good way to learn in the lectorials. Sarah, Laboratory Medicine student.

The learning loop was closed by students performing an online quiz as optional formative assessment which tested their knowledge and gave significant feedback on both correct and incorrect answers. This is a vital part of the process so that students could assess their understanding of each topic before moving onto the next.

Overall each of the lectorials produced some insights for future teaching. In the first lectorial, students were asked to bring three phrases or words from the prerecorded lecture to class. The lectorial was in a large lecture theatre with approximately 110 students, but students were asked to form small groups of 3–5 students and to discuss these three phrases/words and explain them to their peers. After five-minute discussion, they were then asked to volunteer this information to the class. They did not enjoy this at all. The class was too diverse for the students to feel comfortable doing this. Consequently, their responses were not spontaneous and enthusiastic.

For the second lectorial, the students were asked to arrange themselves into groups of 3–5 again and discuss amongst themselves three words or phrases that were important to one of the topics selected from the lecture. They then emailed these using their smart phones, and these words were copied and pasted into a word cloud. Once all three topics had been discussed in groups and emailed, the first word cloud was available and the students again worked in their groups and were asked to discuss one of the words therein. After three-minute discussion time, the students were asked to volunteer their thoughts on one of the words/

phrases in the word cloud. The responses and classroom culture were phenomenally different to the first week. The students were now very keen to volunteer the information, and there were some very lively discussions around the topics. The word clouds were also posted on Blackboard as a study/revision aid. Attendance at lectorials was much improved compared to previous semesters, partly due to the compulsory morphology laboratory now being immediately prior to the lecture and partly due to the increased participation and engagement in the lectorial.

Over the remainder of the semester, the students requested screencasts on 20 additional topics which were prepared using Camtasia and were uploaded to Blackboard within 48 h of the lectorial. The maximum length was 16 min, but the majority were less than 10 min. These were well received by the students, and students felt that these significantly enhanced their learning. The next section examines the outcomes from the class.

9.4 Outcomes

The results of students' examinations (see Fig. 9.2) indicate that the undergraduate students achieved slightly better examination marks than previous cohorts. The mean mark for undergraduates was 52.4% compared to 45.5% in 2013. In the examination results for this course, 56% students passed the examination compared to 44% in 2013. The histogram below shows that the student marks in previous iterations were somewhat bimodal and in this iteration followed a more Gaussian distribution. From this very small study, the students who appear to have most benefited from this delivery style are those who in previous iterations, significantly failed the examination (<40%).

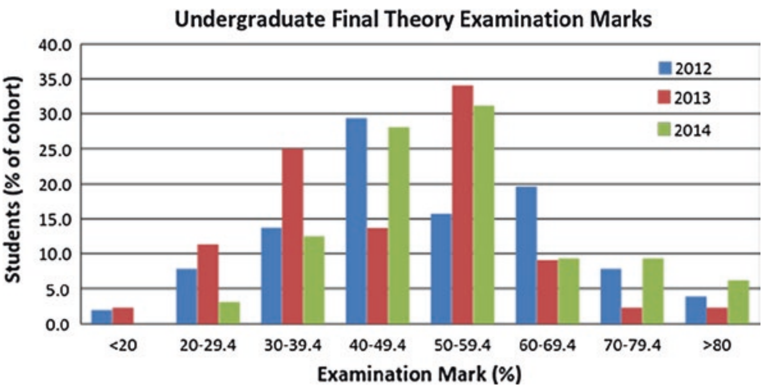

Fig. 9.2 Final theory examination marks for haematology 2 in 2012 and 2013 using a traditional approach and those in 2014 with a 'flipped classroom' delivery

Vignette
My mark has bumped up…Flipping the classroom has been a big challenge for me but overall it has benefitted me the most. Laboratory Medicine student.

Comparisons of final marks for the course are not possible due to changes in assessment practice over this time period. The postgraduate student final examination processes have also changed over this period and cannot be compared.

The personal experience of flipping the classroom provided a very rewarding experience for the lecturer. The lectorials were much more dynamic, engaging and enjoyable. This was also reported by students. However, there will always be some students who do not want to engage with this more active learning strategy—this was particularly true for the postgraduate students who had successfully studied for a degree using the traditional method and had no idea why there was a need for change!

9.5 Future Improvements

Flipping classes in this STEM course highlighted a range of issues. To encourage more students (see Fig. 9.3) to engage in the pre-class activity, it is important to discuss the reasons for the changed delivery style. This should be included in the pre-class activities for the first week. It is also important not to overwhelm the students with too much work. Modern students have a range of commitments beyond the classroom and need to be carefully considered by academic staff. It is important to limit the amount of pre-class work, explain how much it will be and then make sure these preset rules are maintained.

Fig. 9.3 Learning loop in the flipped classroom

The purpose of the pre-class activities is to provide the knowledge and comprehension in an engaging manner to facilitate the students learning. The majority of the pre-class activities for haematology studies require preparation in-house—whilst there are many sources of freely available lectures, these do not include many on the very specific discipline of haematology. However, there are a few YouTube videos that can be used and occasional articles of celebrities with haematological disease that can be utilised as a hook to engage the students and demonstrate the relevance of such information. Before the next iteration, smaller screencasts for the students' pre-class activities could be prepared and these could include some active learning in addition to the passive learning from a recorded lecture. The screencasts could be shorter—10 min of 'soundbites' and a maximum of ~40 min of pre-class activity. It is important to have 5 multi-choice questions (via Blackboard) answered by students prior to coming to class. The answers may not be in the lecture notes, but will be mentioned and flagged as such in the pre-class activities. This will hopefully encourage (and will enable monitoring of) the number of students who engage in the pre-class activities. A study by Weinstein and Wu (2009) showed that weekly pre-class quizzes were an acceptable way of encouraging students to perform the pre-class activities but that a few open-ended questions (Readiness Assessment Tests) that require marking prior to class were a better way of providing some external motivation for the students to complete the work. The various learning management systems, such as Blackboard, may have adaptive release features where further learning material may be released only after they have successfully answered a quiz on the previous material. This can be used when the material is hierarchical—the students must fully understand the first part before being allowed to pass on to the second tier activity. Peer pressure is a great motivator for students to perform the pre-class activity—ensure that for at least part of the face-to-face time they are engaged in group work—their peers will not allow them a free ride!

The purpose of the in-class activities is to facilitate the students' understanding of the topics and to enable them to apply, analyse and synthesise the information that they learned in the pre-class activities.

The effectiveness of the 'word cloud' was clearly demonstrated by this cohort of students. They presumably felt much more ownership of the word cloud and thus felt much more at ease talking about it in the class, and this formed the basis of much very relevant discussion. Anonymous polling using smart phones is a great way to ask quiz questions in class and determine how many of the students have understood or can apply the information. If the majority of students do not have access to mobile technology, then they could hold up a piece of paper with A, B, C or D written on it!

If a significant proportion of the students have the answer confused, then a two-minute lecture on the topic may be an appropriate response. Mind mapping or concept mapping is a useful tool within the class time—it helps the students to draw the links between the different aspects of a topic and facilitates deeper learning. Case studies or problem-based learning is common approaches taken in the classroom and teaches the students how to apply their knowledge and thus stimulate a deeper understanding of the topics. Learning to articulate answers to questions is a vital part of this approach to learning so small group work, and then, sharing with the wider class is very important for the development of their ability to articulate complex concepts and furthermore to answer the examination questions. Finally, some reflection on the reasons for the students to engage with this learning is important to facilitate their own understanding of their learning (metacognition) and thus allow better connection between content and learning objectives. Once the class activities are finalised, it is important for the student to '*Close the Learning Loop*' by directed screencasts and then self-assessment quizzes.

Vignette
…learning the material beforehand, going to the lectorial and listening to the screencasts, plus the practicals, gives you four opportunities to cover the content and the more ways different ways, the more the comprehension. Sarah, Laboratory Medicine student.

This lets the student know that they have understood the topic and can move on to the next one. If a student finds some areas of knowledge that are missing, then this gives them the opportunity to address this before moving on to the next topic.

9.6 Conclusion

One final word on flipping the classroom—it is a lot more work for the academic! Flipping the classroom encourages the students to do some study prior to class (and many of mine do not appear to routinely do any work outside of the classes until exam time) and so they feel that they are also doing more work. Flipping the classroom leaves the academic in control to direct the discussions and topics; however, the class is much more student-focussed and this is the great benefit. The students see value in the face-to-face time and are much more engaged with the material.

Vignette
I think the flipped classroom has really encouraged me to do a lot more reading and learning prior to coming to class, otherwise there is no point in coming to the lectorial if you haven't done any work before…When I compare to last year when we had pre-reading to do, to be honest, I didn't always do it, so I would go to the lecture not really knowing anything. Neha, Laboratory Medicine student.

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Chapter 10
Flipping on a Shoestring: A Case Study of Engineering Mechanics at the University of Technology Sydney

Anne Gardner

Abstract University-wide decisions are rarely made from purely pedagogical motivations so it was that the institutional pressure to use a flipped learning environment was driven by the objective of reducing face-to-face teaching time. In response to this pressure, I started flipping part of a first year civil engineering subject in the spring semester (September, October and November) of 2013. I have subsequently flipped this subject for both semesters in 2014. Since this subject, Engineering Mechanics, traditionally has a high failure rate, I saw it as an appropriate subject to trial a new approach so that I could comment on the institutional initiative from a position informed by personal experience. A flipped learning environment also appeared to align with the collaborative learning framework developed progressively over several years by Dr. Keith Willey and myself (see Fig. 10.1), and this guided the overall subject design. This chapter is an explanation of how I use the collaborative learning framework to support a flipped learning environment.

Keywords First year university · Civil engineering · Engineering mechanics

10.1 Introduction

The development of the collaborative learning framework (Willey and Gardner 2012) was influenced by cycles of change and observation in our classrooms and also by the findings of a research project we participated in which focussed on identifying learning rich practices that arose within professional engineering work. In describing the collaborative framework (see Fig. 10.1) to students, I foreground the practices that students will participate in, and how these practices relate to those they will engage in at work (Rooney et al. 2014, p. 277). For example what

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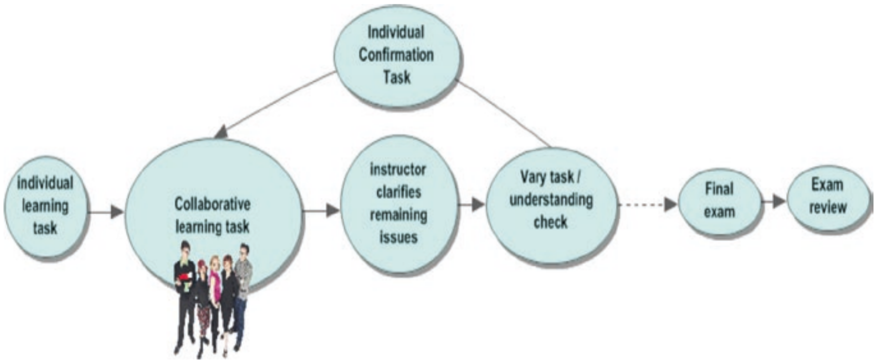

Fig. 10.1 Collaborative learning framework (© 2012 IEEE. Reprinted, with permission, from 2012 Frontiers in Education Conference, 4–6 October, Seattle, USA.)

follows are two vignettes from focus groups conducted with experienced engineers who work in the construction sector and I draw your attention to the order of individual and collaborative tasks (Fig. 10.1):

Vignette 1

Anthony (estimator): Reading drawings and reading contracts and specifications, you have to do by yourself. In my opinion, you have to be able to sit there quietly and not talk to people. You just need to focus. But then after you do that individual thing, then we compare notes on what we've gleaned out of that.

Gordon (operations manager): Usually a tender comes in and everybody that's working on it will get a set of documents. They'll all read it, go off read it and come together and work together, do a workshop…

Anthony (estimator): Well we call them reviews. We have a series of briefings and reviews and it depends on the project how many we have. But the first one will be a few days after we get the document. We'll get together and talk about what's involved in the job, what are the things we need to address.

Vignette 2

Anthony (estimator): So one of the engineers has looked at this and studied the plan and said okay well we need to know exactly where this pipe is. So let's send a surveyor out. So they've rung a surveyor and said go out and

> take a location of this pipe. That's the first step. Then from that, the problem starts, the problem presents itself by knowing exactly where the pipe is.
>
> Konrad (project engineer): That's right. So a few hundred millimetres out can create a big difference.
>
> Anthony (estimator): Then you start looking on the internet saying gees what can we do with this or you ring up a jet-grouting company and say meet me out on site and come and tell us what you can do? Or you might call a consultant and get the consultant out, a design consultant, and say can you come up with a solution for this? So you just go through this process of trying to find expertise or find someone who's done it before…
>
> Arthur (design manager): Or there might be members of the team that have done it somewhere else and they say we did it here and it worked—it was quicker, it saved us time, that sort of stuff… Someone else goes, I did that and everybody chips in.

In both cases, there is individual work first followed by collaborative work including sourcing input from a specialist (a surveyor) and more generally '*looking on the internet*'. This order is followed in the collaborative learning framework with individual work undertaken before class and the face-to-face 'lecture' session consisting of discussion and collaborative problem-solving activities. The collaborative problem-solving activities allow students to develop language skills related to the concepts in the subject by having to explain their ideas to their group members and having to listen to their group members' explanations as well. This content specific dialogue reinforces what they do know and allows them to identify what they don't know yet.

The collaborative learning framework then includes a step where variation is applied to the original problems that students were collaboratively working on. Marton and Booth (1997) identified variation in critical features of a problem as a way of facilitating learning. They found that exposure to differences prompts a reappraisal of existing knowledge, or ways of thinking, in combination with other learners. In practice, this means that when a group completes the in-class problem, the instructor says 'Now what if I do this'? and varies one or more of the critical parameters of the problem. This perspective also aligns with what the experienced construction engineers told us about the way they learn at work:

> Vignette 3
>
> …it's all sort of intertwined in together because there's no project that's always the same. I mean I think if you've built a bridge here, doesn't mean you'll do it exactly the same way in another place. You might have different factors. It's just having to find the possible factors that might, if you need to do night works, shutdowns, they've revolve around what

> you will have to do. So even though if we estimate or bid something on a project, when you get to deliver it, you might – I mean you're talking towards the same goal, same structure, but how you get there might not be always the same either. So I guess there's a bit of problem solving…
>
> (*Konrad—project engineer*)

After variation, there is 'confirmation' task. This is an individual task and, as the name suggests, its' purpose is to confirm what each individual has learnt and has not yet learnt as a result of the collaborative problem-solving process. The need for this task arose from observing groups in class all agreeing that yes they understood the concepts that underpinned the solution, but then not being able to individually solve a similar problem in a summative task. Having a short formative confirmation task allows students to assess how much they individually still need to learn about that topic before they have a summative task. Confirmation tasks can become collaborative tasks by for example running an individual formative quiz and immediately after asking students to complete the same questions in small groups.

10.2 Changing Expectations and Practices

The context of a first year subject means that I have students who have not experienced flipped learning before and many have not changed their approach to learning from their school experience. This means that they are not expecting to have to do some learning independently and take responsibility for this learning. Changing these expectations and resulting practices requires strong scaffolding on my part. My ability to scaffold the learning both inside and outside class has improved with each semester's implementation and I strongly recommend that instructors think about how they are going to scaffold the learning activities for their students as this can significantly impact on student engagement with the activities. By scaffolding I mean I take the time to explain to students why I designed the activity the way I did, what learning opportunities the activity provides them, how students can make judgements about their learning from the activity and how it will enable them to see their world differently (e.g. they will be mentally following load paths whenever they look at a new structure).

Part of this scaffolding process is being able to demonstrate how the design of the subject allows them multiple opportunities to practice the types of skills that they will be expected to demonstrate in the final individual summative task, the final exam. Scaffolding also includes articulating how the subject design aligns with the practices that students will be expected to participate in at work. Making these explicit links has helped the students see the value in learning this way. My scaffolding also includes showing students comments that previous students have made in relation to the flipped learning environment. Two extracts that I regularly use are:

Vignette 4

Engineering mechanics is not a subject that can have 'lectures' in the true sense, a more interactive approach is certainly necessary and I believe Anne has structured the subject well. The concepts aren't overly confusing (yet!), it is more about mastering the problems and calculations which is how the course is directed. I believe that students who don't engage in self-directed learning will struggle immensely in this course as the onus is certainly on the student to ensure they are mastering the material. This is not a bad thing; they need to be weeded out, I get sick of hearing them whinging, nobody is forcing them to do this course!

And:

Vignette 5

I don't agree with Anne Gardner's 'teaching' methods. She posts the slides up prior to the lecture for us to study, so that when we are in the lecture she doesn't teach us - instead she sits back and feeds us questions without covering any content. For someone who lives in the city and doesn't have to work then this is fine, however I live 2 hours away and have a job as well, and find this method of teaching to be lazy on her part and very difficult for me to manage with my current time constraints. It is making me consider withdrawing so I can allocate it to a semester where I feel I will have more time to teach myself the content, the way she seems to want us to.

These comments bring attention to several aspects of the flipped environment that are different to the traditional lecture format. By directly addressing these issues (expectations of students taking responsibility for their learning, allocating time for individual preparation, changing the thinking that learning is 'covering the content') head-on in my second and third semesters of flipped learning I believe I have diffused much of the resentment and negative energy in the classroom that comes from making a change in expectations. Part of this comes from validating the concerns raised in both of the student comments and the course of action proposed by the second student: '*…making me consider withdrawing so I can allocate it to a semester where I feel I will have more time…*'. I acknowledge that students have many and varied time commitments, for example primary care of dependents (which could be children or parents) as well as working to support themselves. The student response above then appears to be a mature and sensible course of action and I recommend that if current students are not able to re-arrange their time commitments to allow them to take the time to prepare for class, that they also seriously consider the option of withdrawing from the subject for that semester.

10.3 Learning Activities

Let's look in more detail at the learning activities I use:

10.3.1 Pre-lecture Preparation

There are several textbooks available about Engineering Mechanics as it is a typical first year engineering subject. I specify one of the available texts and students are directed to read specific sections each week before watching the week's videos (15–20 min long). Each week two types of videos were posted. The first type was basically narrated PowerPoint slides and/or visuals (see example in Fig. 10.2) explaining that week's content, and the second type showed the instructor's process in solving example questions in a 'think aloud' way (Litzinger et al. 2010). Students can download pdfs of the slides and the worked examples. They are then expected to attempt 3 or 4 (depending on that week's topic) questions in the software SPARK^{PLUS} (http://spark.uts.edu.au) which directly relate to that week's material and are set at a level for someone just learning the material. Our learning management system Blackboard (see link in reference list) records which students look at the material and SPARK^{PLUS} records all student responses. However, there are no marks attached to these questions, and they are meant to be for students to self-assess if they have understood what they read and watched and to identify what questions they might want to ask me in the 'lecture' session, or their tutor in the tutorial. These questions are typically multiple choice and/or short answer response. SPARK^{PLUS} allows me to set a multiple choice question and then ask students to justify why they think that is the correct answer or to outline their solution strategy. It also aggregates all the individual responses to each question for ease of presentation of the overall class results.

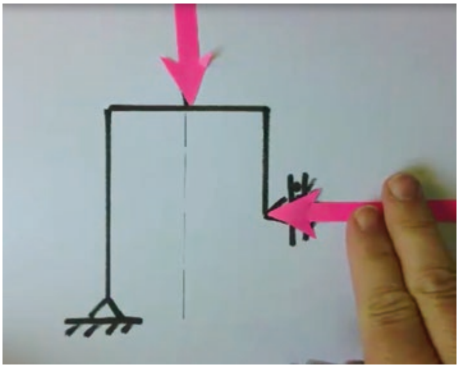

Fig. 10.2 Example of visualisation in video on three force bodies

10.3.2 In-Class Activities

Each 'lecture' session typically begins with me displaying the aggregated results for each question in SPARK^{PLUS} to determine if we (the class) need to spend some time clarifying any topics. This is determined from the histogram of class results and student responses explaining their answers. For example, Fig. 10.3a shows the aggregated student responses to a question where most students gave the correct answer so I spent much less time in class discussing this topic than for the topic related to the question in Fig. 10.3b where the histogram indicated that a significant number of students did not arrive at the correct answer. This discussion includes why the incorrect responses are incorrect as well as why the correct response is correct. Student explanations of their answers are a useful way for me to discover any misconceptions which can then be directly addressed at the start of the class.

Once the pre-lecture concepts are clarified we start work solving problems that I have specifically selected to increase in complexity. Students work on these collaboratively in small groups of 3–5, just with the students around them in the lecture room. During this time I work my way around the classroom listening to the dialogue, asking questions to help groups that may be 'stuck' and identifying what the most common misconceptions are so that I can address these if I judge I need to. This is a dynamic feedback environment between students and between students and myself where I walk the tightrope of not providing closure so early that students don't think for themselves, but if some students are not making headway, not leaving it so long that they are frustrated. This process has been facilitated by holding the class in a terraced lecture space where each level accommodates two rows of tables and chairs on wheels allow students in the front row of each terrace

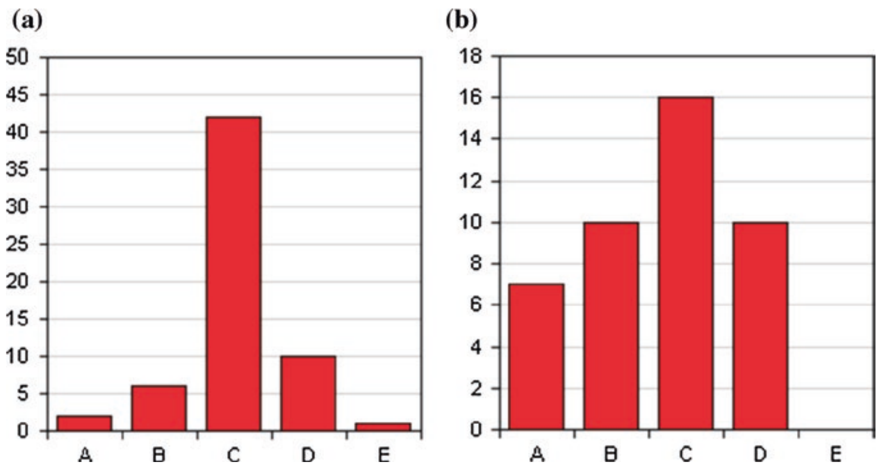

Fig. 10.3 Example histograms of aggregated student responses in SPARK^{PLUs}

to turn around and talk with students in the row behind them. The room layout also allows me to walk between each row to reach every student in the class.

Figure 10.3a indicates that most students have answered this question correctly, so I don't need to spend much class time on this concept while Fig. 10.3b indicates that a significant number of students did not answer this question correctly, so I need to spend class time clarifying this concept.

After an appropriate time (which differs with each question and topic) I ask a group to share their answer—sometimes I ask them to demonstrate their solution on the document camera for the rest of the class. Other activities involve each group of students working with a different value for a specific variable (for example span along a beam) and each group's results are then aggregated to show the value/s along the whole structure.

Towards the end of each topic in the subject, students complete a formative quiz in class. They complete the quiz individually first and hand in their paper then complete the same quiz in groups of four using IF-AT scratch cards (http://www.epsteineducation.com/home/about) or the multiple attempt/multiple choice mode in SPARK^{PLUS} which requires them to reach consensus on the answer within the group before they respond. If they have not indicated the correct answer on their first attempt, they can re-work the question identifying their mistakes, until they get the correct answer.

A feature of the summative assessment in this subject is the use of a threshold exam in week 13 of the 14 week semester. This exam consists of 'pass' or threshold level questions across the whole syllabus and if a student scores 75% on this exam they earn 50% of the exam component of the overall subject result. This means that if a student is satisfied with a pass in the subject, they can achieve this in the threshold exam and not sit for the final exam which is held in the standard examination period. Students who are aiming for a higher grade attempt the final exam to earn additional marks. Students who did not score 75% on the threshold exam are required to sit for the final exam and earn at least 50% in this exam to pass the subject. This exam typically consists of more complex questions than the threshold exam or questions which require the integration of two or more topics to develop a solution.

10.4 Evaluation

Figure 10.4 shows the percentage of students in the class who achieved each overall subject grade. Although the subject is run in both Autumn and Spring semesters, I have included only the Spring semester results because the student cohort in Autumn is quite different to Spring. The typical recent school leaver would undertake this subject in Spring, whereas the Autumn semester cohort comprises students from the mid-year intake and students with advanced standing so the variation in confidence and enabling skills is much greater than the Spring cohort. Also I had a sabbatical in Autumn 2013 so I don't have the data

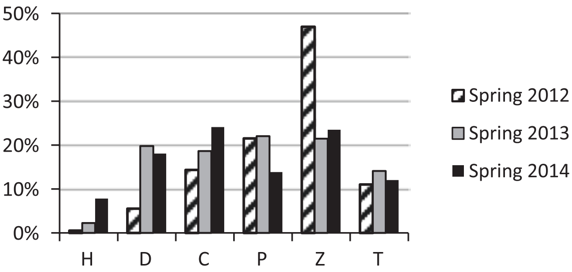

Fig. 10.4 Overall subject results for Spring 2012, 2013 and 2014—H: marks > 84%, D: 74% > marks = 84%, C: 64% > marks = 74%, P: > 49% marks = 64%, Z: marks < 50%, T: offered supplementary exam: 45% < marks > 50%

from that semester. In Spring 2012, the class was delivered in a traditional lecture-based format with 2 × 2 h lectures and a 2 h tutorial each week. The assessment consisted of Assignments: 20%, Class Quizzes: 20% and Final exam: 60%. Compared to Spring 2012, for Spring 2013 (the first flipped semester), there was a significant reduction in the percentage of students at the outright fail grade (Z) and a corresponding increase in the percentage of students achieving at the D and C grades with slightly more students qualifying for the supplementary exam (T). Interestingly there was no change in the percentage of pass level students.

Spring 2013 was the first semester that I tried the flipped learning environment for the statics content of the syllabus and changed the assessment to Assignments: 40%, Class Quizzes: 0%, 2-stage Final exam: 60% (described earlier), but retained the 2 × 2 h lectures and a 2 h tutorial each week. For Spring 2014, the whole syllabus was flipped, the assessment schedule remained the same as for Spring 2013, but the face-to-face time was reduced to 1 × 2 h lecture and a 2 h tutorial each week. Subject results have become increasingly bimodal, i.e. students who pass tend to pass well and there are fewer students who 'just' get over the pass mark of 50%—see Fig. 10.4. I regard this as a positive result as a strong understanding of the concepts in engineering mechanics is required to understand the material in the following subject Mechanics of Solids.

However, as with all comparisons of subject results, the results in Fig. 10.4 must be interpreted in light of additional information affecting students in these cohorts. In this case, the flipped learning environment was introduced along with a changed assessment regime. Another factor that may be influencing these results is that the mark (ATAR) required to gain entry to this degree program has been increasing over the last few years. Hence, I would not claim that the flipped learning environment is the only factor affecting the change in subject results, but it would have a significant contribution to the changes.

Of more value in understanding how students respond to the change in the learning environment are the questionnaires used as part of an evaluation of this process (Gardner et al. 2014; Willey and Gardner 2014). Students in 2014 were asked to respond to a questionnaire exploring their perceptions. Most students 'agreed' that they liked flipped instruction compared to the traditional lecture format (64%). Most also 'agreed' that flipped instruction had a positive impact on their learning experience (71%). The results suggest that some students who didn't necessarily ‘like’ flipped instruction admitted that it had a positive impact on their learning. Feeding this result in particular back to students in later semesters helps to reinforce that my main objective is to design opportunities for them to learn the subject material. It also gave me some evidence that my explanations of why I had designed the learning activities this way and how they could assess their own learning through these activities had been understood by at least some members of the class.

The reasons students responded favourably to flipped instruction were mainly because it prompted them to work more consistently, provided ongoing evaluation of their learning, provided opportunities to receive help in class and the flexibility to engage with material in their own time:

> …I liked it because more time was spent on questions during lecture time.

> …it encourages students to be organised and pro-active with learning, plus provides an opportunity to have questions answered during the learning process, as opposed to it happening at a later stage.

Students also liked flipped instruction because the process helped them learn the subject material:

> I like the fact that we could first get an idea of what we were go *ing to learn with worked examples through the video and then the lecture could be dedicated to more in depth questions we would have trouble with in exams.*

Students also liked the motivating effect of the flipped learning environment:

> … it encourages students to be organised and pro-active with learning, plus provides an opportunity to have questions answered during the learning process, as opposed to it happening at a later stage….

Students commented that the online resources were useful for students who could not attend every face-to-face session, or for whom English is not their native language:

> It’s quite good for the students whose English is not good like me. I can rewind the video when I don’t understand something, but I can’t rewind the class time.

Most students think it is reasonable to expect them to prepare before class because it helps them learn the material, even material that has not yet been discussed in class:

> I used those videos to prepare, and that worked.

However, 30% of these students thought it was unreasonable to expect students to engage with material out of class that had not yet been covered in class. Their reasons included:

- wanting direct instruction:

> I think that the flipped instruction model is not as preferable as the traditional approach. I believe online videos are a fantastic idea for revision purposes and are extremely helpful when going over already covered material. I do not however believe they should entirely replace the approach of introducing new material in the live lectures, but should serve as additional resources.

- associated stress and motivation for formative activities:

  > It created stress, with the deadlines of other subject's assessments approaching, my priorities were securing marks in those subjects, rather than preparing for class with no marks attached. In the early weeks of the semester it was a lot easier to maintain a good preparation for class then it was later on with the realities of full time study and numerous deadlines.

- not having enough time:

  > This is unreasonable because when I sit down to teach myself a new topic, it takes a lot of time whereas if I'm doing homework or something like that I can do it in shorter time periods. Out of class I have limited free time and never a long enough time to teach myself entire new topics. That's what the three hour lectures are meant to be for.

Students reported that compared to the more traditional lecture approach flipped instruction had made them take more responsibility for their own learning, even if they don't like that outcome. Typical comments included:

> Since this model (flipped instruction) has made it easier to fall behind, yes, a much greater responsibility exists for individual learning…because you know you will get the most out of the content if you study it before class. The approach forces you to be more organised as well.

One student reported that passing more responsibility on to students for their own learning made them '*feel like the uni is being lazy*'.

Although the overall indications from the surveys indicates a positive response to flipped learning, some students made strong negative comments demonstrating how the flipped environment did not meet their expectations of how learning should be organised. These attitudes are in line with findings from other researchers in engineering education such as Bishop and Verleger (2013) who reviewed twenty-four studies of flipped learning and found that: '*Opinions tended to be positive, but there were invariably a few students who strongly disliked the change*' (p. 9). These comments have recurring references to 'paying' to being 'taught' in lectures despite the literature finding that lectures are not effective for learning (Lord 1994; Prince 2004; Mazzolini and Daniel 2014). This is where strong instructor scaffolding of the learning design is needed. Effectively dealing with student expectations about what we should be doing and what they should be doing is one of the potential obstacles to successful implementations of a flipped learning environment. However, each semester I have become better at articulating why the subject has been designed this way and how I expect students to benefit from participation, and this has reduced the objections. I acknowledge that it may take some time to effectively change this aspect of student culture, but I remain optimistic that most students will appreciate the learning benefits once they have had experience of a flipped environment.

Increasing student engagement with the pre-class resources is an issue mentioned by other researchers (Amresh et al. 2013). Some of our students suggest we '*attach some sort of mark to it*'. Bishop and Verleger (2013) report that many instructors have a marked quiz on the pre-class material which '*was touted as a highly successful practice*' (p. 9). Everett et al. (2014) report that in their study the main motivation for students to engage with the provided resources was to accumulate these quiz marks and that student preparation was often limited '*to the amount necessary to complete the online quiz*' (p. 5), i.e. students may have been complying with the requirements to get marks, but they weren't necessarily learning the material in any depth. Figure 10.5 shows the number of students who activated the online learning resources relating to drawing free body diagrams (an important but problematic topic in this subject) for the Spring 2013 semester. The blue line in this diagram shows the number of students enrolled in the subject, and this shows that some students had looked at the online resources more than once. While clicking on a file in Blackboard does not necessarily mean that they learnt the material, the number of students that at least opened the online files is an indicator that learning may be happening. The first Monday listed in Fig. 10.5 and the Friday are days when lecture sessions were held so students were motivated to access the material just before the lecture. The peak on the second Monday in Fig. 10.5 shows that having a quiz on that material (even though there were no marks attached) again motivated students to access the material. It is also interesting to see that some students continued to access that week's resources throughout the rest of the semester. This reinforces my view that marks do not have to be attached to an activity for students to participate and that the nature of the participation in this situation is not driven by just wanting to get the marks rather than actually learn the material. There were still some students who did not access the online resources at all, but my attitude is that it is their responsibility to prepare for lecture sessions. I also note that not all students attend the final exam, so if we

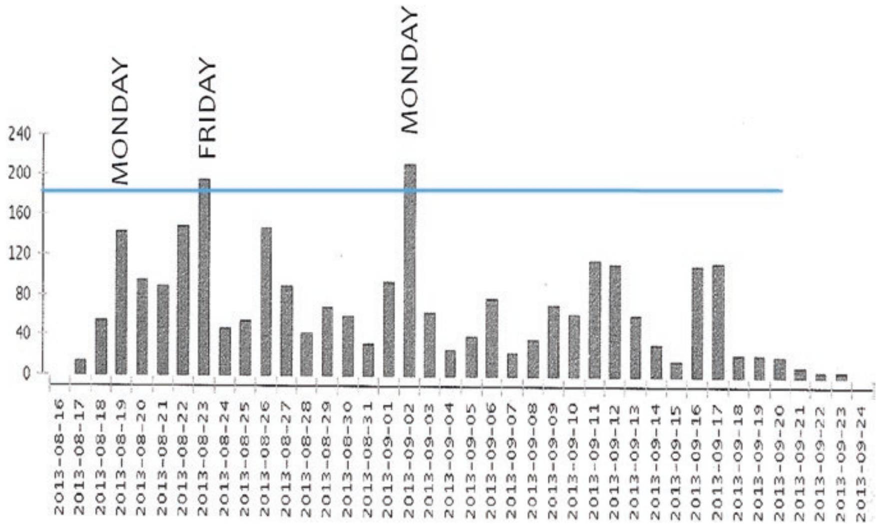

Fig. 10.5 Number of students accessing online resources for one topic in the subject. The *blue line* indicates the number of students enrolled. Monday 19th and Friday 23rd were lecture sessions, and a quiz was held on that topic on Monday 2nd

can't get full participation for a high-stakes summative task, why make that the benchmark for any other activity in the subject?

Since introducing flipped learning in Engineering Mechanics two colleagues in the civil program have introduced an element of flipped learning in their second and third year subjects. Presentations of various aspects of my implementation have taken place at meetings of the institution-wide Flipped Learning Action Group and I have participated in Learning and Teaching workshops for other faculties such as Law and Business.

My satisfaction with my teaching has increased since introducing flipped learning as I spend less time talking 'at' students and more time talking 'with' students about concepts related to the subject, i.e. about what I'm interested in. However, to generate the most benefit from flipped learning, I have found that I need as least as much face-to-face time as with traditional lectures, so that students have the time they need to collaboratively solve the in-class problems.

10.5 Conclusion

A flipped learning environment is not just about changing the way that information is transmitted, but should be seen as an opportunity to use class time for participative learning opportunities, and this is where the real learning benefits are generated. Given the different experience of students, both within a particular subject and between subjects at different stages of their degree, we need to provide scaffolding to assist students to understand how to make the most of these learning opportunities, including how to approach them, evaluate their learning and develop their judgement and the required skills to learn in this new way. Evaluation of this flipped learning environment has highlighted specific aspects of flipping that we need to scaffold for undergraduates such as the time involved in learning for university level subjects that active learning in class is more effective than passively sitting in lectures, but that this requires some preparation on their part for which they are responsible because we are trying to facilitate the development of the skills they will need to keep learning as they enter professional practice. For my part, the experience of using a flipped learning environment means that I can't see myself reverting to using traditional lectures in any future class.

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Chapter 11
Design, Deployment and Evaluation of a Flipped Learning First-Year Engineering Course

Abelardo Pardo and Negin Mirriahi

Abstract This chapter focuses on the design of a flipped learning experience and, in particular, focuses on the types of activities and their scheduling. The problem can be described as how to stratify the type of activities and how they are distributed in time such that students are provided a gradual and engaging approach to achieve the learning outcomes. The flipped learning design model described in this section has been deployed in a first-year engineering course on computer systems at a higher education institution. In the remainder of the chapter, we assume that students with respect to a topic need to traverse the levels of the revised Bloom's taxonomy starting with acquiring basic knowledge about a concept and then making a transition to the point where they can evaluate or create artefacts within that area.

Keywords Flipped learning · Learning analytics · Engineering education · Educational technology · Analytics

11.1 Introduction

Flipping the 'homework versus lecture equation' provides an opportunity for students to engage in socio-constructivist activities in class by becoming familiar with the course content prior to the class time (Houston and Lin 2012). In engineering education, the context in which the case study reported in this chapter is situated, and the need for active learning techniques is even more pronounced (Freeman et al. 2014; Wieman 2014). But embracing flipped learning is rigged with challenges. How can activities be reorganized to make the most of students'

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time in class but also engage them with necessary activities outside of class? How should students divide their effort? How could a conventional course be redesigned to better support students' achievement of the intended learning outcomes?

This chapter showcases a concrete example of how a large first-year engineering course on computer systems has been redesigned as a flipped learning experience overcoming some of the mentioned challenges. A division of activities based on their cognitive load, and their scheduling into stages were conceived to promote a gradual exposure of students to concepts in increasing level of difficulty to scaffold their learning. A set of assessment instruments alongside the activities was deployed to provide students with an opportunity to demonstrate their achievement of the learning outcomes and support their sustained engagement with the course material. Hence, formative and summative assessments were interspersed throughout the course to maximize the preparedness of students. The rest of the chapter describes the main aspects of the flipped learning redesign and how it has been evaluated. An evaluation of the course is included in Sect. 11.4. The chapter finishes with a set of conclusions and an outline of next steps.

This chapter focuses on the design of a flipped learning experience and, in particular, focuses on the types of activities and their scheduling. The problem can be described as how to stratify the type of activities and how they are distributed in time such that students are provided a gradual and engaging approach to achieve the learning outcomes. In the remainder of the chapter, we assume that students with respect to a topic need to traverse the levels of the revised Bloom's taxonomy starting with acquiring basic knowledge about a concept and then making a transition to the point where they can evaluate or create artefacts within that area.

The design setting described in the following section shows one approach to provide a learning experience by combining activity design, scheduling, orchestration, and assessment together that requires active participation from students both before and during the face-to-face sessions.

11.2 Design Setting

The flipped learning design model described in this section has been deployed in a first-year engineering course on computer systems at a higher education institution. The learning outcomes of the course include the configuration, building, and testing of a computer application. The course proposes the use of the Arduino,[1] a widely used microprocessor system with open-source software and development kits as the platform to be used for students' practical experience. The course lasts for 13 weeks, and enrolment has been steady with approximately 300 students in the last two offerings. Students meet three times a week. First, a two-hour plenary session is held in a conventional lecture theatre (although, as explained later, the

[1] See http://arduino.cc.

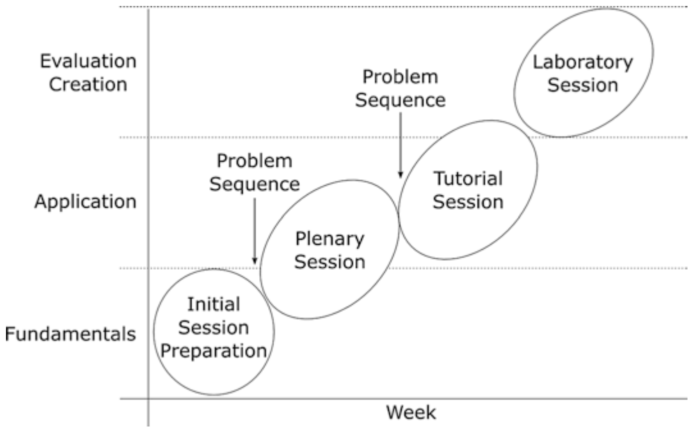

Fig. 11.1 Deployment of assessment and activities from layers into stages

format of the session is not a conventional lecture). Second, a two-hour tutorial session is held in groups of up to 50 students. And finally, a three-hour laboratory session is held at an engineering laboratory with the required infrastructure to work with the Arduino kits, a robot kit, and the necessary electronic equipment (e.g. cables, sensors, and power sources). These sessions are scheduled for groups of 70 students. The staff in charge of the course included one instructor for the lectures (delivered to all 300 students in a theatre), two tutors per tutorial session (groups of 50 students), and three tutors per laboratory session (groups of 70). Some of the tutors participated in more than one session.

Previous editions of the course suffered low levels of engagement of students in lectures which increased the perceived level of difficulty in the tutorials. The instructors felt that in order for students to attain the objectives in the tutorials, a more effective use of the lectures should be considered. In this scenario, the primary objective of the flipped learning design was to identify and deploy activities divided into three layers that are then scheduled throughout the week to sustain student engagement. These layers are shown in Fig. 11.1 and have been defined as follows:

- Fundamentals: Include the presentation of concepts and basic factual knowledge. As a reference, these activities help achieve learning outcomes related to the *remembering* and *understanding* levels of the revised Bloom's taxonomy.
- Application: The activities in this layer require students to apply the basic knowledge about topics. The learning outcomes associated with these activities correspond with the *applying* and *analysing* layers of the revised Bloom's taxonomy.
- Evaluation/Creation: These activities require students to connect the concepts with real-life situations and evaluate their impact. Additionally, they are required to create novel applications of embedded computer systems (sensors and micro-controllers) to solve real problems.

The strategy to deploy these activities is also divided into four stages scheduled each week:

1. Initial session preparation. The activities in this stage are taken from the fundamentals layer to support students' individual preparation for the plenary session and initially introduce them to new topics. After this stage, students should be able to remember basic facts and understand the new concepts at an introductory level.
2. Plenary session. In this two-hour session, students will be given a set of activities from either the fundamentals or the application layer which are solved during the session by students exchanging ideas with their neighbours (informal groups). Each activity is preceded by a brief introduction to situate the topic, and the solution is then collaboratively derived and shared with the entire audience. A *worksheet* (1 double-sided printed sheet) is given to students to collect their solutions for these activities.
3. Tutorial session. In this two-hour session, students are given a set of activities from the application layer showcasing the ideas and concepts covered in the previous stage. The work is done in pairs and under the supervision of tutors. The activities require the production of a solution or clear deliverable to be shown to the tutors.
4. Laboratory session. This three-hour session is carried out in formal teams of four members established at the beginning of the course. The activities in this session are included in the evaluation/creation layer. While some of the deliverables can be submitted to the tutors at the end of the laboratory session, others are produced over several sessions (e.g. a six-week project in the second half of the course).

Figure 11.1 shows the combination of activity layers and stages.

The flipped learning strategy is represented in this design by two factors: the design of the activities for the initial session preparation, and the re-factoring of the plenary session to embrace an active learning framework highly dependent on students' preparation. Although this division and orchestration of activities may seem reasonable to reach the higher levels of Bloom's taxonomy, it is similar to commonly adopted strategies and has the risk of being ineffective. If students do not engage with the activities in the initial session preparation, plenary sessions will not be effective and this effect will trickle to the rest of the activities. Additionally, if the activities in the plenary session are reduced to the mere exposition of factual knowledge, students will perceive the session as a waste of time. Thus, the two crucial aspects of the proposed design are to encourage student engagement in the preparation activities and then schedule a plenary session properly aligned with the overall framework. The next section details the design decisions adopted in each of these two stages.

11.3 Initial Session Preparation

Every week, students are given a detailed description of the activities required for each of the three sessions together with a list of concepts to know, and a set of activities to complete. The information related to the plenary session (which retained its original denomination, Lecture) is divided into two clearly identified sets of activities: those to do before the session and those to do while in the session. Students are explicitly told that the latter need not be completed prior to the face-to-face session. Figure 11.2 shows an example of the information provided for a Lecture. The preparation includes five activities, and the plenary session contains six. Each activity is described in four sections: resources, work plan, assessment, and need to review. The first section points to the required resources, the second gives the instructions and the context, the third is the scheme used to assess the activity (could be self-assessed), and the last one points to the location of information to review the material related to the activity. The preparation activities were designed following three different structures: video with questions, document with embedded questions, and problem sequences.

The video with questions is presented to students as a single HTML document that includes the video as a resource. The videos were recorded while the instructor wrote notes explaining a concept starting on a white sheet of paper. Forcing the instructor to write the content reduces the risk of rushing through the explanation. Restricting the explanation to one single sheet of paper keeps the video length within adequate limits. Additionally, the resulting paper is then scanned and made available for download (a link provided immediately under the video). This

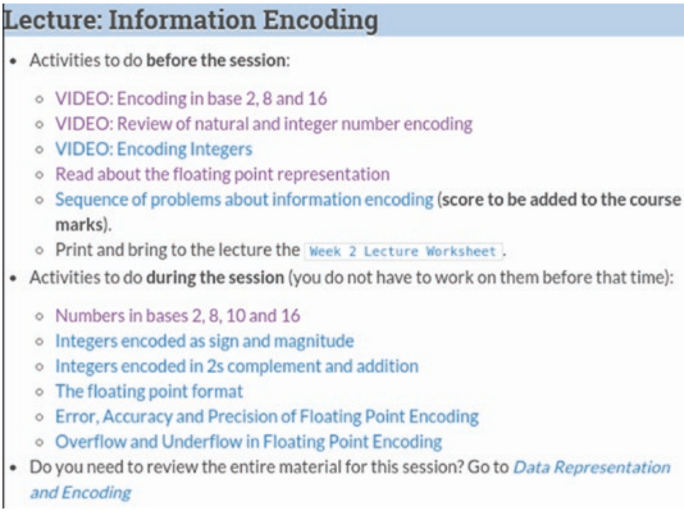

Fig. 11.2 Information about the lecture with two activity blocks

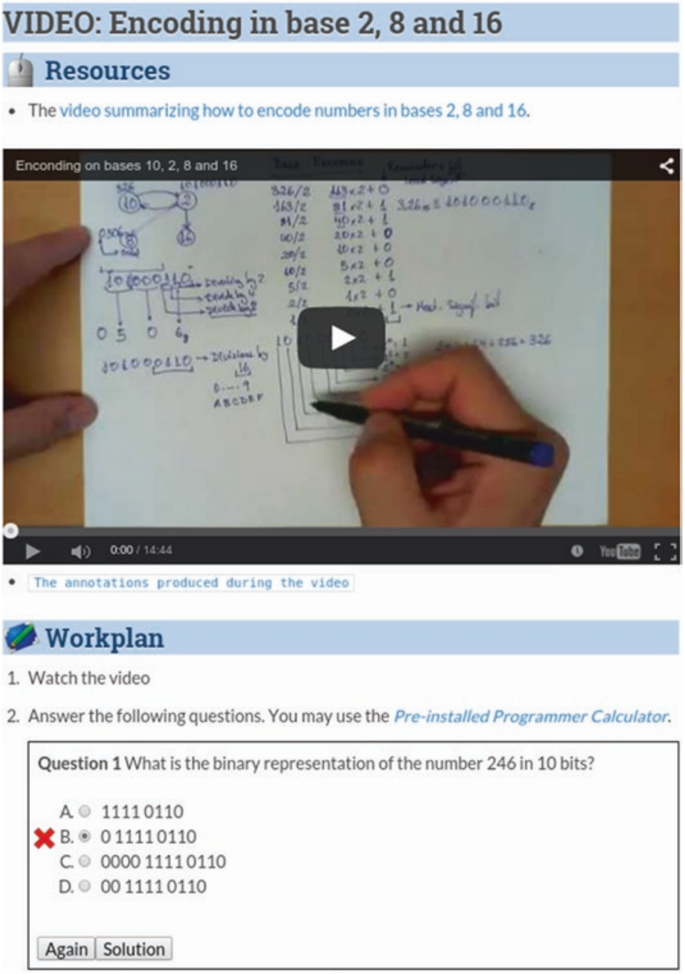

Fig. 11.3 Activity with video followed by formative assessment

production setting offers a low adoption threshold both from the point of view of equipment, and preparation (Guo et al. 2014).

The video is then followed in the work plan by a set of formative multiple-choice questions embedded in the same page. The questions are about the concepts discussed in the video and promote simple factual recall (Karpicke and Roediger 2008). Students can answer the question and grade the answer, and if it is incorrect, they have the choice of either seeing the solution, or trying again. This workflow has been conceived to encourage student engagement in a purely formative format. Figure 11.3 shows one of these video and question activities and the first of several questions included on the same page. Each question can be answered independently.

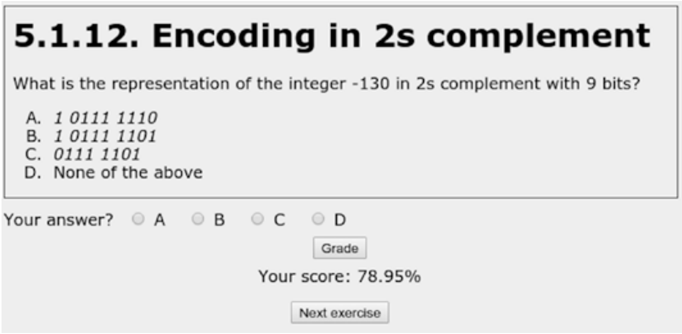

Fig. 11.4 Example of a problem in problem sequence activity

The second type of activity used to prepare for the plenary session requires students to read a portion of documentation and answer additional formative multiple-choice questions. The document format follows the same style as the *video and questions* activity, an HTML document with questions embedded in the middle of the text. The objective is the same: to offer students a formative feedback tool with a non-existent adoption threshold to sustain student engagement.

The third type of activity scheduled to prepare students for the initial plenary session is a problem sequence. This resource is significantly different from the previously described and is always proposed as the last preparation activity. The sequence will have a score that will be part of the summative assessment for the course. The activity consists of answering a sequence of more complex problems about the topic covered previously. Students attempt sequentially a set of exercises framed as multiple-choice questions. If a question is answered correctly, the student's score is increased and it is removed from the set. If the given answer is incorrect, a new exercise is randomly selected from the sequence, and the current problem remains in the sequence. With this workflow, students will receive exercises randomly until they answer all of them correctly. At that point, their score will be 100% and they will be given the choice to reset the sequence. Figure 11.4 shows an example of a problem that is part of a sequence.

In the proposed design, students are required to submit their answers to the problem sequence *before the start of the plenary session* for their score to be taken into account. More precisely, the score of the sequence is read for all students at the time the plenary session starts, and the value is added automatically to their overall course score. This type of incentive is in place to alleviate the risk of students not preparing the material.

11.3.1 Plenary Session

The plenary session is delivered following a structure similar to the initial session preparation consisting of a set of activities (with resources, work plan, assessment and *need to review* sections). Each of them has one or several questions that require students to reason about one of the topics introduced in the initial session preparation activities. A two-sided paper with the summary of the activity and the questions is given to students at the beginning of the session. The instructor precedes each activity with a brief presentation to situate the questions, relate them to the preparation material, and answer any preliminary questions. Students are given a certain amount of time to seed for answers to the questions by discussing with their neighbours. Then, the entire class discusses the final solution. The questions included in the activities require applying the ideas explored during the initial session preparation. The instructor reflects the answers in a worksheet visible to all students.

In these activities, the emphasis is placed on the active participation of the students. A variety of techniques are used for this purpose: voting on the most likely answer to a question, divide and conquer a complex task among sections of the theatre with the sub-problems then combined to obtain the final solution, and casual contests among sections in the theatre. No summative assessment is derived from the session.

After this session, students are expected to be more familiar with the concepts and their application and are ready to complete more complex tasks formally in pairs and supervised by tutors in a reasonably sized group. This is the case of the conventional tutorial sessions that are also included in this course. However, to sustain the commitment of students with a sustained effort, a second exercise sequence is required before the start of the tutorial. This assessment is also summative. That is, its score contributes directly to the overall course score.

11.3.2 Feedback on the Participation

A course design, like the one described, requires a sustained and intense engagement from the students. In order to provide positive reinforcement of this engagement, we deployed an additional dashboard that provides students with immediate feedback about their level of engagement with the preparation activities. The information was divided into four sections and showed the level of engagement with different resources when compared with the average derived from the entire class. Figure 11.5 shows the visual representation of this information. Clockwise starting from the upper left corner, the percentage of videos visualized, the percentage of video questions answered correctly, the percentage of questions in the notes answered correctly, and the score in the exercise sequence are shown. Each section includes two values, the individual and the average over the entire cohort.

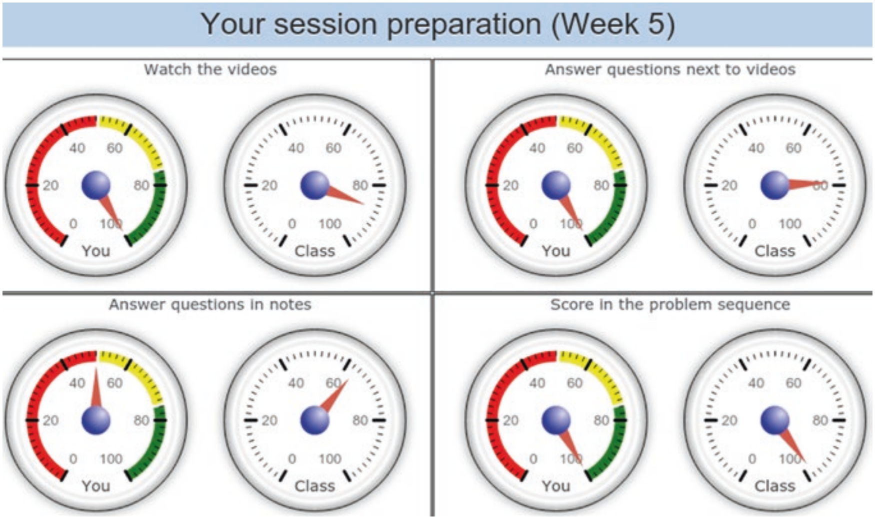

Fig. 11.5 Feedback about engagement with preparation activities

As previously explained, the value shown in the lower right corner is part of the summative assessment. This visualization shows the information up to the time of the plenary session and is updated automatically every 15 min. After the plenary session, the values are reset to zero and the activities for the following week are considered.

Since the preparation activities are supposed to be completed by the students individually, this feedback helps them quickly determine the level of coverage in the preparation activities and gives a sense of position with respect to the rest of students in the class.

11.3.3 Design Effort and Resources

As with any initial design of a course, the recording and production of videos, design of formative and summative questions, and the creation of the activities for the lecture required an important set of resources. All material for the course was created as HTML pages for its delivery in electronic format through the Learning Management System. A total of 36 short videos (duration less than 15 min) were created. The production process was streamlined to require approximately 2 h of work per video and were hosted and retrieved from the YouTube platform.

The course notes included a total of 249 HTML pages. Aside from text and figures, the pages included 178 multiple-choice questions distributed among multiple activities and chapters. Additionally, twenty exercise sequences were created containing in total 219 questions. All material was integrated into a self-contained website created in ReStructuredText[2] format and translated using an extended version of the Sphinx-doc toolkit.[3] The most significant effort was to redesign the in-class activities to provide a higher level of attainment of the concepts related to the learning objectives while providing students the opportunity to participate actively in its delivery. For example, certain activities tackled a problem by dividing into sub-problems that are then assigned to areas of the lecture theatre. After a short-time interval, a volunteer is selected from each area, and the solutions are combined to solve the general problem. These types of activities posed a significant departure from the currently existing material, and as such, required an intense dedication.

The initial deployment of this course required a high workload mostly derived from the rich set of learning resources created. However, as it is the case with most learning designs, the existing structure can now be re-used for future editions of the course with a conventional level of effort.

11.4 Evaluation

While the previous section focused on the design of the flipped learning course design deployed and how data from students' engagement with the online preparation activities can be used to provide them with feedback on their learning behaviour, a form of positive reinforcement, this section discusses the evaluation of the learning design and achievement of the primary intended objective: sustained student engagement. In particular, this section discusses how *learning analytics* data have been used, along with other sources of more conventional data (e.g. teacher reflection and student and peer feedback), to evaluate the effectiveness of the course design.

The term learning analytics is used to refer to the collection and analysis of data captured from students' actual use of online technologies (Clow 2012, 2013; Greller and Drachsler 2012; Siemens 2013) rather than relying on students' self-reports that may be inaccurate (Winne and Jamieson-Noel 2002). In order to provide students with up-to-date feedback on their engagement with the online preparation activities, the following data were regularly captured and visualized: data from students' interaction with the videos including their responses to the questions in the videos and in the notes (HTML document) and their score on the problem sequence that were completed prior to the plenary session. The data not only showed the number of attempts students made on the questions or their score on the problem sequence, but it also revealed whether students engaged with

[2] ReStructuredtext is a plaintext mark-up syntax that can be automatically translated to HTML http://docutils.sourceforge.net/rst.html.

[3] Sphinx Python Documentation Generator http://sphinx-doc.org.

the preparation activities or chose not to. While this information was provided to students as feedback on their engagement as illustrated in Fig. 11.5 earlier, it also helped inform the instructor on whether the strategy deployed was effective for sustaining student engagement and preparing for the plenary session or not.

The collection of such data to inform course design or better understand student learning behaviours is not novel as other studies have reported utilizing such logged data or learning analytics from students' engagement with videos (Brooks et al. 2011; Mu 2010), discussion forums (Lockyer et al. 2013; Wise et al. 2013), and with learning management systems (Beer et al. 2012; Macfadyen and Dawson 2010). Advances in online technologies and data mining techniques have helped better capture and draw on learning analytics to inform pedagogical practice. However, this is only one data source or perspective of the efficacy of a particular course design or teaching approach. A multifaceted approach to evaluation provides a more holistic view of the effectiveness of the approach and areas that could be improved. Hence, the evaluation of the course design discussed in this chapter follows Vigentini et al.'s (2016) integrated teaching development framework that extends Brookfield's (1995) four reflective lenses by adding a fifth lens or data source, learning analytics, and positions the instructor not only as the teacher and course designer but also as a researcher moving from relying on secondary sources towards researching at the core, as illustrated in Fig. 11.6. The spiral at the top within Stage 1 shows the four stances of a teacher-researcher. In our particular case study, the teacher is positioned as an inside-observer actively collecting objective data to discover the effectiveness of the design of the flipped classroom

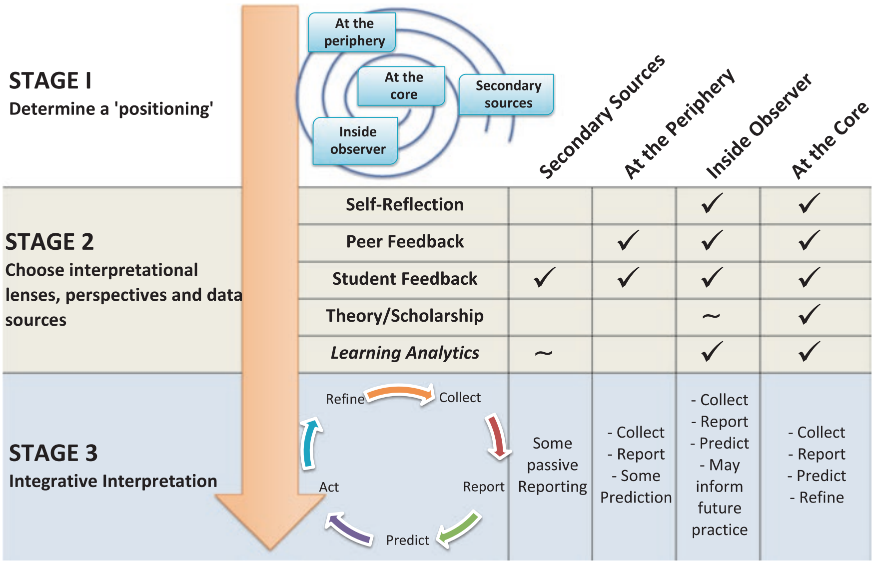

Fig. 11.6 Framework to integrate analytics in teaching evaluation and research (used with permission)

Table 11.1 Evaluation of intended objective (sustained student engagement) from multiple lenses

	Method	Objective 1: sustained student engagement
Teacher self-reflection	The primary instructor reflected on the course and teaching experience throughout the semester	The course design followed a predictable structure and scheduling helping students adopt it as their learning strategy sustaining engagement. There is a noticeable increase in participation in the plenary session (lecture) and in tutorials with students coming to session prepared to answer questions. The visualizations of student activity on the dashboard provided positive reinforcement and motivation to sustain or enhance engagement as derived by the number of student comments derived from it. Further, the analytics captured helped inform me (the teacher) of any misconceptions prior to the plenary session so could tailor the session accordingly
Peer feedback	Peer observation focusing on student engagement during the plenary session, tutorials, and laboratory sessions and of the online dashboard. The primary instructor also discussed the flipped learning approach with colleagues in the department	Instructor peers noted that students appear engaged in the plenary session (lecture), tutorials, and laboratory sessions but that designing flipped activities and resources requires an additional time commitment from the instructor. In addition, colleagues have noted that while visualizations of student engagement and scores are valuable feedback for the students and the teacher, access to the data and the ability to provide such feedback through a dashboard is not readily available to all teachers. The necessary infrastructure and/or skills are required. Additional comments from instructor peers have shown that there is interest in the course design as evidenced by invitations to present the design at various institutions and to be featured in video recordings discussing the approach as a case study used in professional development programs and MOOCs
Student feedback	Informal feedback from students was collected throughout the semester. Future plans are to conduct formal surveys to gather further feedback on the effectiveness of the course design	During the semester, the discussion forum reflected a large number of questions about the preparation activities. Informal feedback from students revealed that they valued the video recordings and formative assessment and appreciated the level of feedback provided by the online dashboard and the positive effect it had in their preparation of the material

(continued)

Table 11.1 (continued)

	Method	Objective 1: sustained student engagement
Learning analytics	Log data from the learning management system, YouTube, and ReStructuredText website was collected	The log data show that the student's level of access to the resources (video and HTML documents) followed a pattern, which peaked before the plenary session (deadline for submitting the questions and sequence problem). Averages of 5389 video events per week were registered during weeks 2–13 of the semester. This level of engagement confirmed that the pattern of preparing material for the face-to-face session was followed by the majority of students. In terms of the online dashboard, log data show that students consistently consulted the dashboard to receive feedback on their level of participation throughout the course. During the 13 weeks, the number of times the dashboard was accessed remained high, at an average of 621 accesses per week (291 students)

preparation activities. As Fig. 11.6 illustrates, associated with this role, is the holistic evaluation of the course design as noted in Stage 2 where a combination of self-reflection, peer and student feedback alongside learning analytics form multiple perspectives of the evaluation of the effectiveness of the course design. The third stage relates to collecting and reporting of data, predicting learning behaviour, and informing future iterations of the course. As Fig. 11.6 illustrates, associated with this role, is the holistic evaluation of the course design as noted in Stage 2 where a combination of self-reflection, peer and student feedback alongside learning analytics form multiple perspectives of the evaluation of the effectiveness of the course design. The third stage relates to collecting and reporting of data, predicting learning behaviour, and informing future iterations of the course.

Table 11.1 shows a summary of the outcomes of the flipped learning course design deployed from multiple perspectives following the framework.

11.5 Conclusions

Designing for flipped learning is a significant departure from conventional approaches. This chapter described one approach to a flipped learning course design that focused on sustained student engagement through four stages of the course: initial preparation activities (online and individual), plenary session (informal collaborative activities), tutorials (problem-solving activities in pairs), and laboratory sessions (collaborative team-based problem application and design activities). In addition, learning analytics captured from students' engagement with the preparation activities each week was visualized and presented to students through a dashboard encouraging them to be aware of their learning behaviour patterns and how it compared with their peers. Such information also informed the instructor of any misconceptions arising from the concepts and online questions and extent of student preparation each week helping tailor the plenary sessions as appropriate. The evaluation of the learning design was conducted from multiple perspectives that married teacher reflection, peer and student feedback, and learning analytics to reveal the extent that the primary intended objective of the learning design was obtained: sustained student engagement.

Future iterations of the course will build on the approach and the findings from the evaluation. In particular, the next step is to refine and extend the analytics captured in order to better identify the misconceptions both from the perspective of the student and the teacher from the preparation activities and the activities occurring during the other stages of the course design. Revisions to the course design will move towards ways of capturing student engagement during face-to-face activities through the use of digital devices in the class or inputting answers to questions or problems online.

The design experience described in this chapter exposed in detail the stages that students traverse when learning and how to provide resources and activities for all of them. The main conclusion derived from the study is that there is a clear opportunity to schedule activities that prepare students better to participate in activities in the face-to-face sessions that are more likely to translate into higher attainment rates. From our point of view, flipped learning provides a solid pedagogical framework worth exploring.

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Chapter 12
Flipped Classes: Drivers for Change, Transition and Implementation

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Abstract Though not a commonplace teaching and learning model, much interest is being generated in flipped classes. The arguments given for parting ways with the traditional lecture, and moving into flipped classes, are well discussed in the literature and have been derived across a broad range of disciplines. However, transitioning both teaching staff and students into flipped learning and teaching (L&T) is an issue which has attracted less attention. Before implementing flipped classes, it is also necessary to identify the range of merits which students attach to this model as well as the challenges they associate with its implementation. These matters are the focus of two research questions addressed in the present work. After presenting an overview of the justifications used to introduce flipped L&T into an engineering thermodynamics unit, the processes used to transition students into this model and the particulars of how it was applied are presented. Feedback (qualitative) derived from a questionnaire conducted at the end of the teaching semester is also reported and used to shed light on the student perspective. The chapter adds to the evidence that changing student L&T styles needs to be addressed at the design stage if introducing flipped classes and that a transitional strategy is required to assist students in adapting to the new learning environment.

Keywords Flipped teaching · Motivation · Application · Survey · Engineering · Case study · Thermodynamics

12.1 Introduction

Technological advancement in the form of high-speed internet connectivity, device portability (smart phones, tablets and computers), the widespread adoption of learning management system (LMS) by tertiary institutions, and the

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ever-increasing expectation that students access learning materials 24/7, all helps rethink the traditional on-campus paradigm of classroom instruction. In many parts of the world, students are no longer compelled to come to campus to gain their first exposure to learning materials or to engage the bulk of learning content. The challenge in such an operational landscape is to then define the "value add" for students who do make the trip to campus. This will be important if teaching staff are to better utilise class time and more effectively engage their students.

Flipped (inverted) classes may be one way to address the above challenge in some taught courses whilst simultaneously encouraging student accountability towards learning. In this context, a common question which materialises either before flipping, or in the midst of transitioning into the diverse realm of flipped classes, centres on "what is the best use of face-to-face time with students?" (Bergmann and Sams 2012). Traditionally, face-to-face class hours have been commonly utilised for "delivery" of content or "lecturing". This historical trend has continued even when media used to convey learning materials diversified through the last half century, from chalk and blackboard, to overhead transparencies and hardcopy printed handouts, whiteboards and (in the last two decades) multimedia files which are accessible online and available in various presentation formats.

On-campus units which are offered through flipped teaching do not just ask students to prepare before class (Mason et al. 2013). Flipped classes are also not merely about avoiding a "pour it in" teaching model, and in many ways flipped teaching also transcends beyond the "keep it flowing" model (Smith et al. 2005). That is because common practice in flipped class tuition is for the lecturer to be physically de-linked, both time and space, with the learner whilst they independently experience their first access to the teaching materials. As such, flipped L&T is not just a pedagogy of different engagement, or merely a process which is better learner-centred. Indeed, it is about transforming classrooms into inquiry-driven learning hubs (Bergmann and Waddell 2012).

For those contemplating implementation of flipped classes when neither the student cohort nor the lecturer themselves have any appreciable prior exposure to flipped tuition, the process can be quite challenging for both parties involved. This is further exacerbated for the lecturers in the absence of peer support/mentoring or readily available resources to help identify the merits (objectives) of flipped classes and assist them through implementation. The present book from which this chapter is derived is one such resource designed to assist a better understanding and more effective application of flipped L&T. Indeed, the shift to flipped classes will not be instantaneous, will not be without additional resource requirement [though some resort to flipping to reduce text book buying (Fulton 2012)], and will not be a small step for instructors nor a (giant) leap constrained to students only.

This chapter provides one case study of how flipped classes were implemented using fairly modest resources. The context is a unit "Thermodynamics" offered through a relatively large class over 2014. The structure of the remaining chapter will be as follows: Sect. 12.2—Context; Sect. 12.3—Drivers to Flip Classes; Sect. 12.4—Transition and Implementation of Flipped Classes; Sect. 12.5—Student Perspectives; and Sect. 12.6—Summary. In the context of this chapter, a "unit" refers to a subject offering that is undertaken over a single study semester and normally forms one of dozens of units which in their entirety comprise a course (also known as a programme or degree in some countries).

12.2 Context

Thermodynamics is a third-year/semester-2 core (compulsory) unit in a number of four-year Bachelor of Engineering courses, including the mechanical discipline. Unit coverage is dedicated to about 75% thermodynamics with the remaining based on heat transfer. The unit features major coverage on the ideal gas equation, steam/water tables and its states, the first/second laws of thermodynamics as applied to closed and steady flow systems, entropy, efficiency and power cycles (Rankine and compression ignition engines) as well as other topics. The heat transfer part addresses the fundamentals of conduction, convection and radiation as well as thermal resistance networks and heat exchanger sizing using the log mean temperature difference (LMTD) method. In addition to the end-of-semester examination, which is mandatory to pass and worth 50% of the total semester score, the unit also features other in-semester works. These in-semester works are broken up into 20% dedicated to laboratories with another 30% for assignments. The assignments are based on (theory) problem-solving, individually based, typically offered in two parts (each worth 15% covering a handful of questions) and are lodged and graded online using testing facilities set up by the lecturer in the LMS. The weekly timetable includes two single-hour lecture slots and a two-hour tutorial slot offered every second week with no repeat lectures or tutorials. There is an expectation the entire class attend all these sessions even though class attendance is not formally registered. Students do, however, attend laboratories twice through the semester, and for these practical sessions, attendance is registered. The unit includes an (open book) end-of-semester examination where students can bring the prescribed text book (Cengel et al. 2012) but no other materials.

In applying a flipped class model, the style of the weekly lecture was changed which affected the way time was utilized, the format of student–lecturer interaction as well as through the use of in-class worksheets to help students self-gauge (self-assess) their learning. At the start of the semester, students have access via their LMS to (static) PDF slides accompanied by recordings (downloadable mp4 files) of screen capture from the last offering of the unit in which traditional lectures (slides) were used. So, in applying flipped classes, pre-class preparation was also facilitated using resources already available and so there is very little additional compilation of audio-visual materials involved. Additional worksheets were, however, developed for use in the face-to-face sessions in the flipped class model and more will be said on these in the ensuing sections.

In 2014, flipped L&T was used in this unit and so thermodynamics included surveying students to help better understand their perspective. This process of seeking feedback took the form of a single questionnaire emailed to each student at the end semester. The questionnaires prompt students to either respond to open-ended questions, requiring a descriptive or qualitative entry (i.e. the expression of views), or ask them to select options in multiple-choice questions. At that point, there were about 193 students enrolled into thermodynamics. Survey participation was voluntary but requires students to return the questionnaires before summative outcomes (final results) were released by the University. This timing was intended to remove likely respondent bias due to final outcomes, even though marks for the in-semester works were already known during the semester. The number of questionnaires attempted and returned (with any number of questions answered) constituted around 19% of those enrolled in thermodynamics.

More comprehensive reporting of the survey results is planned in a follow-up research study. The two survey questions which were put to students and reported in the present work are:

- Give the three best (most valuable) aspects associated with studying using a flipped class model?
- Give three main challenges associated with studying using a flipped class model?

The above-noted survey items are expected to help gain a better understanding of the student perspective in relation to two research questions (RQ1 and RQ2):

- RQ1: What range of merits do students attach to a flipped class model?
- RQ2: What challenges do students attach to a flipped class model?

12.3 Drivers to Flip Classes

In the pre-flip format, traditional lecture time in the unit thermodynamics is largely utilised according to the scheme shown in Table 12.1. In this format, a typical class routine starts with the lecturer first spending a few minutes noting and contextualising the concepts to be delivered in the (immediate) session. After

Table 12.1 Time utilisation in the traditional lecture mode used (historically) in the unit thermodynamics

Time utilisation	Traditional class activity	Roles		Interaction	
		Lecturer	Student(s)	Student-to-student	Lecturer-to-single student
Introduction (Few mins)	Lecturer provides summary of previous coverage and may contextualise today's coverage	Talk @ lectern	Listen	☒	☒
Bulk	Lecturer delivers content	Talk @ lectern	Listen; may ask	☒	☒
Wrap-up (Few mins)	Lecturer provides summary: today's class	Talk @ lectern	Listen	☒	☒

this introductory settling-in period, the bulk of class time is then used for covering slides (content delivery), in what has traditionally been known as the "lecture". The stream of delivery is sometimes broken with the odd question or two from students. On many occasions, classes then conclude with a quick summary to highlight the major concepts undertaken in that class. The opportunity for students to (informally) gauge their (individual) learning and seek personalised support (through the lecturer) is largely absent in this traditional lecture format. The exception is students who then augment the lecture through seeking out-of-class (office) appointments with the lecturer which becomes more challenging to handle with growing class size. This also means that where the lecturer receives (through such out-of-class consultation) multiple queries relating to the same learning concept(s) thus indicating a hurdle that is more commonplace, the lecturer can only address this for the entire class when the next timetabled class session occurs.

The role of a lecturer and class time utilisation in a traditional lecture (as per Table 12.1) is clearly transmissive and akin to the "pour it in model" (Smith et al. 2005). Traditional lectures are also fairly linear in their coverage since student learning is synchronised, both in direction and rate with the progression of the entire class session. As such, the traditional lecture in thermodynamics offered students little opportunity for self-paced, or self-directed, learning. The traditional lecture described by this format also appears devoid of what students might perceive as active learning where they become lead participants who are continuously engaged (at the personal level). It is not uncommon for lecturers to also observe loss of attention from students after some length of continuous delivery. This type of traditional lecture is also less likely to be the casual (non-confronting) learning environment which helps students query concepts. The traditional lecture is also not a teaching approach which allows students to clearly identify the extra value gained by attending classes if the same content is (already) made accessible for them by the lecturer upfront of class (Fitzpatrick et al. 2011). In summary, this framework does not appear to provide much motivation to prepare before class or generate much value-add for those students engaging the on-campus lecture slots, particularly if this content is also recorded and posted via the LMS. The traditional lecture also does not appear to facilitate a structured framework whereby students can continually self-gauge as they scaffold the learning concepts, outside the scope of assessed in-semester works or problem-solving in tutorials. These are some of the drivers for shedding the traditional lecture and going down the path of applying the flipped class model in thermodynamics.

Although the start of a timetabled class in the flipped (reworked) thermodynamics unit is very similar to those in the traditional lecture, Table 12.2 shows the bulk of class time is alternatively less transmissive and more discussion style. The flipped class thus aimed to provide individual students with more opportunity to address their own specific learning requirements. This mode of tuition is also less likely to leave behind some students since class time is not necessarily synchronised (at the individual level), is less likely to confine students into a receptive mode, and may even result in some time savings if students feel confident enough not to attend the flipped class discussions, thereby also freeing up

Table 12.2 Time utilisation in the flipped class model introduced into the unit thermodynamics

Time utilisation	Flipped class activity	Roles		Interaction	
		Lecturer	Student(s)	Student-to-student	Lecturer-to-single student
Introduction (Few mins)	Lecturer explains worksheets used by students for self-gauging	Talk @ lectern	Listen	☒	☒
Bulk	Lecturer engages in discussions	Tour @ space (1:1 support for students and breakout discussions in small groups)	Listen; may ask	☑	☑
	Students self-gauge using worksheets, engage in discussions and ask questions	Or Talk @ lectern (if common challenges are identified, the entire class is addressed)	Gauge and extend learning		

more (lecturer) time for those who do attend (Davies et al. 2013). Another outcome which becomes apparent is to also free up the lecturer from monotonous delivery to instead engage learners in spontaneous interaction which is driven by student needs. In summary, it is believed that whilst the flipped class environment discussed in this chapter remains fairly well structured (Table 12.2), it is relatively less controlling and more autonomy promoting compared to the traditional lecture. This is because it embodies more "attunement" with the lecturer having more opportunity to contribute to each student's learning needs, allows more time for the lecturer to personally interact with individual student thereby embodying more "relatedness", and allows greater "supportiveness" as they have more opportunity to follow the student who becomes more self-determining in terms of the rate of relative focus dedicated to individual topics, and through close dialogue (rather than delivery), the lecturer–student interaction will probably also be perceived as having far more "gentle discipline" (Reeve 2006).

12.4 Transition and Implementation of Flipped Classes

There exists a growing body of the literature on the drivers to implement flipped L&T and its perceived merits. However, there are few studies undertaken into transitioning students into this non-traditional learning environment with most works focussing on the steady-state operation once classes have been flipped. As such, whilst strong motivation may exist on the part of a lecturer to flip their class delivery mode (and relinquish the traditional lecture), the degree of preparedness which students need in order to settle into the new L&T framework is equally important to consider. The other issue that comes up with flipped L&T is how to utilise class time which was traditionally used for content delivery. Both these matters are now discussed in the context of the unit thermodynamics.

12.4.1 Transition

When students are unprepared or not given adequate upfront explanation, a significant proportion of students can take neutral positions in relation to whether they want to be involved with, or feel excited about, the uptake of, flipped classes (Forsey et al. 2013). The transition from being accustomed to traditional lecture delivery into the (new) realm of flipped class discussions can be challenging for both the student and the lecturer. This situation is likely to be exacerbated if either (or both) of these stakeholders have only been exposed to traditional tuition where content delivery is the norm in relation to theory.

In thermodynamics, transitioning students into the flipped class method typically spans the first couple of weeks in the semester. At the end of this settling-in period, students should be able to identify three major issues:

- The need to prepare before coming to class so as to get most out of the flipped class discussion;
- The type of learning blocks which students need to extract from each set of lecture series/slides (already available to them via the LMS), where these are termed “major concepts”; and
- Timetabled class slots are used for discussion of major concepts and not delivery of content.

Over this transitional period, whilst no traditional (slide-based) content delivery or fully flipped classes are yet undertaken, the above three issues need to be accommodated and reinforced. Class time during the transitional first couple of weeks should also exemplify that classes are about engaging in discussions and not content delivery. In a typical class session over this transitional period, the lecturer prompts the entire class to indicate which major concepts they had learned by way of pre-class preparation (via reading or listening/watching to pre-recorded lectures for the chapter covered on that day). During this transitional period of settling into fully flipped classes, the lecturer largely uses the digital projector to sequentially write down and display the major concepts (as interactively nominated by the students). In each class, this process continues until all the main building blocks of learning are listed for that chapter (class session). Whether these major concepts, either individually or collectively, embody “thresholds concepts” or merely relay “core concepts” (Meyer and Land 2003) is not the focus of this chapter. And so, although coincidental in the selection of the term “major concept”, this choice also conveniently avoids the need to define or align it to any of the other two concepts identified in the literature (Meyer and Land 2003). For the purpose of this article, a major concept is a major block of learning that is typically introduced in a specific chapter within the textbook but which can be integrated and applied across chapters. Some of these concepts may be fairly involved (and integrating) such as the first law of thermodynamics applied to a steady flow device like a turbine or more straightforward (and independent) such as the concept of mass flowrate.

As such, through the transitional couple of weeks at the start of semester, the intent is to allow students to better develop a capacity to identify the major blocks of learning associated with each chapter, contemplate these blocks of learning, bring these to the class discussion, and to take more responsibility for their own learning. Differences between this transitional stage and the fully flipped mode of L&T include the instructor still being largely bound to their lectern (so as to use projection facilities and collate the major concepts highlighted by class), students still having little opportunity for peer–peer interaction, the rate of coverage being again largely driven by the lecturer, and no framework for students to self-gauge their grasp of major concepts in class. There is also limited opportunity for personalised feedback to students as the focus is on identifying the major concepts, rather than addressing gaps in the learning of individual students. It is therefore evident that during this transitional settling-in period, the format of class time utilisation is slowly changing from that shown in Table 12.1 to that in Table 12.2.

To help clarify to students the need to prepare before class and use class time for discussions, Fig. 12.1 shows a typical graphic that is usually embedded into introductory unit materials given ahead of starting study along with textual descriptions and links to (short) movies about flipped L&T derived from the World

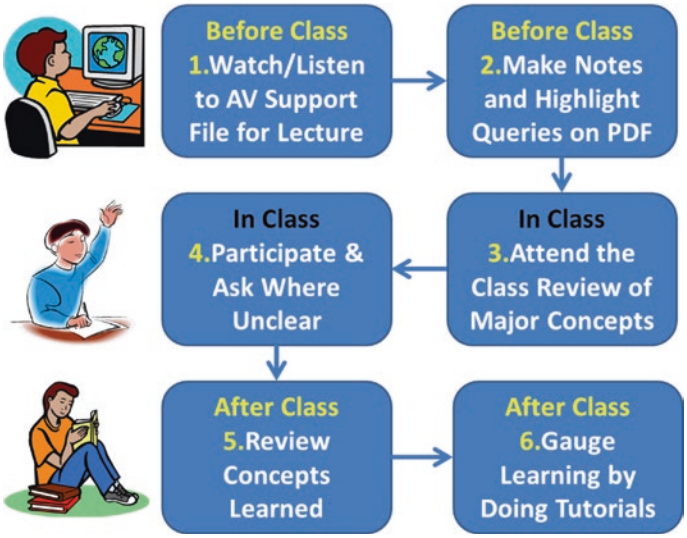

Fig. 12.1 Graphic integrated into unit (course) documents to conceptualise the flipped class model

Wide Web. Finally, whilst the above may serve to highlight to students the expectation of having to prepare, it is the in-class prompting that probably serves to provide the added motivation for that preparation to happen.

12.4.2 Implementation

A starting point for deciding on what to implement in flipped classes (once the initial transitional period finishes) is to identify the best aspects which students perceive are associated with face-to-face classes in addition to the features which also make online learning attractive (Ng 2014). These two aspects can then be blended with the added extension of effective mechanisms to encourage student preparation (before class) as well as self-gauging (self-assessment) of learning (Wilson 2013). In this manner, a more student-centred utilisation of lecture time results in which (active) student-regulated learning is encouraged. Such a rationale will likely provide a good starting point to implementing a flipped class strategy and is the approach taken in the unit of study exemplified by this chapter.

Studies (Crews and Butterfield 2014) indicate students perceive the best aspects of face-to-face classes are the interactive environment (i.e. opportunity to engage in discussions), whereas the more popular characteristics associated with online tuition are structures allowing flexibility (e.g. time of access, rate of learning). However, two key issues need to be considered when implementing flipped classes: structuring the activities which constitute the bulk of class time (Table 12.2) and then transitioning the students into this new model so that expectations are clearer. In the context of the unit discussed in this chapter, one distinguishing feature of flipped class time utilisation is to focus on helping student's gauge their understanding of "major concepts" covered in each chapter (part of the curriculum). Using class time to assist students to handle more challenging concepts is an important attribute of "effective flipped classrooms" (Davies et al. 2013). Class activities like self-gauging and the availability of personalised and instantaneous feedback (in-class) are also believed to aid students in applying self-regulated learning (SRL). This is because through self-appraisal, students are likely to gain a better understanding of their own level of learning particularly in relation to key points (Paris and Paris 2001). Moreover, whilst formative assessment has been linked to both assessment for learning (AfL) and assessment as learning (AaL), the characteristics of students exhibiting SRL do include those who actively "self-evaluate", "seek help from adults" (i.e. teachers), "manage time" and "engage in peer learning" (Clark 2012).

By the end of the transitional settling-in period, students will be aware that flipped class discussions will largely focus on the major concepts of learning in every set of lecture slides which are already accessible via the LMS. By using a declared weekly schedule of chapter coverage in the unit, students are also able to identify which coverage they are expected to prepare before attending the flipped class session. The analogy used in class to explain "major concepts" is the

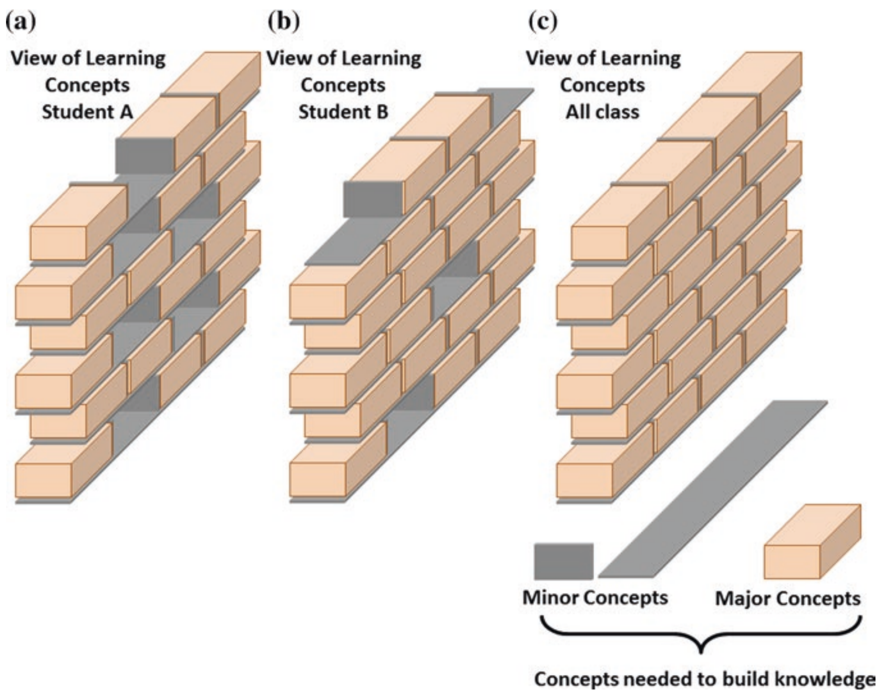

Fig. 12.2 Student (A) and student (B) come to the flipped class discussion armed with their own understanding (and gaps) of major concepts—(**a**) and (**b**). In-class discussions and worksheets to help students self-gauge their learning then aim to help learners reinforce all the major concepts and fill any additional gaps

likeliness of a wall of learning that needs to be erected. Pre-class preparation is designed to help students cover many of these concepts in their own time and set questions aside to be raised (in class) in relation to the more challenging concepts. The flipped classes then focus on the major blocks of learning, through the self-gauging done in class (via worksheets), or the student–lecturer interaction during the bulk of class time. In this way, and as shown in Fig. 12.2, when the initial transitional period of settling-in has lapsed, the fully flipped class sessions move further into providing more student-centred support to help learners complete their understanding of the major concepts in thermodynamics. As such, the fully flipped class in thermodynamics takes the form of an interactive session where the lecturer is not tied to the lectern but routinely moves between the rows and students to provide assistance. Moreover, classes usually involve the handing out of worksheets which query students on the major concepts in each chapter, thereby serving to both encourage preparation and help students self-gauge their learning. In these sessions, students are encouraged to work with their peers whilst considering the worksheets. These worksheets do not include problem-solving (which is done in tutorials) but rather require students to explain different aspects of theory. Whilst through the semester many of these worksheets will need to be developed, they probably constituted the only additional resource allocation needed outside the scope of also adding some textual or graphical (Fig. 12.1) descriptions of flipped class L&T into the introductory unit documents made available at the start to semester. An outcome of this case study is therefore to also exemplify that (in some forms) flipped L&T can be applied with only modest resource extension beyond what may already be available for units delivered using the traditional lecture.

12.5 Student Perspectives

Samples of student feedback from surveys returned are presented in Tables 12.3 and 12.4. This section also includes a summary of observations based on these data and a discussion of its implications in relation to RQ1 and RQ2. Student

Table 12.3 The [three] best (most valuable) aspects associated with studying using a flipped class model

	Student comments
Active learning and unit engagement	I found that attending the flipped classes, it made you engage a bit more in the unit, instead of sitting there trying to listen for so long, So that meant that you could actually retain more of the information
	All students are engaged in their learning
	I feel like more time is dedicated to the specific needs of the student in areas they struggle in, rather than a broad spectrum approach on material that may be very easily understood by a text book
	I can study according to my time as all the recording has already presented in the blackboard so I can prepare at home and attend the flipped classes to get the major concepts or if there is something I need to ask
	It made the lectures more useful as you already knew what parts of the content you found more difficult, thus you knew to pay more attention or ask questions if you needed
	It encouraged me to work with fellow students
	The lectures were more interactive as it was more of a discussion
	Discussion and class handouts to gauge my learning motivated me to prepare before class
	I was more engaged in the class, because during the classes was not the first time seeing the content
	All students can get a personalised education
	More time to ask questions and clarify concepts
	More interactive, more interesting
	Having a lecturer there that was willing to go around the room and help with questions when you had one was a big benefit to the class model
	Gives you more time to ask questions to lecturer about the topic

(continued)

Table 12.3 continued

	Student comments
	Increase interaction and personalised contact time between students with lecturer
	Recoded lectures, which allow stopping and starting the lecture any time
	It puts the responsibility of the learning onto the student, i.e. you are going to get out what you put in
	If you can't make it to a lecture you still have all the key materials
	More challenging = intriguing
	Flipped classes engage us in learning and dig our interests to learn more than just sitting in the class and listen to the teacher
Learning and cognition	I remembered much more of the content, compared to traditional lectures
	Better understanding
	It made it a lot easier to develop a full understanding of the content that we were learning about
	I was more prepared for the assignments and tests, than what I normally am
	Focuses more on analysing the fundamentals, than remembering facts
	Discussing or explaining concepts to peers made sure I understood the content more
	Deeper understanding
	Obtain a deeper understanding
	I could evaluate from opinions on solutions much better compared to traditional lectures
	Less notes taking but more knowledge consolidation
	It saved Yasir [i.e., the lecturer] from going into a lot of detail with easier concepts; he had time to focus on trickier concepts and really making us understand them
	I liked how it afforded lecturers more time to explain the most important content while leaving the rest to our preparation for the class
	I seemed to have a deeper understanding of the concepts
Pre-class preparation	It forced me to go through the material before class (something I always want to do with other classes but never actually get around to) as I knew I would fall behind if I did not
	Forced you to prepare for classes
	Prepare questions
	It forces the student to read or review the lecture content prior to the class, which is beneficial to getting the most out of a lecture
	Better prepared for lectures
	If you are prepared before the class, the flipped lecture really allows you to apply the theory and go more in depth for specific problems
	More incentive to prepare for lectures prior to class
	More efficiency and less time spending on study

Table 12.4 The [three] main challenges associated with studying using a flipped class model

	Student comments
Active learning and unit engagement	I felt that the flipped class is equivalent to online studying, where I do everything myself
	I work full time; I struggle to find the time to do watch a lecture before a class as well as attending a class
	The challenge doesn't lie in the method; it lies in the students engaging it
	In my opinion I think flipped class is very better for those students who are not working. It is hard to catch up for Student like me who work and study at the same time. Student who work, they hardly have time to listen lecture before come to class especially international students. What I think is that it would be lot better if you delivered a lecture instead of flipped class. I personally don't like flipped class. I doesn't suit me that's all I can say
	Flipped classes can be easy to fall behind in
	Keeping up with other unit, which are not flipped that makes it harder not being run in similar class
	Keeping up with the content. I tried to manage my time for this unit according to the unit plan but most of the time we seemed to be ahead of schedule in class, this made preparing for classes more demanding than if we stayed on schedule
	Printed sheets at every session were another interesting method that I found it challengeable and it was useful as you had to work with other students
	Very difficult/near impossible to keep up at end of semester
	Takes out a lot of time
	You need to have at least a computer for applying the flipped class model to your study style. It would be complicated compared to only hard copy handouts and also makes more difficult to take notes in MP4
	The temptation to leave it and do it next week is always there
	Check the unit schedule regularly to make sure you are preparing for the correct chapters and keeping up with the discussion sessions
Learning and cognition	It was a completely new way of learning which took a while to get used to
	Trying to understand things by myself
	It takes too long but it is really effective
	I focus better with face to face delivery of content rather than watch pre-recorded lectures
	Discussions in the flipped classes challenge us to learn and study more
	If you're not familiar with the setup of class, can take some getting use too, but when you properly get into the process of the flipped class model then it feels beneficial
Pre-class preparation	If all my classes were flipped I may battle to have time to watch all the lectures before the lecture as it would be very time consuming but I suppose worth it in the long run
	Staying on track with the content, as I sometimes forgot to prepare, I would then have to do double before the next lecture
	If the days before the class you had something from a another unit that needed a lot of focus due to assessments, and the flipped class can be put the side, and then make you feel unprepared for the class sometimes
	Finding extra time to watch the lectures

(continued)

Table 12.4 continued

	Student comments
	I had to give more time before class than after class—which I was used to, and so it took me hard time to break that habit of learning
	Finding the time to review the material prior to the lecture
	Had to make sure you prepared before class or you didn't get the full benefit of the discussion
	Having to watch an entire lecture and prepare for the class is more time consuming than just actually watching the lecture which is 45 min–1.5 h long. You actually have to take notes. If this isn't done it feels like a waste of time coming into class because you are unaware of the content
	If by chance I do not have an opportunity to go through the slides and chapters before the lecture then I a feel lost during the lecture. This occurred multiple times during the semester during submissions for other units
	Added pressure to prepare before classes (only becomes a problem towards the end of semester)
	Flipped classes somehow make us manage our time more efficient because we need to prepare before attending the classes otherwise we don't know anything
	I failed to watch lectures for one week and attending the lecture was not extremely useful, I would imagine that people who never prepared would feel lost in lectures
	If you hadn't prepared before the lecture, it was difficult to follow
	Been prepared for the flip class
	Good time management required to stay prepared for classes
	Not preparing discourages you from attending class as your time would be better spent catching up, rather than struggling to understand the presumed knowledge during class time
	As this was the first time doing a flipped class it took me a while to get into the habit of the system

feedback (responses) is presented in each table under three subheadings determined post-survey: active learning and unit engagement; learning and cognition; and pre-class preparation. For brevity, these tables do to encompass all the textual feedback received but instead capture samples of the feedback under the different subheadings.

12.5.1 Research Question 1

Amongst the merits identified by students in relation to the flipped class model applied to thermodynamics, is that it appears to be a more engaging student-centred approach. Some feedback also indicates it is a framework which better addresses the specific needs of each learner rather than applying a "broad spectrum approach" of coverage (using the choice of term from one respondent). The nature of classes also provides more opportunity for student-to-student interaction as well as the ability to ask questions (from the lecturer). Whilst the upfront availability of class lecture materials (via the LMS) means students are more familiar with the class coverage (probably in line with blended learning), the application of handouts and discussion style environment (rather than a transmissive lecture) helps students gauge learning, but simultaneously provides a stronger motivation to prepare. Student comments also identify that whilst the flipped class model has merits in relation to their learning, it does also put more of the responsibility for learning on their shoulders.

12.5.2 Research Question 2

Challenges with the flipped class model include having to find sufficient time to prepare before coming to class, particularly if learners are both studying and working at the same time, if assessments (from other units) are also due or towards the end of semester when study time allocation becomes scarcer. This highlights that whilst some students clearly see the merits associated with flipped classes, more effective time management may be needed on their part and some will take time to settle into the new framework. However, lecturers will also have the challenge of staying on-track with the declared schedule of class coverage to help students identify the material needed for preparation before attending. The offering of other units of study, using traditional lectures, also poses a challenge in terms of L&T style consistency. Some students also appear to favour, or are better accustomed to, face-to-face lectures and the traditional style lecture. The availability of (off-campus, at home) computer facilities is also an issue that should be kept in mind in relation to the effectiveness of applying a flipped class model.

12.6 Summary

Technological developments as well as the wider interest into flipped classes and its adoption by lecturers stir debate into the merits of continuing to utilise traditional lectures if teaching materials are already made available online. The need to adopt more student-centred L&T also means a greater emphasis should be placed on addressing the needs of the individual learner and helping them develop an active approach to learning. It is therefore not surprising that same have asked “shall we mourn the passing of the university lecture?” (Forsey et al. 2013). There is, however, another perspective to consider which is that “the lecture model-putting dozens, hundreds, or even thousands of students in a room with a professor-endures because it makes economic sense” (Berrett 2012). Other challenges to implementing flipped classes relate to the availability of (fast) online and computing access to help enable pre-class preparation (Bergmann and Waddell 2012).

Whilst this chapter does not seek to promote flipped classes as the overriding or quintessential model to running study units, it has shed light on two aspects which are important for those considering moving into flipped L&T: transitioning students into the new model and subsequent implementation and design of class time activities. In doing so, the study has also presented some student perspectives relating to the merits and challenges of flipped classes. The above has been contextualised in an engineering thermodynamics unit moved from the traditional lecture to a flipped class model. The case study has also demonstrated that moving into flipped L&T can also be done with modest additional resource requirements. Whilst students do perceive merits with flipped class learning, some of the challenges reported relate on the ability of effectively managing time so as to achieve pre-class preparation, particularly if students have appreciable work-related commitments or other assessments due for submission.

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Chapter 13
A Technology-Enabled Flipped Classroom Model

Paul Gagnon, Redante Mendoza and Jan Carlstedt-Duke

Abstract This chapter presents the approach taken by LKCMedicine, NTU Singapore to re-imagine the learning and teaching paradigm. Building on the creative and skilful weaving of the strands of technology, curriculum and pedagogy, we create a unique DNA. Central to the development of the LKCMedicine, DNA is the replacement of a lecture-based curriculum via a rich and seamlessly integrated technology-enabled team-based learning (TBL) pedagogy. To that end, we present how our mobile technologies play a key role in ensuring that pedagogy remains at the forefront of the learner experience. The chapter outlines how to exploit mobile and tablet technologies to (i) dispense with face-to-face lectures, (ii) facilitate personalised learning, and (iii) actively engage students through extended communication opportunities.

Keywords E-Learning · Flipped Classroom · Team-Based Learning Pedagogy · Learning and Teaching DNA · TERESA Learning Framework · Technology Enabled Learning · Blended Learning · E-Learning Ecosystem · Mobile Learning · E-Portfolio · Virtual Library · Curriculum Management System · Learning Activity Management System

13.1 Introduction

In 2010, Nanyang Technological University (NTU), Singapore and Imperial College, London (ICL) embarked on a collaboration to create Singapore's 3rd medical school, known as the Lee Kong Chain School of Medicine (LKCMedicine). Apart from a

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mandate to address the primary healthcare needs of Singapore's ageing population, LKCMedicine was also challenged to adopt a new educational model which made extensive use of twenty-first century information technology to enhance the medical education curriculum. Much of the literature with respect to what has been done to date in more recently established schools, both in Singapore and abroad, reflects existing eLearning patterns/norms, i.e. platforms are adopted which are cost-effective, scalable, supportive of flexible distribution of content, as well as facilitative of information exchange between students and faculty. In short, Learning Management Systems like Blackboard, Moodle, Sakai are adopted which support the delivery of content, collaboration via discussion boards and rudimentary learning analytics around clicks and access to course materials and communication tools therein.

Accordingly, this chapter demonstrates how LKCMedicine weaves the threads of technology, curriculum and pedagogy to construct its own teaching and learning DNA. Further, we showcase our re-imagining of the *blended learning* or *flipped classroom* narrative. This required managing three main challenges: (1) conceptualising a learning framework capable of integrating all aspects of learning in both a digital and physical environment; (2) developing an infrastructure capable of supporting the integration of disparate instructional systems deemed essential to the delivery of a highly mobile, paperless Team-Based Learning (TBL) curricular experience; (3) ensuring that all E-Learning innovations are extensible, insofar as possible, to the greater NTU learning community.

13.2 The Flipped Classroom: Constituent Elements

The term '*flipped classroom*' is a useful metaphor to describe what, in many instances, has been conventionally accepted over the past ten years as '*blended learning*'. It is also instructive to note that the term '*blended learning*' has been around since the early 1920s when it was known as 'supervised correspondence study' (Bonk and Graham 2006) and in our context here at LKCMedicine, the terminology of the '*flipped classroom*' is best understood as the appropriate mix of eLearning and face-to-face (F2F) instructional design principles and processes to create the necessary 'conditions of learning', that is, '…[whereby] certain observable changes in human behaviour take place' (Gagne 1977).

This key educational principle, that is, conditions which lead to observable changes in behaviour, is central to the strategy and pedagogy we pursued in seeking to integrate activities, resources, support and assessment known to be consonant with existing and effective (F2F) team-based learning practices.

Mindful of the notion that the best recipe for success in any '*flipped classroom*' is the '*magic of the mix*'; the following are deemed essential ingredients of our own unique blend of eLearning and F2F offerings. Across all content and curriculum, our '*flipped classroom*' model aims to:

- promote and build upon the 4Cs of learner engagement: Curiosity, Challenge, Context and Control;

- facilitate what is known as 'cognitive rehearsal, i.e. I learn when I share what I learnn';
- encourage the idea of value sorting of learning materials into high value, medium value and no-value;
- validate the value of longitudinal learning which is crucial to the medical profession (Maisie 2006);
- support the presentation of multiple passes of material to promote deeper understanding;
- innovate around existing F2F and online pedagogical practices;
- ensure 24-7 access to learning materials;
- embed flexibility with respect to curriculum development, delivery and evaluation of content;

13.3 Alignment of Strategy and Pedagogy

The first order of business was to craft an E-Learning strategy to support the student experience of the LKCMedicine curriculum and TBL pedagogy. Integral to the development of the strategy was to envision what the student learning experience within a flipped classroom might look like, and then build the E-Learning ecosystem to meet those needs. Step one then was the creation of a typical Case Scenario, reflecting the way in which the students would be engaged in a learning process.

The scenario which follows represents what we consider a generalizable '*flipped classroom*' experience. It is also central to the subsequent development and utilisation of four major learning technologies which now constitute the LKCMedicine E-Learning Ecosystem. However, because the digital student is mobile we needed to ensure that the technology supported an untethered and paperless experience, with 24-h access anywhere, anytime, regardless of whether or not the Internet is available. To achieve this untethered functionality, two applications were created that supported downloading of all digital learning content, including clinical assessments, onto a tablet device for storage and eventual synchronisation with servers as and when necessary.

With respect to generalizability, we also maintain that the events that occur in this scenario closely reflect the type of learning experience possible in LKCMedicine and the rest of the university, for example, the piloted TBL model in the university's Renaissance Engineering Programme (REP).[1]

[1]The Renaissance Engineering programme was selected for its resemblance to the medical school insofar as it had a fixed curriculum and top students especially selected to meet exceptional standards of practise.

- **Scenario: Campus Seminar Room**

Chin Kiat, his teammates and the rest of the cohort arrive at their seminar room on the NTU campus. They are chatting with each other, while at the same time, starting up their iPads in preparation for their F2F session on 'The Cardiorespiratory System'. He and his teammates have connected to the WiFi network, logged into their iLKC course site and are reviewing the morning announcements. 'Any of you planning to go to that research presentation this afternoon,' inquires Chin Kiat.

'I saw that,' replies Jun-Dir,' but I thought we had agreed to a study group this afternoon?'

'We can do both, we'll simply postpone the SG until after the lecture,' replies Catherine, aka CAT.

'Can't as I have another commitment,' interjects Chin Yee.

'Not a problem,' replies Li Ching, 'We can use our virtual classroom again to meet later in the evening…say around 8:00 pm. I will volunteer to do the first presentation.'

All nod in agreement just as the faculty facilitator enters the classroom. 'Good morning everyone, I trust you all had a great deal of fun covering the assigned content for this session?' 'Good! That means you are now ready for the first challenge of the day? I am opening the gate for this week's Individual Readiness Assessment (IRA). 'Wait…he raises his index finger, 'don't forget you only have 20 minutes to answer the questions.'

All the students open the assigned IRA activity within their Learning Sequence. As part of the LKCMedicine individualised anywhere, anytime learning experience, each student, during the previous few days, has already been online and started to work through the assigned learning resource sequence, consisting of lecture recordings, pdfs, ppts in preparation for this F2F phase of their flipped classroom TBL experience.

Once the session facilitator opens the sequence 'StopGate', the students see the assigned series of 15-20 questions, with single best answer responses. These questions focus on their understanding of the foundational learning materials/resources they reviewed before coming to class.

Individually, and under closed book conditions, they work on their answers. After 20 minutes the moderator, announces enthusiastically: 'Time's Up! Please quickly submit your answers.'

All students submit their questions and advance to the next activity wherein they encounter another 'StopGate' which they know will be opened as soon as they have assembled in their Learning Teams.

All members in their assigned Teams now compare their individual online answers to the same set of questions. They decide on a Team Leader to submit, via the online 'Scratchie' (see Fig. 13.1) their agreed upon best choice of answers.

Li Ching is the Team Leader this week and takes charge. 'Okay, I can see that we all agree on answers 1, 3 and 5, but we have an even split on the remaining 7 questions. Jun-Dir, let's start with you, can you explain why you chose D….?'

While each of the 9 Learning Teams in the class repeat variations of the same exercise, the faculty facilitator goes online and in the sequence monitor reviews the overall results of the individual responses to determine which questions seem to be correctly answered and which generate significant disagreement, based on individual responses. He makes a note of the questions where there is significant disagreement to ensure that he follows-up with the whole group for clarification.

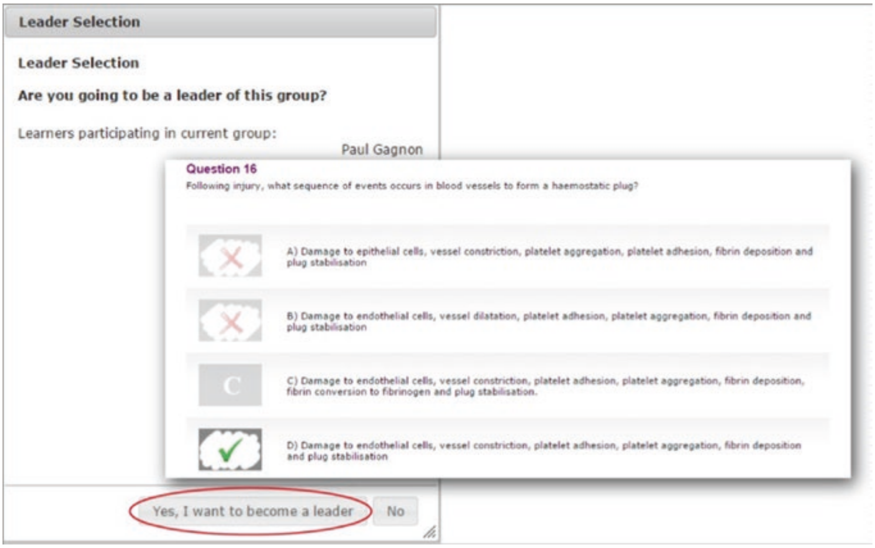


Fig. 13.1 Team leader selection and scratchie

While he completes his online review of the spread of individual answers, the 7 teams work their way through the assigned questions, discussing among themselves, deciding on their best answers, and then 'scratching' the online answers to determine if their collective choice is right or wrong. After working through the question set the Team Leader submits the results on behalf of the group. These results are recorded online immediately in their gradebook, along with Burning Questions which will be discussed later in the large group setting.

During this time Professor Lee, the Content Expert has entered the room and joined the moderator in reviewing their answers. He then takes up his position at the side of the room where he will observe and be available should further AE discussion warrant his input.

After 30 minutes, the moderator projects the team responses to each of the questions onto the overhead screen. The moderator begins by highlighting where the groups are in agreement, checks for burning questions, sees none, and moves to the 3 questions where the teams do not agree.

The team leader for each of the groups is then asked to explain its group's reasoning processes governing the final selection of their answer, and other team leaders are invited to respond. The groups are given 5-10 minutes to resolve their differences and come to an agreed decision, which they submit via the online learning app. The process repeats for each question.

Meanwhile Professor Lee listens to the discussion and when the students become confused he is called upon by the moderator to assist by clarifying ....

Guided by this scenario, the next step was to adopt a '*reverse engineer*' mindset and build the requisite learning ecosystem, as described below, to ensure the case scenario could be fully experienced. As discussed earlier, our mandate was to innovate around the integration of (i) technology, (ii) curriculum and (iii) pedagogy to ensure a tight alignment. Furthermore, such an alignment had to

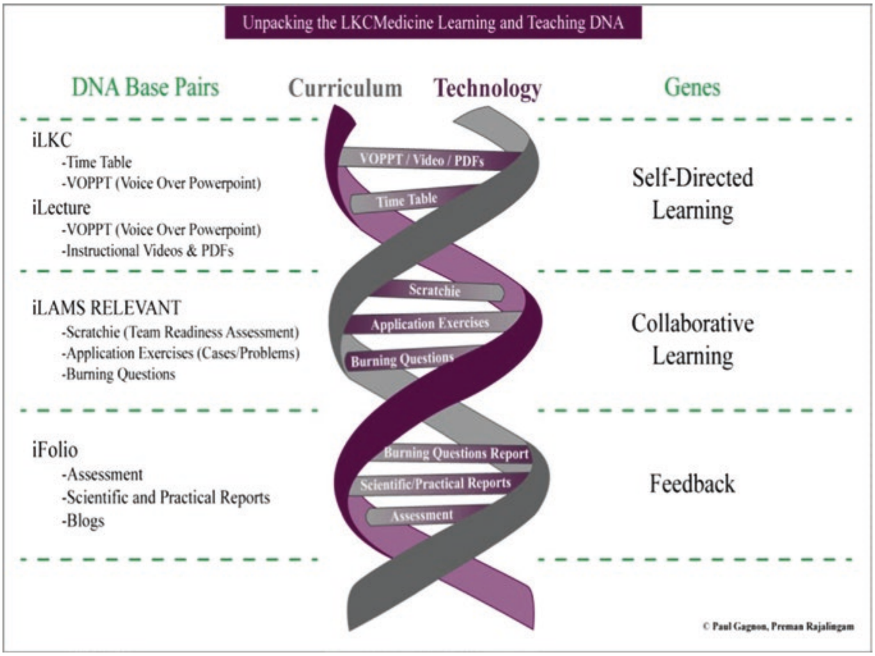


Fig. 13.2 Unpacking the LKCMedicine learning and teaching DNA

fully support the '*flipped classroom*' agenda, and key aspects thereof: an engaging, interactive and self-directed learning pedagogy. We were, in effect, creating the educational DNA that would characterise the LKCMedicine learning model and, hopefully, by extension, support the broader university eLearning narrative. Figure 13.2 represents this snippet of the LKCMedicine Learning and Teaching DNA. Strands 1 and 2 represent Curriculum and Technology, respectively. And the bonds aligning the two are the aspects of active and self-directed learning central to the experience of our flipped classroom TBL pedagogy at LKCMedicine.

13.4 The TERASA Learning Framework

In both conceptualising and building the learning ecosystem, it was essential that a learning framework serves as a general blueprint. Seminal work in this area has identified three primary elements to be considered in developing the online environment: Resources, Tasks and Support (Oliver 1999). Building on this triumvirate and replacing tasks with activities, a novel learning framework evolved: Technology-Enabled Resources, Activities, Support, and Assessment (TERASA). Figure 13.3 provides a summary of the key descriptors associated with each aspect

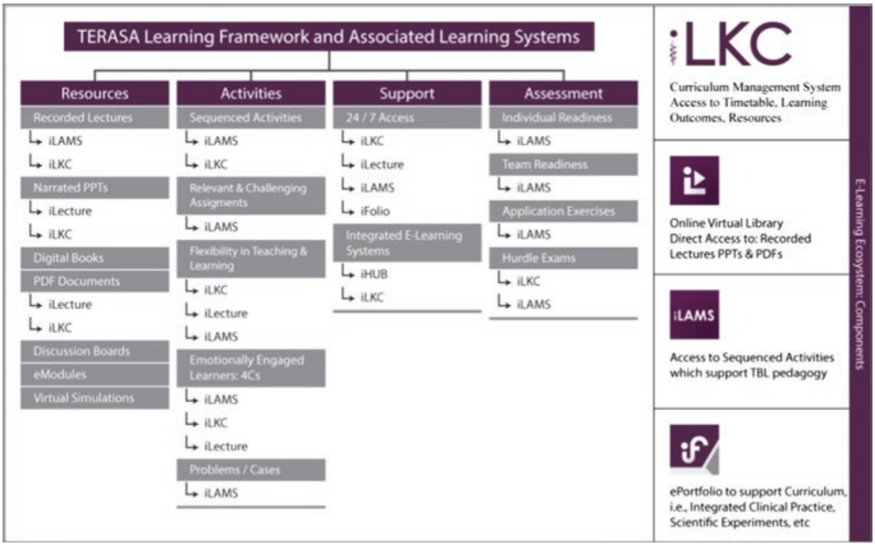


Fig. 13.3 TERASA learning framework and associated learning systems

of the TERASA Model, as well as the designated eLearning system that reflects and supports each aspect of the model.

13.4.1 The Constituent Elements of the E-Learning Ecosystem

The elements of the E-Learning ecosystem[2] combine to support student pre-class and in-class activities. As reflected in Fig. 13.3, there are four key elements forming the ecosystem. In this part of the chapter, we outline (i) what these are, and (ii) how they integrate to support the learning and teaching narrative at LKCMedicine.

[2]E-Learning Ecosystem refers to the efficient and productive integration of infrastructure, i.e., bandwidth, network and hardware; software solutions designed to run on the infrastructure, i.e., learning management systems, rich media systems; and content, i.e., learning tasks, learning resources and learning support enabled by the healthy symbiosis of infrastructure and solutions.

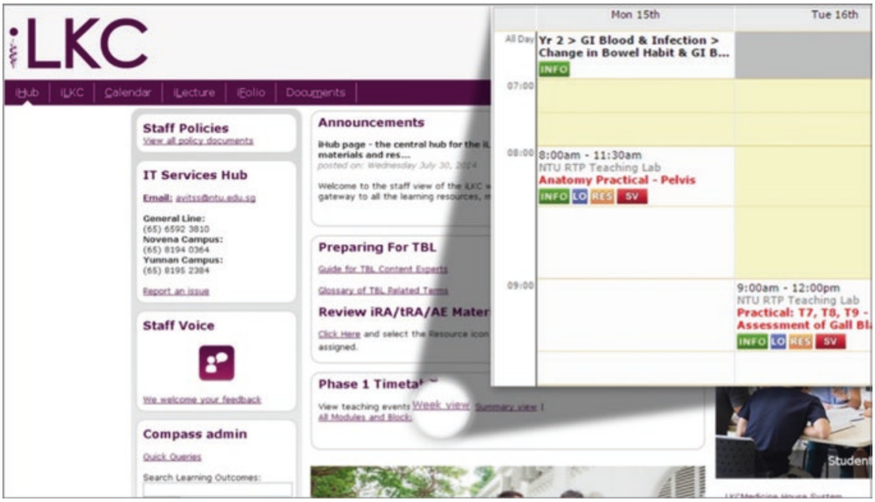


Fig. 13.4 Element # 1: iLKC—the curriculum management system

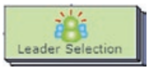
13.4.1.1 Element # 1: ILKC—The Curriculum Management System

Compass,[3] or iLKC as we have named it, is the school's adopted curriculum management system (see Fig. 13.4). Created by the University of Sydney to support a Problem-Based Learning (PBL) pedagogy, we imported and customised it to support all aspects of our Team-Based Learning curriculum. It is a one-stop point-of-access for all students, faculty and staff. Each calendared teaching activity (TA) supports and reflects the principles of self-directed learning and transparency. For example, upon accessing the scheduled TA, individuals and/or teams are provided four types of information, accessed by clicking on one of the four associated rectangular buttons displayed within the time and date of the learning activity: (1) Information (INFO); (2) Learning Outcomes (LO); (3) Resources (RES) and (4) Student Voice (SV).

Key to the integration of technology in support of pedagogy and curriculum is the extent to which it enables self-directed learning and reflects the principle of transparency, that is, I know what I am about to learn, when, where, why and how. In turn—and consistent with the idea of providing intermediate and self-directed interaction in preparation for the actual classroom TBL learning event, all the learning resources required to prepare for the classroom experience must be available within what we call the RES learning bucket. More importantly, insofar as tracking of the learning experience is concerned, all LO and RES are linked and mapped to an overall curriculum framework. The SV provides an opportunity for an immediate after the class bilateral exchange with respect to the efficacy of the

[3]Link to UoS: http://smp.sydney.edu.au.

Table 13.1 LAMS sequence activity tools

	The table explains how each tool supports the specific curriculum and/or pedagogical activity
	Available up to two weeks before the actual classroom session, students can launch the sequence and view a short 3–5 min Introduction by the content expert who created the learning materials. This ‘Booster’ or ‘Elevator Speech’ serves to ‘engage’ them by providing a brief synthesis related to how this material links to previous resources, and ‘activates’ their thinking with respect to the materials they are about to review. Ideally, it provides a roadmap to help them focus on (i) what content is really important, (ii) what content may be for information only, and (iii) what content serves as a scaffold for the next TBL or clinical session
	Within the learning resources are links to the actual resources students must review before they arrive in class. Each linked resource takes them directly to the exact resource found within the iLecture app on their iPad (see element 3, below)
	At this point, they encounter a stop gate which is opened when they arrive for the face-to-face TBL session
	The first in-class TBL activity requires them to complete an individual readiness assurance (IRA). This TRA is crafted to assess how much of the foundational knowledge they have understood during their reading of the assigned learning resources. Upon completion of the IRA, they advance to the team readiness assurance (TRA)
	This stop gate is opened when they have all completed their IRA
	This feature supports the selection of Team Leader before the release of the TRA. This allows the students to decide who will answer on their behalf the TRA and AE exercises. These answers are then automatically recorded in each students’ gradebook
	The most innovative and engaging feature, however, is the online TRA ‘scratchie’. Based on the principle of ‘scratch and win’, it allows the Team Leader, who both leads the discussion/debate, to ‘scratch’, on behalf of the team, and see whether their consensually developed answer is correct or not. If the Team is right, they see a green tick; if they are wrong, they see a red X (see Fig. 13.1). This is another example where the technology seamlessly supports a highly engaging, interactive and self-directed classroom learning experience. Individual team scores follow a standard format: 4 marks if they are correct on the 1st attempt; 2 marks if they are correct on the 2nd attempt; 1 mark for the 3rd attempt; and 0 marks thereafter

(continued)

Table 13.1 (continued)

	The next activity in the sequence process is the submission of Burning Questions. Having completed the Scratchie/TRA submissions, the Teams are encouraged to submit questions that they feel they absolutely must know before leaving the session. From a pedagogical perspective, this aspect of the technology provides an opportunity for collaborative enquiry. Teams raise issues that may have arisen during their discussions, and for which they may need further explanations. This is in contrast to the …raise your hand if you have any questions…scenarios that currently reflect higher education experiences in many institutions of higher education. These burning questions are then broadcast to the LED screens strategically placed along the walls in the TBL seminar rooms. Facilitators and content experts now have a rich and dynamic array of content from which to direct further enquiry. For example, to further support the highly engaging and collaborative enquiry, these questions are then reviewed by the facilitator and re-assigned to different Teams, who, in turn, research online and then report back to the larger class
	At this juncture, all Teams take a lunch break before reporting back for the application exercise (AE). Only then is this stop gate opened
	The AE consists of cases/problems requiring the Teams to do more research. It is open Internet requiring them to analyse, synthesise, evaluate and apply what they already know. In this respect, the AE, like the TRA, supports and encourages a vibrant and dynamic active learning environment. Team answers continue to be recorded in the background. The main difference here, from the TRA/Scratchie experience, is that all Teams share their results simultaneously by raising coloured cards to indicate which answer they chose: A/B/C/D/E—as the case may be. A sea of the same colours indicates a shared consensus; a sea of different colours allows for the facilitator to probe as to why the difference, with the Teams being required to defend their choices

classroom event. The INFO icon provides the students with information as to (i) where each teaching activity is taking place, (ii) which 'content experts' will be present and (iii) the daily transportation schedule to ferry them between their two campus locations. The LO list the specific Learning Outcomes (LO) to be met in the upcoming classroom activity, which may be a TBL, clinical, practical or lab session.

13.4.1.2 Element # 2: ILAMS—The TBL Template Sequence

Accessible via iLKC and the RES bucket assigned to each calendared TBL classroom session, the Learning Activity Management Sequence (LAMS) see Table 13.1 allows for targeted and controlled sequencing support for all pre-class

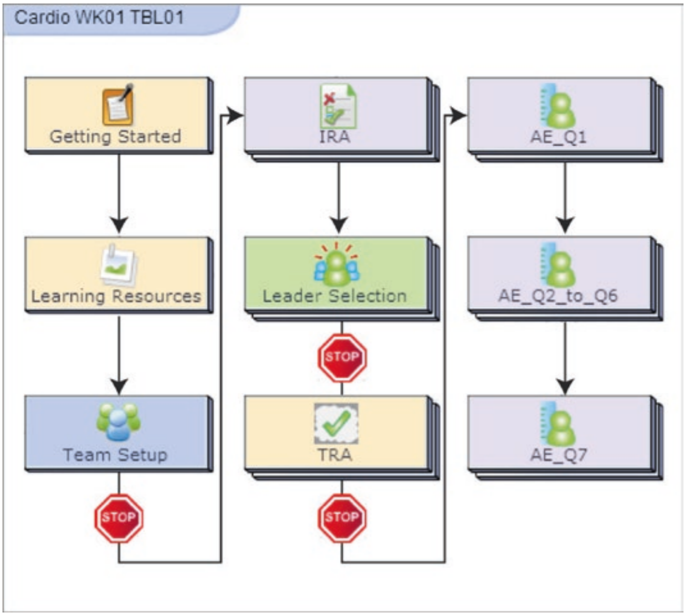


Fig. 13.5 Element # 2: iLAMS—the TBL template sequence

and in-class activities. The LAMS template, therefore, forms the backbone of the TBL delivery experience (see Fig. 13.5). Apart from the sequencing support described above, iLAMS features several key customisations unique to the TBL support process: One, it allows back-end creation and assignment of Teams before each TBL sequence is released to the students. Two, it enables Teams—before the Team Readiness Assurance (TRA) is released, to decide who will be Team Leader and thereby, answer on behalf of the Team the TRA ('Scratchie') and Application Exercise (AE) questions. Three, the online 'Scratchie'—a major addition to the LAMS tool set, replaces the traditional paper based TBL IF-AT forms now prevalent in many TBL classrooms worldwide.

13.4.1.3 Element # 3: ILecture—Virtual Library iPad Application

Consistent with the mobile and paperless strategy, and concomitant with the vision of supporting self-directed, anytime, anywhere access—irrespective of the availability of wifi or internet, we chose to issue iPads to all our students and customise apps to support the one-stop concept discussed earlier. Our first customised iPad app is known as iLecture. As can be seen in Fig. 13.6, the interface reflects a virtual library experience: Years are suggestive of library stacks, while shelves are mapped to prescribed Years, Teaching Blocks, Modules and Courses, i.e. Y1 > CardioRespiratry > Breathlessness > Human Structure and Function. Students are

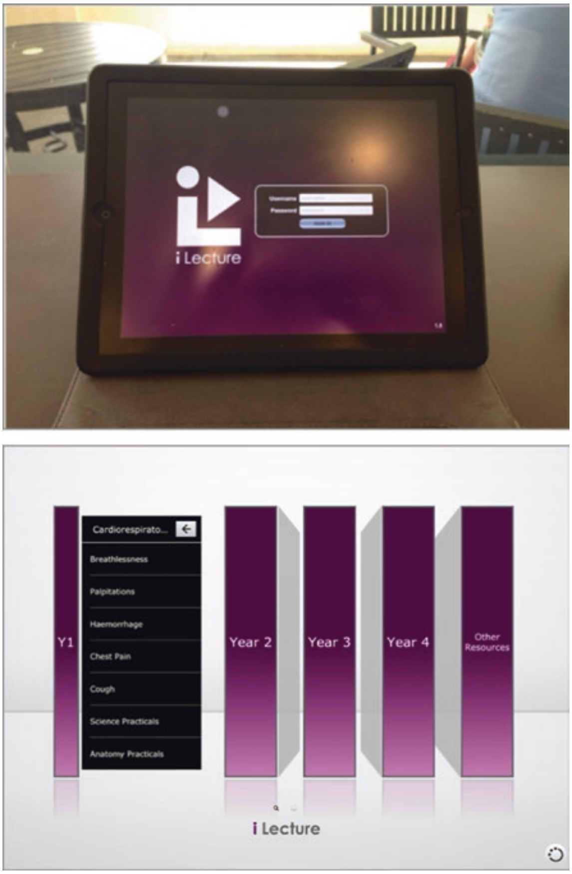


Fig. 13.6 Element # 3: iLecture—virtual library iPad application

able to download onto their iPads all 2 years of their prescribed learning resources, consisting of narrated ppts, videos and pdfs. This material can then be easily viewed and annotated, at their leisure, regardless of where they happen to be.

13.4.1.4 Element # 4: IFolio—A Purpose Built e-Portfolio

The iFolio (see Fig. 13.7) is another customised iPad app designed specifically to support all aspects of student activity associated with Clinical Communication, Methods, Practice and related assessments. The key imperative driving the development and implementation of this application was to leverage on our mobile strategy. Two factors dominated our thinking in this regard: (1) We wanted to ensure students received timely and immediate feedback on their clinical assessments; and (2) we wanted a paperless solution to the time-consuming and resource intensive manpower allocations that have, heretofore, characterised medical school

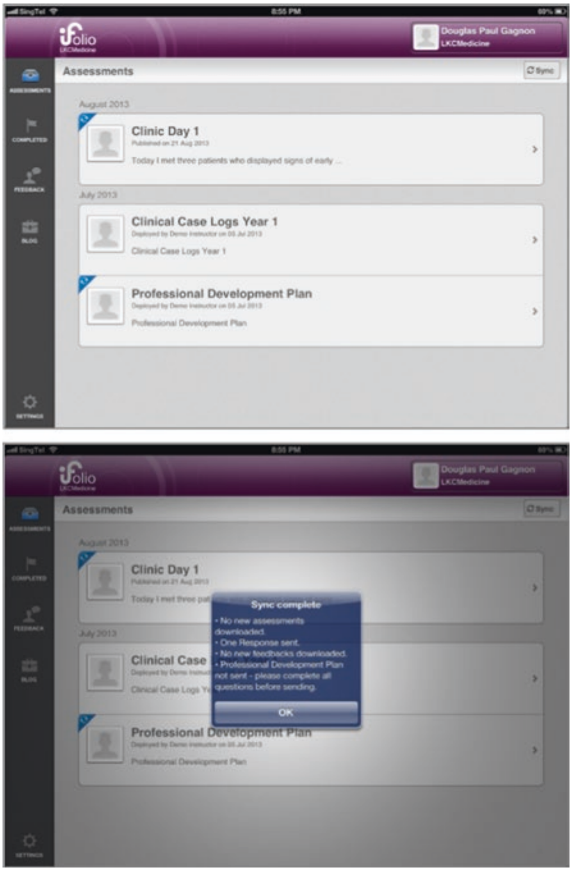


Fig. 13.7 Element # 4: iFolio—a purpose built e-portfolio

management of this aspect of the medical school curriculum. Specifically, in the past a student would be observed by a faculty member or a clinician, who would fill out an assessment form, which, upon completion, would be submitted to the school's hospital administrator. This would then be sent via mail to the school's curriculum administration centre, where the marks would be recorded, the paper filed and the student informed via mail as to the results. This could take upwards of a week or two and by that time the feedback would lack the immediacy of the moment, i.e. the student would have moved onto another topic and much of the import of the feedback would be lost. Now, with the mobility provided by the iFolio, the assessment is completed online and the students are able to view it immediately after completion of their sessions. The iFolio also features a blog to support text, graphics and self-recorded video uploads. Such self-directed and/or assigned reflections on their clinical experiences enable the development of a rich learning narrative, i.e. over time students can see how well they have responded to clinical scenarios as they move through clinical settings along the way to overall competency as a trainee doctor. Not only does this serve as a valuable personal resource for review of their activities over time, but the iFolio becomes a potentially important repository as they move forward into their residency training.

13.5 Translating the Model from the Medical School to the University

A year after the successful launch and running of the LKCMedicine TBL Learning Model, and consistent with the initial directive to develop with extensibility and scalability to the greater NTU community in mind, the University leadership decided to begin the rollout of the LKCMedicine DNA model, selectively within the University.

To that end, the Renaissance Engineering Programme (REP) was chosen as most suitable to pilot TBL. The decision to focus efforts on REP was predicated on many similarities the programme and the students share with LKCMedicine. For example, both cohorts are of a similar size, 78 for LKCMedicine's second cohort and 70 for REP. Both consist of the very best students in terms of GPA and motivation. And both follow a set curriculum, particularly within the first 2 years.

Given the similarities, it made it easier to set up REP with a similar set of resources, albeit with some modifications around the applications and supporting software. Like their medical counterparts, the REP students were provided with mobile devices (iPads), and their own version of iLecture, renamed iREP. Similar to iLecture, it supports downloading and mobile access to student learning resources. Unlike LKCMedicine, however, the REP calendar and access to LAMS is not via iLKC. Instead, the REP students and faculty use the campus learning management system called iNTULearn, a customised version of BlackBoard with an integrated version of LAMS.

Notwithstanding the similarities among students, there remained differences with respect to faculty that had to be addressed if the translation was to succeed. Unlike the medical school, where the professors knew from the onset that they would be supporting a TBL pedagogy, the engineering faculty had, for the most part, been lecturing throughout their careers. They had to be encouraged and then supported in their understanding of what it was they would need to do if they were to be successful in transitioning from the comfort zone of their lecture-tutorial style to the more collaborative and self-directed pedagogy of TBL. This shift required careful planning and coaching to ensure that both faculty and the students understood the implications with respect to the impact on their respective teaching and learning experiences.

In addition, to these differences, there were a few innovations that the Engineers requested with respect to delivery of the TBL pedagogy to support the engineering curriculum. The more notable ones are: (1) they wanted to fold in the laboratory sessions as part of the TBL sequence; and (2) they wanted to use the REP-LAMS to create an activity for peer evaluation.

In the second semester, another innovation related to the delivery of the TBL experience was proposed. The professors of these courses, recognising that the writing of suitable questions to drive the IRA/TRA and AE activities was already available online, decided to replace LAMS with third-party software owned by Pearson. Learning Catalytics was selected for the IRA/TRA exercises and Mastering Engineering for the AEs. It needs to be stressed that key to the replacement of the LAMS 'Scratchie' experience was ensuring that the Learning Catalytics for IRA and TRA provided the type of immediate feedback that characterised the LAMS 'Scratchie' experience.

Another major factor that influenced faculty to select both Learning Catalytics and Mastering Engineering was that both applications have an extensive question databank. This repository of questions, more than anything else, means that the professors are able to focus on the key aspects and skills germane to successful TBL classroom facilitation, rather than having to focus on the construction of elaborate question and problem sets. For the second semester then, the faculty innovated around the AE methodology. They incorporated problem sets requiring individuals to attempt solutions alone, followed by discussions with their teammates on the conceptual framework of their solution/s, as well as the correct answers. Upon completion of this activity, they would submit their team's solution for larger group discussion.

13.5.1 Growing Interest

Aside from the REP adoption of TBL, there were also a few professors on campus and in other schools who, upon hearing about the success of the LKCMedicine DNA model, approached us for help in converting their current courses into TBL. These courses include: Pharmaceuticals, Evolution, Chemistry, to name but a few. A note of caution here: These faculty members run TBL in a rather ad hoc fashion. This particular adaptation also fits in with the larger university agenda to promote a Technology-Enabled Learning (TEL) experience. This is characterised in the adoption of currently available technology, such as clickers, mobile phones, Google surveys—as well as physical (non-virtual) resources such as IF-AT forms, pen and paper, flipcharts and whiteboards.

13.5.2 Challenges

It is important to note and briefly discuss the challenges that first attended the implementation of the 'flipped classroom' in both LKCMedicine and REP.

13.5.2.1 Top of the List Is the Management of Technology and Infrastructure

Given the relatively short timelines for TBL to be up and running in both schools, and the pre-requisite that failure of the technology equated with a return to pen and paper, we focused on ensuring that all delivery systems could support the user load, both outside and within assigned learning spaces. This included: (a) promoting and acquiring enhanced network bandwidth, (b) ensuring adequate WiFi connectivity, and (c) testing all Team Table connections to projectors and/or LED monitors were all working properly to ensure uninterrupted the in-class online learning.

13.5.2.2 The Role of the Faculty in TBL Was also Inherently Challenging

A great deal of time had to be spent preparing the faculty to adapt to the required changes in teaching style, methodology and development of resources. A major aspect of this transformation was managing the 'mindset' change related to faculty identify in the classroom. TBL requires that faculty relinquishes their role as the central and oftentimes, sole purveyor of knowledge in the classroom. They had to learn to accept their new roles as facilitators of learning and not the traditional dispensers of information. By way of example, one professor related that he was uncomfortable with TBL because he had no more interaction with his students. Asked why, he said that it was because the 'students are learning on their own!' making him feel not so important anymore. We leave you the reader to ponder both the positive and not so positive implications of this reflection.

13.5.2.3 Student Acceptance of Ownership of Their Learning

Not only did the faculty have to be encouraged, so too did the students. Both the LKCMedicine and the REP students were accustomed to the lecture pedagogy, where test preparation and associated study habits are culturally highly ingrained. Understanding and accepting the changes required for the TBL flipped classroom was also indeed a challenge for the students. The LKCMedicine students adapted more easily, in part, because the school highlighted from the start of the admission process that TBL was one of its distinguishing features. For the REP students, TBL proved to be more challenging. These students had already started their university career with lectures and necessarily had to adjust after the fact. Their two main complaints are related to the preparation work required prior to the TBL class, and the 'burden' of having to be prepared, not only for themselves, but also for their respective teams. For example, in one of the peer evaluation sessions, some students complained that the additional reading and viewing (of video lectures) that they had to do prior to attending a TBL class required that they spend

2–3 h per week studying for a 3 AU course. When probed as to how much time they spent studying prior to a lecture class that ran concurrently with the TBL class, their response was: ‘Zero hours…We just go to the lecture and wait to be taught.’

While TBL ensures readiness, self-accountability and self-direction in preparation for the IRA, it also creates an impression among the students of a burden of accountability to the team during the TRA. For the REP students, this additional accountability to self and the team is sometimes perceived as heightened pressure which they do not feel in the lecture system. They explain that they feel the pressure only at the point of examination, which is usually once or twice during the semester.

13.5.3 Moving Forward

While it is recognised that both students and faculty will experience some initial discomfort, the visibly higher levels of student ‘engagement’,[4] collaboration and self-directed learning align well with the stated intent of the university to integrate technology, pedagogy and curriculum and thereby promote a ‘re-imagining’ of the learning narrative. To that end, the NTU plans on expanding the number of modules delivered using the TBL flipped classroom pedagogy. Within REP, for example, the new target is that by 2017, 60% of the curriculum is to be delivered via TBL. Other schools and programmes have also expressed interested in delivering some of their modules in TBL.

To promote this agenda, and build on the LKCMedicine and REP success to date, the Teaching, Learning and Pedagogy Division (TLPD) of the University holds regular workshops to introduce the faculty to the principles of TBL. The TLPD also invites professors who are ‘innovative’ and ‘ready’ to join an accelerated course on converting their courses to TBL, called ‘The TBL Boot Camp’. Run offsite this course for selected instructors requires them to design, develop and evaluate their lessons in TBL mode, building on their previous semesters’ learning materials.

An integral aspect of the boot camp course is that all participants continue to have access to all TBL Clinics before and during their TBL delivery. They are also monitored for their facilitation skills, and the students are surveyed about their experience. The performance of the class is also studied. The professors are encouraged to write, publish and/or share their TBL experiences with the community. After they successfully finish their module in TBL format, they get awarded a certificate in TBL Practice.

[4]This was evidenced by professor and content expert observation of tRA and AE discussions within and among Teams.

13.6 Conclusion

This chapter presented the LKCMedicine story of how the threads of technology, curriculum and pedagogy were constructed to form its own teaching and learning DNA. Further, we showcased our re-imagining of the *blended learning* or *flipped classroom* narrative. This required managing three main challenges: (1) conceptualising a learning framework capable of integrating all aspects of learning in both a digital and physical environment; (2) developing an infrastructure capable of supporting the integration of disparate instructional systems deemed essential to the delivery of a highly mobile, paperless Team-Based Learning (TBL) curricular experience; and (3) ensuring that all E-Learning innovations are extensible, insofar as possible, to the greater NTU learning community.

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Chapter 14
Flipping a Postgraduate Classroom: Experience from Griffith University

Kriengsak Panuwatwanich

Abstract In this chapter, a case study on the use of flipped classroom approach with a postgraduate engineering course at Griffith University in Australia is presented. The aim of this case study is to demonstrate an actual design and implementation of the flipped approach as well as to discuss various issues associated with it. The chapter firstly details the contextual background and motivation of the author for using the flipped classroom approach for this particular course. It then elaborates on the details of the design and implementation and discusses the main outcomes associated with the use of flipped approach. In particular, it provides examples of specific activities and pedagogical techniques employed during the classes. The chapter concludes with a reflection on the implementation and highlights key insights into the application of flipped classroom approach within the context of a postgraduate study. Challenges and opportunities are also discussed with the view to improve future implementations of the flipped classroom approach.

Keywords Flipped class · Postgraduate engineering · On-campus mode · Online mode · Ownership of learning · Hybrid teaching method

14.1 Introduction

While the traditional face-to-face method of learning in higher education has been challenged by an online learning paradigm such as MOOC, it has been widely argued, however, that such development in fully online education programs has progressed without the proper guidance of a pedagogical model, and this has led to growing student dissatisfaction, which in turn affects attrition rates (Alonso et al. 2005; Summers et al. 2005). In fact, this concern has long been ingrained in the nature of distance education itself, irrespective of the technologies involved.

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Although the degrees offered through distance education (in the form of present day online degrees) have become more accepted and gained legitimacy, the need for traditional face-to-face lectures and tutorials as the primary mode of delivery of a formal degree still prevails in most universities (Butt 2014; Shachar and Neumann 2010). An argument remains that face-to-face interactions of students and faculty enhance the process of "social learning", which is essential to successful education.

Against the backdrop of these two competing modes of learning, a "hybrid" teaching method was developed to capitalise on the advantages of online multimedia course materials while harnessing the benefits of traditional face-to-face learning environment. Such integration of these two different delivery modes was also carried out and proposed with the view to provide a unique learning environment that is conducive for students to be proactive in their learning. Within this environment, students are empowered to take the ownership of their learning and to use the "deep approach" to their learning, which can be developed from "a felt need to engage the task appropriately and meaningfully, so the student tries to use the most appropriate cognitive activities for handling it" (Biggs and Tang 2007, p. 24). In creating such environment, the classroom is "inverted" or "flipped" whereby "the events that have traditionally taken place *inside* the classroom now take place *outside* the classroom and vice versa" (Lage et al. 2000, p. 32). In other words, this method of "flipping" the classroom requires the students to study the course materials outside of formal class time (mainly through online multimedia resources) and the teachers to use the formal class time to carry out collaborative and interactive activities relevant to that material (Butt 2014). In this way, formal class time can be used more effectively for students to carry out higher-order thinking activities (Brame 2013).

14.2 Context

For this case study, the flipped classroom was implemented in the postgraduate engineering course offered at Griffith University in the first semester of 2014, namely 7201ENG Project Management. This course deals with the traditional and modern principles of project management such as project life cycle, project selection, project planning and monitoring, value management. Fully convened and taught by the author of this chapter, this particular course was offered in both on-campus and online modes, with class sizes of 68 and 52 students, respectively. As part of the Griffith School of Engineering's Master of Environmental Engineering Online program, this course was developed to include learning materials and resources that are designed and structured to fully support online learning. These same materials and resources were also used to teach the on-campus students. Accessible by students enrolled in both on-campus and online modes, these learning materials and resources consisted of:

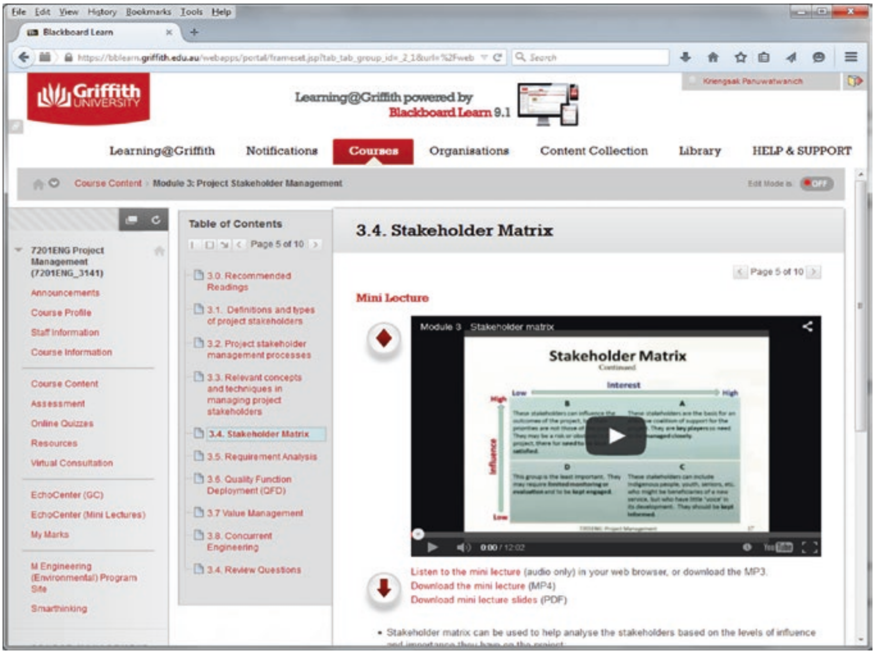

Fig. 14.1 Screenshot of the 7201ENG course website

- Web-based course contents with hyperlinks to downloadable mini lecture recordings;
- External online resources such as e-books and videos;
- Online quizzes for formative assessment purpose;
- Online discussion board primarily for questions and answers; and
- Virtual consultation sessions for online students to interact with the course convenor in real time.

The above resources were available to the students through the course website, which was hosted on the Blackboard Learn LMS (Learning Management System) platform (see Fig. 14.1). As shown in Fig. 14.1, the students can navigate through the resources using the main menu on the left pane of the webpage. Relevant mini lecture recordings were provided for each of the topics listed in the table of contents. Each mini lecture was accompanied by downloadable lecture slides. Review questions were supplied at the end of each module as a prompt for key assessable concepts. Online quizzes with instant feedback were further provided for the students to test their understanding of the contents. The marks from these quizzes were only indicative for formative assessment purpose and were not included in the final grading.

Attendance in this course was not compulsory. This means the students had the flexibility to attend on-campus classes or to study online, regardless of their actual mode of enrolment. The flipped classroom approach was used with the classes scheduled for the on-campus students at Griffith University's Gold Coast campus. In term of the learning objectives, the course was designed to ensure that the students have the ability to:

- Explain the nature of a project and its life cycle, as well as key project management knowledge areas that are critical to the management of an engineering project.
- Reflect on professional experience and compare real-world practices and theories to identify similarities and differences as well as other key issues.
- Investigate, analyse and apply various project management techniques to different and unseen scenarios.
- Critically evaluate and justify appropriate project management techniques to effectively managing various phases of an engineering project.
- Prepare a professional written report that provides a critical evaluation of the actual applications of specific project management knowledge areas within the real-world context.
- Calculate and solve problems using appropriate project management methods/ techniques.

The assessment scheme consisted of the following tasks:

- A personal reflection of the student's project management experience (individual report, 10%);
- A critical analysis of a real-word project with respect to specific project management practices (pair-work report, 20%);
- A development of a case study report of a real-word applications of specific project management practices (pair-work report, 30%); and
- An end of semester examination to test fundamental project management knowledge (individual, 40%).

The course contents were made up of eight modules, which were delivered across 13 teaching weeks. These modules covered major project management concepts including: fundamentals of project and project management; project life cycle management; project stakeholder management; project procurement management; project planning and control; and project audit and termination.

The weekly lecture time slot was typically three hours with no tutorials/workshops. The first week of the lecture was set aside for orientation to familiarise the students with the learning objectives and outcomes, assessment scheme, online learning resource navigation, and most importantly for the flipped classroom environment narrative. The last week of the course was reserved for a revision. Effectively, there were 11 weeks remained for the delivery of all course modules.

The students who were enrolled in this course had a prior engineering degree and are majority (more than 90%) international coming from Europe, Africa, South America, Middle East, and Asia. About 60% of them had previous professional work experience. It should be noted that the flipped classroom approach had never been used before in this course and other courses in the program.

14.3 Motivation and Drivers for Using Flipped Classroom

14.3.1 Motivation

In the traditional classroom approach, the author would teach the students by explaining through lecture slides that were made available prior to each class, together with the use of some case studies and short discussions where applicable. After the end of each class, the recording of the lecture was automatically uploaded to the learning management system (Blackboard Learn), which was immediately made available to the students. Although this approach was reasonably well received by the majority of students in the past, the author noticed an increasing number of comments in the course evaluation results citing that the general teaching style was merely "a regurgitation of the materials already provided in the lecture slides", from which the students can read by themselves. Through a reflection of teaching, it was identified that the author always rushed the class through all the lecture slides, attempting to cover all the materials scheduled for that week within the class time. When the author tried to engage students in a discussion, he always rushed the student to quickly conclude the discussion in order to move on to finishing the rest of the lecture materials. Coupled with the nature of a project management course, which has been labelled as not particularly interesting and exciting among engineering students, this teaching approach was deemed to be attributable to the lack of engagement reported by many students. Consequently, the author identified flipped classroom as a strategy that could capitalise on the readily available lecture materials to better engage the students.

14.3.2 Drivers

At the university-wide level, the flipped approach was already used in some courses offered at Griffith University. There was, however, no pressure from the university on academic staff to implement it. The main drivers for the author to experiment with the flipped approach are:

1. The opportunity to utilise the formal lecture time more effectively to enhance students' learning experience using various learning activities, given the availability of well-developed online materials and learning resources provided in the course that enabled the students to learn the materials in their own time.
2. Postgraduate students generally have a higher level of maturity as independent learners and are presumably likely to complete the pre-learning which is an important determinant of successful flipped classroom. In addition, the majority of them have some work experience; they would be more likely to productively engage in the discussion during classroom activities.
3. The moderate class size of the on-campus student group (68 students) in this course was also reasonably suitable for carrying out group activities without

needing the assistance of a tutor to facilitate the activities. The venue was also suitable to accommodate group activities.

The only concern was that the students were predominantly international; many might have been educated in the traditional education system and might have a level of English fluency that might be considered challenging for group activity discussions. Nonetheless, the author believed that the overall contextual factors within this specific course are adequate for the flipped classroom approach to be implemented.

14.4 Design and Implementation

The flipped classroom design employed in this course followed the model presented in Fig. 14.2, which was adapted from University of Queensland (2013).

According to the model, there are four main elements associated with the flipped classroom design that need to be considered. It is also essential that these four elements are constructively aligned with the learning objectives of this course. In other words, the flipped approach needs to be carried out with the learning objectives in mind. The four elements consist of:

1. *Independent learning*—This element is concerned with the learning process carried out by the students prior to attending a flipped classroom (i.e. pre-learning). This element requires considerations regarding information/contents/materials needed by the students to carry out the pre-learning and how to access them.
2. *Learning engagement*—This element is concerned with the kinds of activities that develop an engaging and active learning environment. This includes the considerations regarding how intra-class communication can be fostered and how to motivate the students to attend the classes. The evaluation of how the students demonstrate their learning in order to determine the success of flipped classroom also needs to be considered.

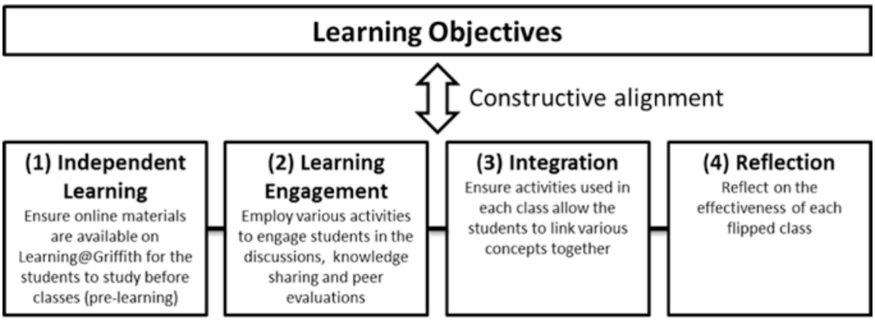

Fig. 14.2 Flipped classroom design model (adapted from University of Queensland 2013)

3. *Integration*—This element is concerned with how the learning activities can be linked together to allow the students to see the "big picture" of what they are learning. This requires considerations regarding the activities, tools or resources to ensure the students perceive the outcomes that are integrated and in line with the learning objectives.
4. *Reflection*—This element is concerned with the system required to reflect on the effectiveness of the flipped classroom, including the in-class facilitation, students' achievement of ownership of learning and shared understanding of meaning.

(see also Chap. 2 for further details on these elements)

Within the context of this course, the first element, independent learning, was fulfilled given the extensive online materials made available through the *Blackboard Learn* platform (known by the students as "Learning@Griffith") as mentioned earlier. This provided necessary environment and resources for the students to independently complete their pre-learning prior to attending the flipped classes.

To successfully achieve the second and third element (learning engagement and integration), three main sequential components were employed in every flipped class: (1) recapitulation of the key concepts required to achieve the learning outcomes; (2) group activities and/or class discussions on relevant topics; and (3) debriefing of the outcomes of group activities and class discussions that are in alignment with the learning objectives.

Recapitulation of the key concepts allowed the student to focus on the essential project management theories addressed in each flipped class. It also served as a revision of the key concepts against which the students could validate their initial understanding of the concepts. Group activities and/or class discussions served the purpose of creating an engaging learning environment as well as provided an opportunity for the students to test their understanding of the concepts and apply relevant knowledge within a given scenario. To ensure meaningful outcomes of the learning activities, a debriefing was carried out to align the outcomes of the activities with the learning objectives. A debrief included the summary of the activity outcomes via presentations by the students. This was followed by discussions on any key issues relevant to the concepts that emerged during the activities.

Out of the 11 weeks set aside for delivering the course contents in this particular course, the flipped approach was implemented as a trial with 6 classes across weeks 2–5, 9 and 10. These 6 classes were chosen based on the topics that the students would potentially benefit from hands-on activities that can directly serve as a formative mechanism to assist them in completing the assessment tasks. The remaining classes were delivered in a traditional approach with a mix of workshops and guest lecturers. Table 14.1 summarises the details of each of the 6 flipped classes along with the pedagogical approach, in-class activities and resources used. It should be noted that the "main activities" column represents those activities occurring during the class. Prior to attending each class, the students were expected to pre-learn the relevant materials.

Table 14.1 Flipped classroom activities

Teaching week	Key concepts	Pedagogical approach	Main activities (all in-class)	Resources used
2	Influence of organisational structure on project management	Problem-based learning	Designing appropriate organisational structure for different types of organisations (group work)	Activity sheet describing four different company scenarios
3	Project life cycle and work breakdown structure	Problem-based learning	Mapping the life cycle of a hypothetical project and developing work breakdown structure (group work)	Activity sheet describing Griffith library book digitisation project (hypothetical)
4	Stakeholder management and requirement analysis	Case-based learning	Analysis of Heathrow T5 opening day chaos (class discussions)	Case study documents—Heathrow T5 Project Youtube Videos—Heathrow T5 on BBC news
5	Quality function deployment	Problem-based learning	Product design using quality function deployment (group work)	Activity sheet describing lunchbox design project and QFD matrix template
9	Project scheduling (time + resource)	Problem-based learning	Project scheduling exercise and project management game (group/individual)	Exercise question + what-if scenario online game (thatpmgame.com)
10	Project risk management	Case-based learning	Brainstorming to identify project risks through a case study (group/individual)	Kuala Lumpur flood control case study Google Form TagCrowd.com

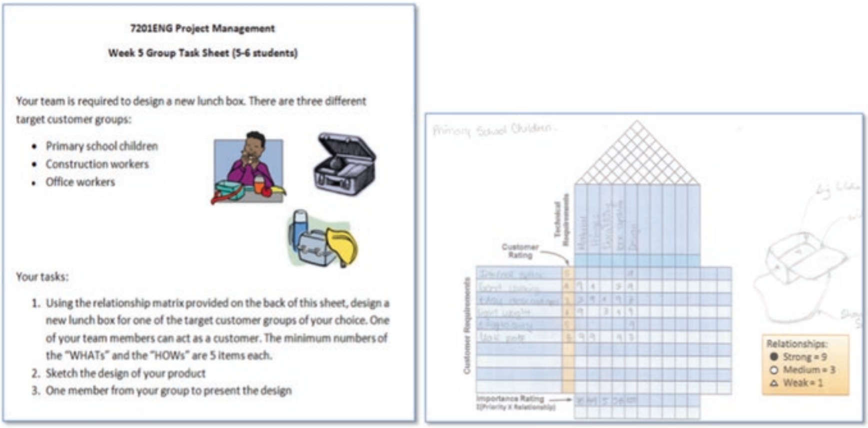

Fig. 14.3 QFD activity sheets

As shown in Table 14.1, the two main pedagogical approaches employed are problem-based and case-based learning. Problem-based learning (PBL) is an effective approach to engaging particularly engineering students in solving life-like problems by working together as a team to identify appropriate solutions to the problem (Gamble et al. 2008). Through this process, students are provided with the opportunity to develop their interpersonal and communication skills, critical thinking and problem solving capabilities, as well as project management aptitude (Du and Kolmos 2006). Meanwhile, case-based learning (CBL) allows the students to engage in an open-ended exploration, which encourages the students to debate, discuss and explore ill-defined issues in a structured, goal-directed manner (Srinivasan et al. 2007). A mixture of these two approaches was used to ensure the students could develop a combination of the above-mentioned skills. It should be further noted that these two pedagogical approaches were the main techniques used to achieve elements 2 and 3 of the flipped classroom model presented in Fig. 14.2.

To give an example, PBL was used in Week 5 to teach the fundamental concept of quality function deployment (QFD), which is to utilise the correlations between customer requirements and product specification attributes in designing a product or service. The students were asked to form a group of 5–6 to design a lunch box given different groups of customers. Each group was provided with a task description and correlation matrix sheets (see Fig. 14.3). Based on the assigned target group of customers, each group had to identify relevant requirements and the features of the lunch box that would meet these requirements. The group would have to then identify and evaluate the relationships between these requirements and features, and use these relationships to calculate the weighting of each design feature. Finally, the group would have to use this information to sketch a design of the lunch box. A representative from each group would have to also give a presentation to the class about the design. At the end, a debriefing was carried out for the

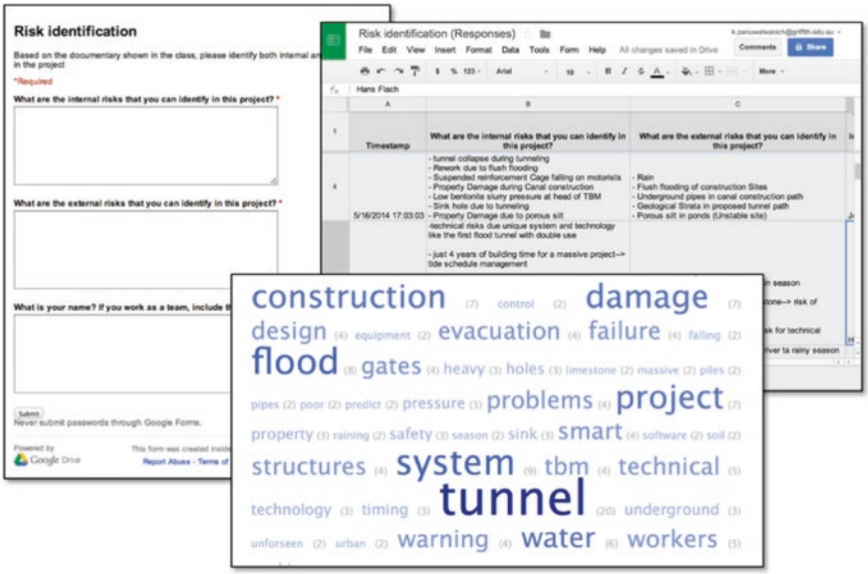

Fig. 14.4 Crowdsourcing activity in week 10

entire class to reflect on the activity with respect to the QFD applicability, benefits, advantages and disadvantages.

Another example is the use of CBL in Week 10 class, which was on project risk management. In this week, a documentary on "Kuala Lumpur flood control" was used as the case study. The students were asked to identify different types of risks from the documentary shown. As shown in Fig. 14.4, Google Form was used to initially "crowdsource" the answers from the students. These answers were then populated and processed to generate a word cloud via the Tagcrowd.com website to illustrate the common risks identified by the class. These risks were then used to initiate open discussions in respective of the project risk management concepts that the students pre-learned before the class. This proved to be an effective technique in engaging student, which addresses element 2 in the flipped classroom model presented in Fig. 14.2. At the same time, this technique also provided immediate feedback on their understanding of the topic.

14.5 Evaluation and Outcomes

In evaluating the effectiveness of each flipped class, observation was made by the author during the in-class activities. The observation was made on how well the students on average meet the learning outcomes of the key concepts by measuring the performance of the activities they carried out. The main indicators are accuracy of answers, quality of arguments and abilities to make sound justification. To assess students' engagement, the students were observed on how active they were in carrying out group activities and during class discussions; attendance was also monitored. To obtain more in-depth feedback, a formal focus group was conducted with nine volunteer students during the middle of the semester to gauge their experience with the flipped classroom approach. Overall students' grades were also compared between the face-to-face and online cohorts.

During the classes, students appeared to respond extremely well overall to this teaching method. It was observed that most students took a very active approach in carrying out the group activities, debating with each other and researching online materials to solve the problems and justify their answers. Attendance was very consistent. These indicated the achievement of major desirable outcomes of flipped classroom: active learning and engagement as well as ownership of learning. In addition, students also benefited from the pedagogical approaches employed; these are mainly learning how to: deal with uncertainties, make appropriate assumptions, and ask the right questions. At the end of each flipped class, the majority of students showed accurate understanding and judgement of the concepts learned although it was observed that some students seemed to struggle to understand some of the concepts.

In terms of the overall performance of the students in the course, final grades were compared between those students enrolled in the on-campus mode in 2014 (with flipped classroom) and 2012 (without flipped classroom, base year), to provide an objective indicator of students' achievement in these two different learning environments. Table 14.2 compares the frequency of students in each grade band. It should be noted that Griffith University replaced the descriptive grading schema (HD, D, C, P, F, etc.) used in 2012 with the numeric schema (1–7) used in 2014. Although different, all grade bands in both schemata are based on the same percentage marks. Both schemata and relevant equivalent percentage marks for each grade band are included in Table 14.2.

According to the table, it is apparent that the proportions of the 2014 students achieving the highest grade (27.9%) is much higher than those from the 2012 students (11.5%), given similar course contents, assessment schemes and student

Table 14.2 Grade comparison between 2012 and 2014 on-campus student cohorts

Grading schema	Frequency (%)			
2012 Schema	2014 Schema	Mark (%) equivalence	2012 Class (not flipped) (52 students)	2014 Class (flipped) (68 students)
High distinction (HD)	7	≥85	12	28
Distinction (D)	6	75–84	52	25
Credit (C)	5	65–74	29	41
Pass (P)	4	50–64	6	6
Fail (F)	3 and below	<50	2	0
		Mean	75	77
		Median	76	76

demographics. However, the proportion of the 2014 students who achieved the second highest grade (Grade of 6, 25%) is much lower than those from the 2012 class (D, 51.9%). The difference between the mean and median scores of these two different cohorts is only marginal. An independent sample t test was conducted, and it indicated that the difference between the mean scores is not statistically significant ($t = 0.449$, $p < 0.05$). Based on these results, it can be implied that: (1) the use of flipped classroom might benefit those students who have a proclivity for such non-traditional learning environment in achieving the highest grade, whereas (2) a number of students who preferred traditional learning methods might be affected such that their performance were merely mediocre. Given various factors can affect student performance, using overall grades to assess the direct impact of the flipped classroom implementation should be interpreted with reservation.

As a supplement, the student experience surveys results were examined to ascertain the efficacy of the flipped classroom approach. Numerically, the overall satisfaction score of the present (2014) course was 4.2/5.0, slightly higher than that of the 2012 (4.1). The satisfaction of overall teaching quality was 4.5/5.0, which is also higher than that of the 2012 (4.2). Analysing the qualitative feedback provided by the students, it was found that many students enjoyed and appreciated the benefits of the flipped classroom as they were engaged in various activities that provided opportunities for them to apply their learned knowledge and to interact with their peers. They found that this helped to better understand the concepts and was a great way to encourage the students to learn, as one student described…

> “This was definitely my favourite course this semester; the course content was engaging and interesting, and the concepts could be applied in many different contexts. I also really enjoyed the flipped class room approach; it wasted less time compared to other courses where the instructor would just regurgitate material that the student could figure out on their own. Also holds students accountable for preparing beforehand. I also enjoyed the learning activities incorporated into every lecture—really helped to solidify the concepts.”

A focus group with nine students was also conducted to seek additional opinions, and some key findings associated with how flipped classroom helps improve students’ experience derived from this focus group are summarised below:

- Flipped classroom provides opportunities for the students to apply relevant knowledge within a controlled environment. This gives an instant reflection and feedback on the students’ understanding of the concepts.
- Students felt that they have to keep up with the pre-learning every week so they are able to complete the activities well during the class. In this way, the students automatically build up their knowledge gradually over the semester rather than cramming their study at the end of the semester.
- Flipped classroom makes the class more interesting and engaging, as the students get to participate in a wide range of activities.

Although the grade comparison may not objectively indicate how the flipped classroom approach directly improves the performance of the students, the qualitative feedback clearly illustrates the value of this approach being implemented in this course.

14.6 Challenges and Opportunities: A Reflection

While the author found the flipped classroom approach provides an excellent opportunity to utilise more effectively the lecture time and available online resources to benefit students' learning experience, a number of challenges were observed, which if addressed, will surely enhance the effectiveness of the flipped classroom implementation. These challenges are described below

As discussed earlier, one of the unique elements of the flipped classroom is that the students must study the online materials prior to attending a class. This is in fact one of the determinants of a successful flipped classroom. If the students do not complete the required pre-learning, they would not be able to carry out certain in-class activities within the given time. In the present case, a number of students studied the materials just an hour before the class started, while some admitted not having gone through the materials prior to the class at all. In a few occasions, some groups were unable to adequately complete the tasks due to the sufficiently lack of required prior knowledge, which was clearly shown on the work presented at the end of each class. Although the students learned in the end what they did wrong from the feedback on their work, they could have spent a more quality time on the tasks to achieve higher-order learning objectives (e.g. analysing, evaluating and creating) within the Bloom's taxonomy (Krathwohl 2002), rather than trying to study and understand the materials, which they could have done prior to the class. The lack of pre-learning has thus reduced the value of the flipped classroom and perhaps the performance of the students.

The need to balance the "technical" contents included in the flipped classroom also emerged as another challenge. On one hand, there was a need to ensure that all the important contents are covered (for the course not to be seen as being "dumbed down"). On the other, it was not practical to include all these contents as part of the activities used in the flipped classes. Therefore, decisions need to be made on which concepts were most important and suitable for each flipped class. These decisions also had an impact on the choice of activities employed to ensure the students understand the technical contents while achieving other high-order learning objectives. In the context of this case study, the author found that some activities were very effective in achieving this aim while others were not much so. In some classes in which the contents covered were highly technical, the author felt the need to "play it safe" by reverting to the traditional teaching approach.

The author believes that the choice of activities is another major challenge where a lot of time and effort are required to fine-tune the activities such that they maximise the levels of achievement of relevant learning outcomes. In this case, assessment methods used to measure the effectiveness of each flipped classroom activity should be carefully considered and administered to gauge improved student learning outcomes. For example, mini-tests might be used in pre- and post-flipped classes to identify learning improvement.

Given the flipped classroom implementation presented in this case study was experimental in nature, the author strongly believes that there are many opportunities in using this approach to enhance learning and teaching practices within the engineering education context. The most important opportunity is that this approach provides a lot of room for teaching innovations to be utilised. In this case study, the pedagogical strategies used to underpin the in-class activities mainly include problem-based learning and case-based learning. These strategies enable the author to administer various activities ranging from team-based product design competition to online project management games in order to stimulate students' active learning and to develop critical thinking and analytical skills. The flipped classroom approach makes it possible in the future to incorporate other innovative pedagogical methods, such as gamification, into the course to further enhance students' learning experience and outcomes. Finally, implementing the flipped classroom in a postgraduate level provides a platform for students to share and learn from each other's experiences in a team-based environment. Because a postgraduate class tends to consist of international students as majority, the students will have a chance to learn how the knowledge is applied in different cultural contexts. In other words, the flipped classroom approach allows for the process of "social learning" to fully induce positive learning experiences among the students.

14.7 Conclusion

This chapter presented a case study on the use of flipped classroom approach with a postgraduate engineering course at Griffith University in Australia. The aim of the case study was to demonstrate an actual design and implementation of the flipped approach as well as to discuss various issues associated with it. The chapter firstly detailed the contextual background and motivation of the author for using the flipped classroom approach for this particular course. It then elaborated on the details of the design and implementation, and discussed the main outcomes associated with the use of flipped approach. In particular, it provided examples of specific activities and pedagogical techniques employed during the classes. The chapter finished with a reflection on the implementation and highlighted key insights into the application of flipped classroom approach within the context of a postgraduate study. Challenges and opportunities were discussed with the view to improve future implementations of the flipped classroom approach.

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Chapter 15
Flipping the Learning of Subdivision Design for Surveying Students

David Mitchell

Abstract The discussion in this Chapter will explore aspects of the development, application and evaluation of the *Land Development* course in the RMIT University Surveying program that relates to the flipped classroom. The particular example discussed is the development of an active learning model to support a broadacre land subdivision design project which was delivered to approximately sixty-second year undergraduate students. The experience of flipping the classroom revealed that the approach better speaks the language of the students, helps students of all abilities, helps busy students, helps struggling students, increases student-teacher interaction and student-student interaction. The result has been that students have a better grasp of the relationship between theoretical and practical aspects needed on graduation. We also learnt that the approach in this course will vary in its relevance across all the courses in the Surveying program. For those courses where some of the lessons may be relevant, some degree of cultural change will be needed as approaches to teaching and learning change.

Keywords Flipped class · Virtual bus tour · Active learning · Surveying course

15.1 Introduction

Core learning in RMIT's surveying degree program involves the study of cadastral surveying (defining property boundaries, subdivision, and property law) and land development (design and approval of subdivisions). As many graduates will gain employment in cadastral surveying companies, student knowledge in these areas has a large bearing on their employability and career-readiness. It is also essential for accreditation by the Surveyors Registration Board of Victoria (SRBV) as a licensed surveyor. One of the key roles of graduates of the RMIT Surveying

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program is the design of land and building subdivision layouts. Another key role for graduates is applying for approval of subdivisions through the land use planning system (i.e., *land development*).

Throughout their Surveying program our students are exposed to many practical and technical concepts and tasks, and they are very comfortable working in this sphere. However, some students have more difficulty understanding legal and policy frameworks and how they may be applied. Another area of study that moves some students out of their comfort zone is tasks that require design skills, as this is sometimes at odds with the methodical approach encouraged in much surveying learning.

This Chapter focuses on experiences in addressing these issues in the course *GEOM2075 Land Development,* as it requires students to develop both a deeper understanding of the policy and legislation related to subdivision approval, and to undertake a design of a broadacre land subdivision. The approach to teaching and learning in response to these issues has been to increasingly use Problem-Based Learning (PBL) to encourage a deeper understanding of the legislation and policy, and design skills. Student feedback reports that PBL improves their motivation to learn. Students respond very well to case studies and problems are derived from real industry projects. The Land Development course is structured around a Project-Organised and Problem-Based Learning approach. Project-organised involves flipping the classroom so that in-class activities involve project-work assisted by on-campus lectures and tutorials, where appropriate, that support the project. Learning activities are aligned through explicitly linking the theoretical and practical activities based on constructive alignment.

A problem-based approach provides students with the necessary theoretical knowledge, and guidance on how to solve the practical problems related to subdivision design. Experience has shown that many of the students respond very well to the practical project tasks related to the design of subdivision layouts, and less well to the traditional lecture/tutorial delivery model. Aligning projects with real world projects emphasises the relationship with the graduate attributes sought by employers and learning outcomes of the surveying program. From this active learning approach the students develop new understanding. In the Land Development course students are required to design a multi-lot broadacre land subdivision so that it is consistent with the planning scheme and the subdivision design guidelines that are provided in Clause 56 of all planning schemes (colloquially called “Rescode”). This is the major assessment task for the semester.

These core fundamentals have remained a central part of my approach to teaching and learning. However, it became increasingly clear that students were seeking flexible delivery models and more active learning. The difference in student learning needs was evident in an increase over time in the number of students accessing online course materials, and to the consistent positive feedback related to active learning activities. It has also become clear that there is a need to cater for an increase in diversity of learning needs, and that some students have significant external pressures that keep them away from class sometimes—and in some cases—often. These students rely heavily on the online materials for their learning.

15.2 Initial Approaches to the Design Project

The land development design project has traditionally been divided into two parts (i) a review of the evolution of design principles as illustrated by housing estates from the 70s, 80s, 90s and 2000s visited on a bus tour, and (ii) using these design principles and knowledge of the design controls to undertake a design of the project site. The first submission required a comparative analysis of the design elements of the housing estates visited, and a discussion on the evolution of design trends. The second submission involved a full land subdivision design of the project site.

My initial approach to teaching and learning for the design project derived from earlier approaches where class time predominantly involved lectures. Class time was dominated by lectures that took the students through the knowledge required to undertake the subdivision design, as well as the major aspects of the land development approval process in Victoria. Exam results showed that the better students responded well and demonstrated a good understanding, whereas on average the poorer students received lower marks for the exam than their project marks. Project design quality also varied considerably across the student group.

Lectures were supplemented selected active learning opportunities. A key component of the subdivision design project is a full-day bus tour early in the semester that requires students to analyse land subdivision design trends in the housing estates visited. Each estate is from a different era and illustrates the changes in the design trends of residential development between the 1970s and today. The initial approach was to take the students on a bus tour that visited four housing estates. The commentary provided for each estate concentrated on design elements and trends and is the basis for students to make a comparison of the strengths and weaknesses of each of these estates. Students were then asked to review each estate and comment on the design strengths and weaknesses. The message presented on the tour is very much based on contemporary practice, drawing on input from leading consultancies, and providing ideas on what are the specific elements of "good design". Students are asked to consider housing estates in ways many have not done before. A frequent comment afterwards is that it was more enjoyable than they expected. The second active learning opportunity occurred in class time following the bus tour, and involved a tutorial where the lecturers reviewed the key elements of each estate visited and used the time to clarify the requirements for the comparative analysis assignment.

Overall student feedback has consistently demonstrated that they value the design project and the bus tour as parts of the course they enjoy the most. This is evident from the formal *Course Experience Survey* (CES) in 2013: "*The bus tour is a good interactive way to explore design trends of subdivisions from different years*", and "*the major assignment (subdivision) was a lot of fun and really meaningful*".

After submission of the assignment involving comparative analysis of design trends, students would then work on their design project. Class time was largely

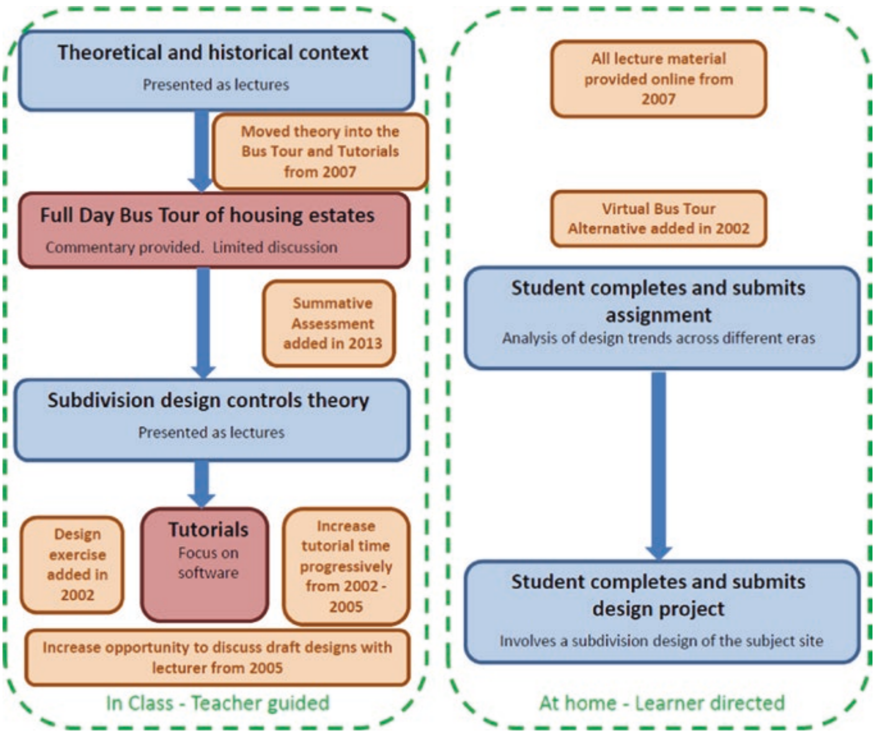

Fig. 15.1 Initial approach to teaching and learning with regard to subdivision design (activities in *red* indicate more active learning, those in *orange* are changes made to flip the class)

dedicated to the theory of the design controls in the planning system that informs their design. However, from 2002 class time was also used to do a practice hand-on design exercise that guided students through the step-by-step processes of creating boundaries for lots, roads and reserves. Other tutorials were offered to support the learning of specific CAD and drawing software as needed. The way that class time was traditionally used is illustrated in Fig. 15.1 with the passive learning activities in class represented in blue, more active learning in red, with changes to flip the classroom illustrated in orange.

While the CES scores for this course have remained consistently high, student feedback and anecdotal evidence have both been the drivers for an increased awareness of the changes in approaches to student learning and also the increased diversity in learning needs. One of the early issues that required addressing was that the time in class predominantly involved passive learning in form of lectures, with occasional tutorials. What we found was that the good students tended to do well in all assessment tasks and demonstrate strong understanding, but the poor students performed badly at assessment tasks. There tended to be a big difference in learning levels.

The response was to incrementally introduce greater amounts of active learning into class time, supported by an increased amount of resources available online. One of the challenges has been how to do this while still maintaining a high level of student engagement and satisfaction.

15.3 Development and Application

While acknowledging the continued value of high level tuition on the complex policy level aspects of planning, there has been an increased emphasis on this learning being supported by discussion and active project-based learning. My approach has been to supplement a PBL approach with providing high level tuition on the more complex policy issues. This has been predicated on ensuring my knowledge remained current through high-level involvement in industry activities, and inviting guest speakers to provide the latest in industry trends.

As illustrated in Fig. 15.1, the shift towards a flipped classroom started with more time in class being spent on active learning, supported by an increase in the provision of learning materials online. Since 2007 all lecture and tutorial materials used in class time have been provided on our Intranet (Blackboard). Blackboard usage data indicates that this is used intensively by a percentage of the class which emphasises the diversity of learning needs and styles.

Class time has been increasingly devoted to tutorials that focus on specific elements of the design project. These include more discussions in class time on the various stages of their design (site analysis, design response, initial design) before and after the site visit. In 2002, a leading consulting company was engaged to develop a tutorial that provides a practical demonstration of the process they use to design broadacre land subdivisions, and how this relates to the guidelines (Rescode). Since 2005, there has also been more class time dedicated to providing feedback on draft student designs. This approach has been the basis of a more active set of tutorials and workshops that guides the students through their design.

The increase in tutorial time has resulted in teaching staff spending more time walking around helping individual students. It is a great opportunity to assess which students are struggling with the task and have the student-teacher interaction necessary to remove any learning blocks. As Bergmann and Sams (2012, pp. 23–26) note, the benefits include increased student-teacher interaction, and class time is directed more to the students who need the most help, while the good students also benefit as they can validate their work with the teacher.

In 2002, a design exercise was introduced based on a perceived need to provide greater guidance on the practical aspects of commencing and developing a land subdivision design. It was purposely designed to be very hands-on, and has involved the use of ruler and pencil to bring the principles back to basics. This design exercise follows on from the bus tour and the report on design principles, and subsequent lectures on the subdivision design planning controls. In the design exercise students are provided with details of the design constraints on a site, as well as desired lot sizes and reserve location.

They are guided through a process for firstly creating a road network, and then eventually the lots. This has generally provided students with a good foundation in the skills required to commence their own project design. It has generally been very effective, but only for those that attend. While the tutorial materials are also provided online, usage statistics indicate that student who do not attend are less likely to work through the tutorial in their own time. Another limitation of the approach has been that students who lack the skills in CAD or drawing software packages, need to spend more time learning a new software package than other students. A refresher tutorial has been provided on one software package for students interested, and for many students this is sufficient. However, should class time be devoted to this for a small number of students? I have tended to rely on informal peer support for the individuals who need further guidance with specific software packages. However, the next step may be to develop an instructional video (or borrow one) that can be used out of class time as needed.

15.4 Virtual Bus Tour

What we found was that the best students demonstrated very good understanding of issues raised during the bus tour, while a small number of students had limited engagement in the process and their learning was limited. Another issue was the limitation in the flexibility of delivery of the bus tour learning. Although students occasionally did not attend the bus tour for various reasons, there was initially no alternative learning material provided online. In response an online "Virtual bus tour" was developed in 2002 to:

- Provide a self-drive alternative for those who could not attend.
- Supplement the issues discussed on the actual tour with an online commentary.
- Increase the learning options and opportunities.
- Accommodate a wider range of learning styles.

The Virtual Bus Tour online material was developed incorporating maps and photos and text, as an alternative to attending the full day excursion, as well as providing online material for all to use. This information is offered through Blackboard and provides information for students on the housing estates and the places visited in the actual bus tour. Students who elect to do the self-drive option draw on this material and are provided with maps that indicate the route the bus takes, and specific stopping locations linked to the online discussion. In addition to assisting students who were unable to attend the tour, it enhanced the learning experience for those who were able to attend the actual bus tour.

In 2014, the bus tour commentary was audio-recorded and these audio files will be available to students in 2015. CES responses consistently rate the bus tour and virtual tour information as one of the best components of the course. Student feedback has been very positive. An example from 2013 is: *'The bus tour is good interactive way to explore design trends of subdivisions from different years.'*

15.5 Assessment

In order to assess the depth of understanding by the students of the theory presented, a combined formative and summative assessment model was trialed in 2013. The assessment provided an opportunity for students to attempt previous exam questions at the time the theory was presented in class and to gain feedback on the quality of their answers prior to attempting the exam at the end of the semester. This involved substantially altering the class time to commence with a shorter lecture followed by the students attempting a question from the formative assessment that tests knowledge of the lecture material presented in that session and allows for group discussion. Lecture materials were available on the University's learning management system (Blackboard) providing students with the opportunity to review these materials prior to the relevant class.

Time was made available at the end of each session for students to work in groups to provide an answer to each question. While no directions were provided on how to organise themselves in groups, most groups divided the task up with each person preparing a response to a part of the question. Each group was then required to submit their final answer by the following morning. Students who cannot attend the class can read the material on Blackboard prior to the class and submit electronically.

As Bergmann and Sams (2012, p. 87) point out, formative assessment in class provides the opportunity for the teacher to have a dialogue with students:

> As we interact with our students, we are constantly having a dialogue with them. We are making sure they understand the learning objectives. We are prodding them and pushing them to learn as deeply as they can. A key component of this is our questioning strategy.

This has been the experience with the formative assessment in Land Development. It provided an opportunity to interact with students and address their level of understanding of the question asked, how to structure answers, and also to identify students who may be having difficulty understanding the concepts.

Student performance in the middle levels (i.e. Credit and Distinction) appears to be the most improved, when compared to assessment they undertook prior to the formative assessment and the exam. These are often the students who have good skills in undertaking the practical aspects of the course, but some difficulty in articulating the theory around this practical work. It is these students who appeared to benefit the most from the in-class discussion around how to answer the question to the required standard and the key points (Mitchell and McLaughlin 2014, pp. 555–563).

15.6 Feedback

Providing effective feedback to students is a key to development of their knowledge. Students desire both timely and detailed feedback and this has increasingly become a time challenge for teaching staff. In Semester 1, 2012 the quality of feedback was considered to be inadequate and this was reflected in the student responses in the Course Evaluation Survey that year. This included Good Teaching Scale (64.7%) and Overall Satisfaction Item (82.4%) scores which were lower than the average for the previous 5 years. This was also reflected in specific CES comments about the need for increased feedback on assessment tasks.

In response, I implemented the use of an e-Portfolio (Google Sites) to improve the breadth and timeliness of student feedback for projects in cadastral surveying and land development courses. Students were able to "share" their 'site' with employers, peers (if they choose) and graduates to gain additional feedback on the quality and technical competence of their work. The CES responses in 2013 were greatly improved, with the response to the question "The teaching staff normally give me helpful feedback on how I am going in this course" improving from 53% (in 2012) to 94% (in 2013). Similarly the response to the question "the staff put a lot of time into commenting on my work" improved from 59 to 88% during the same period.

15.7 Evaluation

Overall student feedback has been consistently positive over a number of years. The CES Good Teaching Score for the Land Development course has averaged 84% (agree or strongly agree) since 2009 with an average Overall Satisfaction Index of 95%. When asked "What do you most like about this course" the most common responses can be categorised as:

- The direct link between the material presented, assessment and what they will be required to do on graduation.
- The bus tour is enjoyable and interesting.
- The design project is related to the theory, is industry based, and enjoyable.

Feedback from graduates also supports that the broad approach to teaching and learning in this course promotes interest and improved understanding. For example, a comment from a 2013 testimonial was:

> I still look at estates and subdivisions and think of when they may have been designed due to what I learnt. There are many other aspects of this subject that I think of day to day. I completed land development 3 years ago.

However, it is important to consider whether the students have been able to conduct higher quality activities as a result of the move towards a flipped class. This is a much harder question to answer and few definitive conclusions can be drawn. When asked on their CES to respond to the question *"This course contributes to my confidence in tackling unfamiliar problems"* student responses have varied over the last 5 years (see Table 15.1). The dip in 2012 appears to be linked to the overall reduced satisfaction related to insufficient feedback. However if we look at the other years, there seems to be a strong positive response.

Another measure is the consistency of exam and project performances. Figure 15.2 illustrates the exam and project scores from 2003 to 2014. Performance in the project seems to be relatively consistent throughout this period. This probably means that innovations in teaching towards the flipped classroom have helped maintain the quality of work despite a recognised change in learning needs and styles over that period. In other words we have just kept up with student needs, and more evolution will be required going forward. However there appears to be a small increase in the exam performance during this period. The conclusion that may be drawn here is that the combined benefit of the changes made to teaching and learning have had a small impact in real terms.

Another parameter is the student perceptions of how these innovations help them. Following the introduction of the formative/summative assessment model, students were asked in both 2012 and 2013 the general question "Assignment 1 was useful in preparing me for the exam".

The results presented in Table 15.2, show that the average Likert response fell between "agree" and "strongly agree" that the assignment was useful in preparing the students for the exam.

Table 15.1 Likert responses to the question "this course contributes to my confidence in tackling unfamiliar problems"

	2009	2010	2012	2013	2014
This course contributes to my confidence in tackling unfamiliar problems	93%	100%	53%	88%	88%

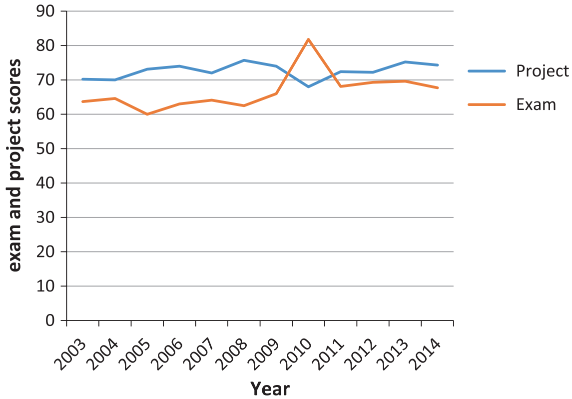

Fig. 15.2 Exam and project scores since 2003

Table 15.2 Responses to the questionnaire (Mitchell and McLaughlin 2014, p. 6)

	No. of responses	Average Likert score
2013	29	5.9
2014	19	5.6

However student responses on the CES in 2013 and 2014 (in particular) have emphasised a desire for even more lecture and tutorial material and resources to be placed online (Blackboard). This will be a focus of future changes. This seems to suggest that students are comfortable with and have embraced the flipped approach.

15.8 What Can Be Improved for the Next Iteration

This Chapter has outlined a process of gradual evolution towards a more flipped classroom based on active PBL, and that has evolved in response to student feedback. Student feedback and improved understanding indicates that there is justification to take the flipped class concept further—but incrementally. An observation is that more effort is needed to take the poorer students on the journey by explaining how this flipped approach can work for them. Students need strategies to improve their organisational skills and how to use their time in class more effectively. For example, more time needs to be spent in class on developing student skills in report writing and plan preparation with teacher input.

Entwistle and Peterson (2004) reinforce the importance of the coherence across all components of the teaching–learning environment, as well as an alignment of all these teaching and learning elements with clearly defined educational aims. My experience has been that weaving a clear and integrated narrative around the learning aims and objectives for the land development course is key to engagement and effective learning. This combination of coherence and clearly defined aims is important for all students, but particular for the poorer students.

A challenge is to address the pressures that take some students away from both their in-class and online learning activities. Some of these enhancements will begin by asking the question: "What activities demand my physical presence"?

The next evolution is to leverage technology to increase interaction with students. One way to do this is to complement some of the online theoretical content with online video material that summarises key learning for this task, and to further develop the tutorial sessions to be even more active and increase participation. As Bergmann and Sams (2012) note, students like learning online as it speaks their language and is consistent with the increase of digital devices both in the class and outside of class time.

The design exercise has been important in providing students with the skills to commence their project design. More class time needs to be spent on related activities, including the preparation of their final report and plan preparation and presentation. Some students each year have identified, from doing the design project, that they need more assistance in using CAD packages for the design. To assist all students, the development of instructional videos will need to be considered and placed online for those who can't attend tutorial sessions. Alternatively, suitable instructional video material may already exist that may be applied to the land development course.

15.9 Final Thoughts

Our understanding of the variety of ways students learn has increased, but we have not yet caught up with our provision of alternative learning materials and resources.

Student feedback has increasingly emphasised two aspects—the value of face-to-face tuition on project based activities, and online access to learning materials. Student feedback and class attendance numbers consistently support that, on any given day, there is a relatively even split between students who seek the classroom experience, and those that prefer online delivery. There is still a role for lectures where key knowledge can be presented (especially foundation knowledge, or specific technical learning). However this needs to be provided in a way that also caters for those students who prefer only online access to course materials.

Another lesson has been the importance of learning through action and contextualising through discussion. Practical projects and tutorial sessions are where we see the real value in being able to add value to online content, and enrich material presented in lectures. They provide the opportunity for students to:

- Work in groups and undertake group discussions.
- Have face-to-face discussions with fellow students, the lecturer, tutors.
- Undertake active learning.

They also provide the opportunity for academic staff to:

- Gauge the level of understanding of the group on a particular issue.
- Get to know students through one-on-one dialogue.
- Assess the understanding of each individual student.
- Assess whether individual students are experiencing non-academic problems.

We have to blend together opportunities for face-to-face tutorials with online access to lecture materials, podcasts, in a way that allows students to access these resources from their preferred device at a time that suits them.

15.10 Conclusion

Our experience of flipping the classroom is that the approach better speaks the language of the students, helps students of all abilities, helps busy students, helps struggling students, increases student-teacher interaction and student-student interaction. Online instruction at home frees class time for learning.

We believe that the result has been students who have a better grasp of the relationship between theoretical and practical aspects needed on graduation. However, the approach in this course will vary in its relevant across all the courses in the Surveying program. Also, for those courses where some of the lessons may be relevant, some degree of cultural change will be needed as approaches to teaching and learning change.

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Chapter 16
Flipping a Collaborative Classroom to Gain Deeper Understanding of the Health System

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Abstract The Health Systems and Policy course provides a broad introduction and overview of the Australian health system but has had to overcome the challenge that many students anticipate a dry and boring course of limited relevance or interest. We decided to take a different and more integrated approach that would foster deeper learning through the introduction of collaborative processes that placed students at the centre of class discussions. Learning objectives, teaching activities and assessment were realigned, and activities were developed to establish foundational knowledge

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outside the classroom that would inform and support discussion, reflection, engagement and debate within the classroom. The following chapter maps our teaching team's journey through the redevelopment of The Health Systems and Policy course. The chapter is divided into four sections. The first describes what we did, the second outlines how we did it, and the third reflects on our experiences. Some members of the teaching team maintained regular diaries of the semester; these reflections inform section three. In the final section, we briefly discuss some 'next steps'.

Keywords Teaching · Collaborative learning · Active learning · Flipped classroom · Student engagement · Team work · Public health · Higher education · Undergraduate

16.1 Introduction

16.1.1 How Did We Get Started?

Our teaching team is responsible for PUBH1103: Health Systems and Policy (HSP), a first-year core course in the Bachelor of Health Sciences (BHlthSc) programme at The University of Queensland (UQ). The programme provides a pre-clinical and professional pathway for students seeking a career in health. Across the programme, students engage with courses covering a range of disciplines including biomedical sciences, public health, health behaviours, research methods, ethics and health policy.

Health Systems and Policy provides a broad introduction and overview of the Australian health system. It examines: the key contributors to health care; the functions, financing and policy processes within the system; use of the system and associated care pathways; and contemporary issues facing health policy makers. The course aims to establish a critical perspective by introducing students to the key stakeholders and decision makers linked to health policy making processes. It also weaves a 'social determinants of health' perspective through the curriculum, to ensure students develop awareness of the impact of health systems and policies on different population groups.

Health Systems and Policy has had to overcome the challenge that many students anticipate a dry and boring course of limited relevance or interest. However, in recent years the health policy environment has been a vibrant space generating much food for thought through national and state elections, system reform agendas and intense political and media debate. The teaching team intentionally works to integrate 'hot' policy issues into the theoretical and historical content of the course. Students frequently comment the course was more engaging than they anticipated.

> I thought the teaching team did a really good job at making a course that I expected to be boring, quite interesting. (student, SeCat)
> A subject that I thought would be really boring (I'm sorry—it's just policies and government) [was] very enjoyable and one of my favourite subjects. (student, SeCat)

With all this in mind, the old adage 'if it ain't broke don't fix it' could have been used to justify maintaining the course's existing structure and format, but the teaching team became increasingly concerned HSP was becoming stale and not achieving higher-level learning outcomes, so we decided to take a different approach.

A core driver for course revision was our commitment to fostering critical thinking and deeper learning (Biggs and Tang 2011; Ramsden 2003). Reflecting on existing course materials, we were cognisant that our efforts to foster critical thinking were based on the critique of materials in the classroom, largely relying on the transfer of knowledge and skills from the teacher to the student: clearly a limited approach (Dall'Alba 2005; Whetten 2007). To redress this, a more integrated approach to delivery that would foster deeper learning was sought through the introduction of collaborative processes that placed students at the centre of class discussions (Biggs and Tagg 2011). Learning objectives, teaching activities and assessment were realigned, and activities were developed to establish foundational knowledge outside the classroom that would inform and support discussion, reflection, engagement and debate within the classroom (Biggs and Tagg 2011).

The following sections map our teaching team's journey through the redevelopment of HSP. In reflecting on this journey, we have endeavoured to draw on the voices and experiences of students gathered through two brief in-class surveys and group discussions recorded via Padlet (student response software). The university also conducts a Student Evaluation of Courses (SeCat) in the final weeks of the semester. The SeCat survey covers eight questions to explore students' perceptions of a range of elements including feedback processes, learning materials, aims and goals, and assessment. Responses are recorded on a Likert scale ranging from 5—outstanding through 1—very poor. A measure of overall satisfaction with a course (Q8: 'Overall, how would you rate this course?') provides a basis for monitoring trends across the university. The SeCat evaluation also includes two open-ended questions: what were the best aspects of the course, and what improvements would you suggest? The response rate to the SeCat was 77% (n = 100). The data collected across the semester for this chapter were approved by the university's Behavioural Research Ethics Committee.

16.2 What Did We Do?

In 2014, we flipped our teaching delivery and moved to a collaborative classroom (Johnson et al. 1994). The course had followed a relatively traditional method of delivery using a two-hour lecture and a one, or one and a half, hour (resources permitting) tutorial format which was replaced with a three-hour 'lectorial (a shift to integrated teaching and active learning space)'. By moving to a collaborative classroom, the aim was to shift students from passive to active learning with a focus on higher-order thinking skills (Johnson and Johnson 2009; Wolfe 2012). At the beginning of the semester, students were assigned to a tutorial group of up to 10 students (15 groups in total drawn from the initial enrolment of 150) and were required to sit and work with their group for the entire semester. Five members of the teaching team in addition to the lecturer worked in the classroom and were each responsible for three groups. Group discussion was interspersed throughout the lectorial to promote the co-construction of understanding and knowledge around key topics and questions (Johnson and Johnson 2009; Wolfe 2012). The collaborative classroom was new to most of our students, but many acknowledged the learning they gained from group discussions and the benefits associated with '*engagement*' (student, SeCat) with their peers:

> … the smaller groups inside of the bigger lecture group was a really great way to learn. Although it wasn't apparent to us in the beginning of the course, this learning method has really helped stimulated my learning. (student, SeCat)
>
> …the lectorial aspect which incorporated the 2-way communication characteristic of tutorial classes into a large lecture setting. This lectorial aspect made lectures highly interactive and interesting to learn, as opposed to merely listening to a long lecture. Because the lectures were interesting, I feel that I learned more from lectures. (student, SeCat)
>
> Very interactive. The group discussions were an excellent way to reinforcing [sic] material and understand different perspectives. (student, SeCat)

For some students, the need to work collaboratively with peers was an initial source of anxiety, but as Johnson and Johnson (2009) advocated, it provided an opportunity for many students to discover how participation can enhance learning and positively affect their self-esteem.

> While I was trepidations [sic] about the groups/lectorial format at the beginning, I soon found it was a great way of learning. (student, SeCat)
>
> At first I didn't like it [the group interactions] but it grew on me as I became more confident in the group and [it] became very helpful. (student, SeCat)

The benefits associated with a shift from didactic teaching to collaborative learning surprised some students who did not initially anticipate the scholarship that could be gained from working with their peers in this way. As one student commented: 'I was repeatedly surprised by my fellow students' (student, SeCat).

Although the vast majority of feedback about the collaborative classroom was affirming, this method was not experienced positively by all, with one student suggesting: 'the forced engagement actually detracts from learning and makes it very easy to disengage' (student, SeCat).

16.3 How Did We Do It?

Many changes were made to the organisation and delivery of the course, but the following section focuses on core changes made to assessment and technology. The issue of teaching space is also discussed as it is integral to teaching in this way.

16.3.1 Assessment

The Health Systems and Policy teaching team has always endeavoured to align learning objectives, teaching activities and assessment, but the changes made in 2014 were designed to further enhance the course by taking an integrated approach across all stages of the teaching and learning process. Learning objectives were closely aligned with assessment, with learning activities providing a conduit for this alignment by emphasising student-centred learning grounded in class-based activities and discussions (Crosling et al. 2009; Whetten 2007). The assessment items for HSP consisted of: weekly workbook tasks; two online modules (larger workbooks supported by readings and multimedia rather than lectures); weekly critical blogs; and online quizzes. All assessment tasks were completed by individual students, while the workbooks and blogs provided a scaffold for collaborative discussion and engagement.

16.3.2 Weekly Workbooks

To support collaborative processes, and consistent with the flipped approach, students were required to engage with materials (e.g. readings, multimedia) and complete a one-page workbook of related questions before each class. The workbooks were designed to ensure preparation and comprehension of key materials (Whetten 2007) that could then be used to springboard into deeper discussion focused on concept exploration, meaning making and active demonstration of critical thinking processes (Crosling et al. 2009). Reflecting on the workbooks in the SeCat evaluation, many students commented on the benefits for their learning.

> The worksheets [sic] were actually very relevant to each lecture, and made you have to research in advance to be able to contribute to group discussion… Best format of a course I've had all year. (student, SeCat)
>
> The weekly workbooks were extremely helpful with my learning. (student, SeCat)

However, not all students appreciated the flipped approach, with a small number of SeCat respondents commenting they felt: '*The continuous workbooks were a bit intense*' (student, SeCat) and added an additional load to their finite study time.

> I couldn't study as much for my other subjects because I was always doing the (unnecessary) workbooks for this week. I think there should be fewer questions on the workbooks - for my other subjects we don't have compulsory workbooks each week. (student, SeCat)

16.3.3 Weekly Critical Blog

The 'Eat the Week' (ETW) critical blog activity involved a brief structured weekly blog designed to assist students to develop critical thinking skills. Each week a question was posed at the end of the lectorial that focused on current policy debates and agendas at state and national level. Students were required to take an affirmative or negative position in relation to the question and present an evidence-based argument to support that position. Students could submit blogs as an independent piece or a rebuttal to another student's posting.

Box 16.1: Eat the Week Blog—Student Exemplar

The $7 GP co-payment will make the health system fair for everyone.
I believe that access to health care should be available to all within our society. Bulk billing promotes this idea of universal health insurance. The $7 co-payment could only be considered fair if it does not prevent people in need from accessing care. According to the Grattan Institute, some of the lowest income households already spend up to 20% of their disposable income on out-of-pocket healthcare costs, while the median spend for households in the highest income decile is less than 1% (Duckett 2014). A modest sounding, but cumulative, $7 per GP visit, compounded by number of family members, will stretch that percentage for low-income households even further, to a level that would prevent them from accessing health care, in order to cover other essentials such as food and utilities. It would have no impact on the higher-income households as they are not currently [sic] bulk billed. Rather than equalising the health system, the proposed co-payment would serve only to create further disparity.

Duckett (2014), *Higher health co-payments will hit the most vulnerable*, viewed 10 July 2014 http://theconversation.com/higher-health-co-payments-will-hit-the-most-vulnerable-29590

Few students provided a rebuttal of their peers' work, and the majority addressed the set questions, but they did appreciate the opportunity to 'read each other's blogs' (student, SeCat). Students also valued the opportunity to critically reflect on current policy debates and agendas.

> Application of knowledge to real-world in discussions on a frequent basis (as opposed to just theory) [through] Eat The Week blogs. (student, SeCat)

In particular, a vibrant national debate over changes proposed in the 2014 Federal Budget to increase medical consultation charges through a $7 general practice co-payment provided an excellent opportunity for engagement (see Box 1) (Williams et al. 2015).

16.3.4 Technology

16.3.4.1 Padlet

The lectorial worked through blocks of materiel followed by in-group discussion of key topics and questions. 'Padlet', a student response software that resembles electronic sticky notes (see Fig. 16.1), was used to allow groups the opportunity to feedback to the broader class. Padlet provided a safe space for students to express their ideas and ask questions during broader class discussions and the opportunity to reflect on this material after class.

> While I didn't love completing the paddles [sic] sections of the lecture, I found them extremely useful to look at when going back over the material to revise for quizzes. (student, SeCat)
>
> It was very interactive with peers as well as technology and so it was very engaging. (student, SeCat)

The use of this form of technology to support teaching was new for many in the teaching team. As a result, there was some initial apprehension about its inclusion, but the ease with which it was adopted by students and the presence of multiple teaching team members who could continue the class if there was a technical glitch, helped to alleviate these concerns. However, while Padlet provided an excellent prop for the collaborative learning environment, the students made it clear they did not appreciate its overuse, so a number of more traditional methods to support group engagement and discussion were also incorporated, including 'butcher's paper' (see Fig. 16.2). The results of these group deliberations were scanned and uploaded to the course Blackboard site.

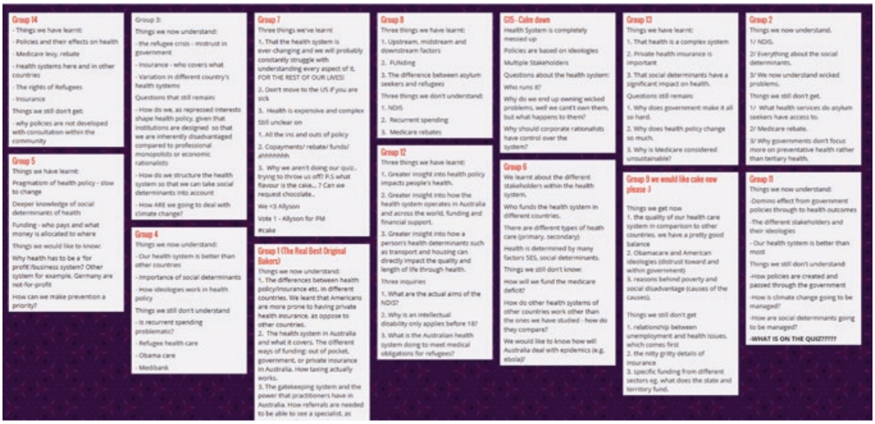

Fig. 16.1 Example of a Padlet page considering: 'three things you've learnt and three things you things that still aren't clear?'

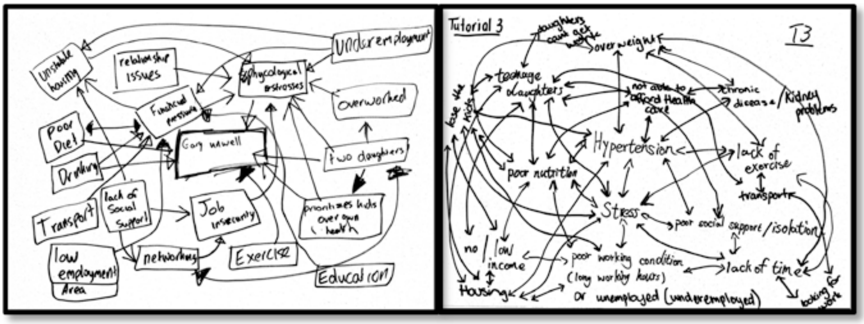

Fig. 16.2 Example of a Butcher's paper exercise: what's contributing to Gary feeling unwell?

16.3.4.2 Blackboard and the Learning Pathway

All courses at the university are required to maintain a Blackboard (BB) site as a repository for learning materials and course-related information. There is limited consistency across sites, but most include links to readings and other learning materials, interactive discussion boards and blogs, assessment information, online quizzes and links to upload assignments. The lack of consistency means that each semester students must learn how to navigate different BB sites to access essential information. The flipping of our curriculum meant that we needed to be clear on what was required from day one so students could come to the lectorial prepared. To support this process, we drew on the Learning Pathway, developed by leaders in teaching development at UQ's School of Engineering (as highlighted in Chap. 3), to step students through the course on a week-by-week basis. The learning pathway was divide into weeks that outlined what students needed to do before class, what they needed to bring to class, what we were doing in class, and what they needed to complete after class (see Fig. 16.3).

By providing a pathway that guided students through the learning process, we found they were able to meet the core requirements of the course and come to class prepared. Students also commented that the learning pathway helped them to: 'keep on top of what was required and expected in class' (student, SeCat) and they appreciated the ease with which they could navigate BB.

> I like how the course had a timeline of all the events, the blackboard page for the course was well set out (student, SeCat)

16.3.4.3 Teaching Space

The shift to a collaborative classroom would not have been possible without an appropriate teaching space. The flipped classroom approach takes teaching out of lecture theatres and into a 'flat' teaching space with active learning. We were fortunate to have access to a large stepped lecture theatre (capacity 300) that had

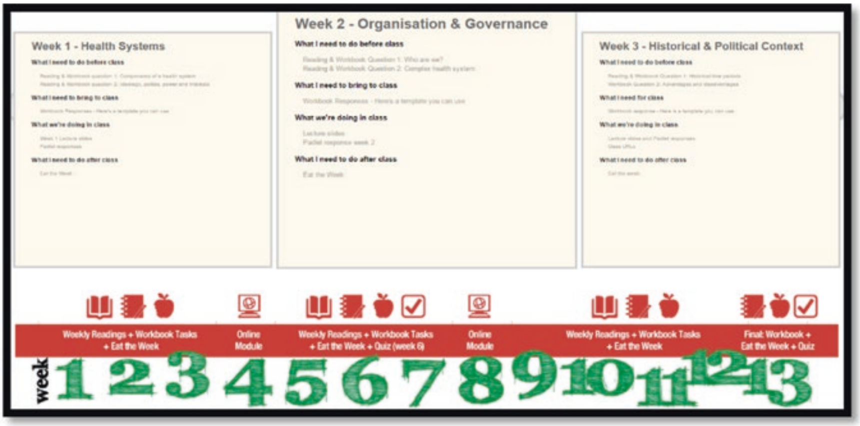

Fig. 16.3 Example of the learning pathway in health systems and policy

movable chairs and allowed students to work around the desks. All students were allocated to a tutorial group of up to 10 students and a space within the lecture theatre where they were required to sit for the semester. Five tutors/facilitators each had responsibility for three groups.

16.4 Reflections from the Teaching Team

In reflecting on the delivery of HSP prior to 2014, the teaching team believed the course was able to establish core knowledge and skills, but in line with Baxter Magolda (2012, 33), we agreed it had not done enough to support students to learn how to deal with the 'adaptive challenges' they would face outside university. Graduates must hold more than the technical knowledge required in their field, and they must also be able to exercise initiative, accept personal responsibility and practice self-direction (Kegan and Lahey 2009). The didactic approaches we had used did not support the development of these 'self-authorising' skills (Kegan and Lahey 2009, 28); rather, they reinforced reliance on authority for guidance and information. To address this shortfall, we drew on the methods outlined in Baxter Magolda's (2012) Learning Partnerships Model, to facilitate a joint partnership with students to support the development of self-authorising skills. This approach requires students to take more responsibility for their learning and the teaching team to relinquish authority over learning. This shift in the student–teacher dynamic was not a straightforward process, as the following diary entry recorded by a member of the teaching team personifies:

> I think that the lectorial format represents what might be the first step in true independent learning for these students. The format encourages us to treat students as adults who must exercise their own agency and autonomy in this class—we make ourselves available to

> those who make the effort to ask us questions and seek clarification. It's an important lesson that I think some students are grappling with (teaching team member diary)
>
> The teaching team's hard work in developing different padlet questions and encouraging debate mean none of the activities fall flat in the first or subsequent lectures and I get a sense that students understand that in this class, expectations are different. By the end of the course, I am left with a strong feeling that the students understand they have been treated as adults (teaching team member diary)

Four of the five lectorial-based teaching team members (there were nine members in total responsible for delivery, development and marking) had previously run separate tutorial classes for HSP, but none had experienced a flipped classroom or large-scale collaborative approach. Each team member was responsible for three groups, moving between them to assist with facilitating discussion and group exercises, support interactions with technology and answer questions. This change from being a core driver of discussions and imparter of information, as practiced in a traditional tutorial, to developing a learning partnership with students, engaging and supporting them to take responsibility for their learning was the source of frequent discussion and reflection in weekly teaching team meetings. From the very first lectorial, the teaching team was challenged by the shift in roles and the demands of a collaborative approach, particularly with how to spread out time evenly across groups, and ensure students understood the content, assessment and other core items.

> In more traditional tutorials, I am more accepting of student demands because I carry the responsibility for their learning only on my own shoulders. This new format is confronting in its demands on autonomous learning—for students and for me. I reflect on the contradiction of feeling apologetic about my lack of time for each student and frustrated by students who don't seem to be putting in the effort (teaching team member diary)
>
> I don't feel the same legitimacy to 'butt into' discussion or interject when members of the teams are dominating conversation. I'm quite avoidant of confrontation when I don't feel part of a group, and I definitely feel at the periphery of these teams (teaching team member diary)

A central concern for the team was how to support individuals to engage and learn in a large collaborative space. Some of these concerns arose from students who were also coming to terms with the need to adapt to the collaborative approach and accept responsibility for their learning. Some students were initially dependent on the teaching team's authority and guidance and would anxiously seek the attention of team members to assist as soon as group activities commenced. Some teaching team members initially reinforced this anxiety and over-responded; however, as the semester progressed, all parties began to adapt to their new roles, particularly the student groups who became more self-authorising, directing and facilitating their own discussions.

> I loved how we were forced to participate which assisted in the learning process (student, SeCat).

Not all students were comfortable with the change in student–teacher dynamic or the shift in responsibility for learning. This discomfort was expressed by a small number of students in relation to the need for individual communication with the teaching team: 'More chances to speak with tutors and gain feedback' (student, SeCat); and the desire for a more traditional lecture format where content was delivered and received:

> The more lecture-esque lessons towards the end of the semester were better for learning. (student, SeCat)
>
> … more theoretical learning. That would have helped me more. (student, SeCat).

The issue of students taking responsibility for their learning links closely to the need to ensure adequate and appropriate support for students to adapt. The ability of teaching team members to assess the capabilities and support needs of students was constantly challenged in the lectorial setting. In comparison with traditional tutorials, it was more difficult to determine students' understanding of key concepts and assessment items as we did not hear all points of a discussion or have the opportunity to ask targeted questions which would usually uncover gaps in knowledge and understanding.

> I find it hard to judge who is quietly competent and who might need extra assistance. Throughout the semester I remain unsure as to whether individuals are brave enough to speak up (in their smaller groups or in the class) if they don't understand key concepts. Compared with formal tutorials, I think that some students seem to be missing the point with assessment or understanding, that previously I would have weeded out through targeted questions of concepts that I know are difficult. (teaching team member diary)

16.4.1 Group Dynamics

Within the confines of any classroom, the management of student groups and their internal dynamics is always a challenge. In moving to a collaborative classroom, which relied on group interactions to facilitate and support learning, we were particularly cognisant of these issues.

> I remained concerned that I can't help relatively young and inexperienced students to manage complex and uncomfortable group dynamics, which I can't always pick up because I have limited time to distribute to each group. As a teaching team we offer tips for 'being good team players' on blackboard, but I'm not sure who reads this information or if it has any impact. (teaching team member diary)

The majority of groups worked well, requiring little external management to keep them on track. To some extent, this was managed by the requirement that each group member took on one of the three key roles (leader, scribe and timekeeper) at least once during the semester.

> It's actually surprisingly easy to superficially massage these [group] dynamics because we want different 'leaders', 'typers' and 'timers' for each exercise. This means I can encourage different team members to speak up and drop in and out of conversations to monitor dynamics (teaching team member diary).

A few groups did encounter difficulties, leading the teaching team to question whether such issues would have occurred in a traditional tutorial setting. In particular, one team member reflected that her initial concerns about a dominate team member were well founded and that perhaps more could have been done to manage the group dynamics:

> During the group discussions my concerns about the alpha team members play out: here, let me do it and directing their own words be typed out for group padlet responses … Later on, one of the older students will ask to transfer groups because she finds one of these alpha students too confronting. I wonder if I should have done more to manage group dynamics, and also how this would have played out in a more managed setting, like a traditional tutorial (teaching team member diary).

Conversely, in other instances intervention by the teaching team or the students helped to address group issues. For example, one teaching team member found her initial concerns about the exclusion of group members were overstated as the students negotiated their own management processes.

> Today I watched as the two boys' in my second tutorial group, also made up of eight girls, completely changed the dynamic of their group. The girls don't really seek the boys input in group discussions and they tend to sit in a tight group leaving the boys to sit at the end. But today the boys weren't sitting in their usual spot, they arrived early and were sitting in the middle of the group space, which meant the girls had to sit around them. Amazingly, when the group discussion started the girls actively sought the boys input. I'm now glad I didn't say anything to the girls last week about making sure they included the boys. (teaching team member diary)

In another group, a teaching team member identified that the motivation and abilities of students appeared unevenly matched.

> After marking module one I am concerned that students in tutorial group 10 are missing the opportunity to see higher quality work (in group discussion and blog for Eat the Week etc.). As much of the learning is premised on the students learning from each other, a group where many are struggling presents a challenge to the model. I suppose I see one particular student in the group as keen to learn …he seems to be trying hard, his assessment looked like he had really tried but hadn't quite hit the mark; however most other members of the group (there are only six) submitted work that was at base standard or below. (teaching team member diary)

The teaching team discussed many strategies to address this challenge, including moving the student to another group, but as the group was already small (a result of early semester withdrawals), there was a concern that the shift would disadvantage others. In the end, a novel solution was found that provided broader benefits.

> Our eventual solution was for me to ask for some volunteers from a group where there was lots of discussion to move into the smaller group. Three friends volunteered to move and this changed the dynamic so that the overall quality of the discussion improved. I checked in a few times with the student I had been concerned about and he was much happier to have a few engaged students to talk with. Interestingly, even members who hadn't engaged when the group was smaller appeared to contribute more once the new members joined. Importantly the impact of taking three from the high functioning group was negligible (teaching team member diary)

16.4.2 Class Engagement

Across the semester, the level of engagement and quality of students' discussion of key topics was greater than we had ever seen in HSP. Reflecting on this following a session on health policy responses to the social determinants of health, one teaching member noted:

> I have been presenting this content to postgrads and undergrads for many years, but that was the best class discussion I have ever experienced. The level of debate and critical reflection was amazing. … I was on a high for days. A definite highlight of my many years of teaching. (teaching team member diary)

The students also appeared to appreciate what we were striving to achieve, with many commenting on the active debates and discussions that arose from the lectorial sessions.

> I found that the lectorials were intellectually stimulating and enjoyed the in class discussions. (student, SeCat)
>
> I liked the buzz and energy of the class discussions. (student, SeCat)
>
> The group discussions were an excellent way to reinforce material and understand different perspectives…also loved how discussions and debates were encouraged. (student, SeCat)

16.4.3 Feedback Processes

A final point of reflection relates to assessment and feedback. Workbooks and ETW blogs were not marked on a weekly basis; instead, students selected their two best submissions from each for final submission and marking. Marking of weekly submissions was not possible due to resource constraints, but more importantly, as outlined above, the workbooks were designed to support the flipped classroom and establish foundational knowledge and generate class discussion. The content of workbooks was regularly discussed in the lectorials; this verbal feedback was designed to support students' self-evaluation (Boud and Molloy 2013).

While weekly workbooks were not marked, the students also completed two online modules—these were essentially more detailed workbook tasks. In an effort to generate effective feedback loops to support learning (Boud 2015; Sadler 2010), both for the modules and workbook tasks, we marked and provided extensive feedback on the modules in weeks four and eight. The final ETW blog and workbook submissions were marked in weeks 11 and 13, respectively. Despite our efforts to provide comprehensive, timely written feedback on the modules, and broader verbal feedback on the workbook and blogs, the course received a SeCat rating of 3.73 for feedback (the overall course rating was 4.1).

Reflecting on this process, we found that students clearly demonstrated more authority over their learning as the course progressed; however, this did not appear to extend to assessment. Student comments to teaching teams members, reinforced in the final course evaluation, outlined how helpful the workbook tasks were in assisting them to stay on top of the content and participate in class discussions. They also identified clear gains for learning and knowledge, but despite these benefits, they still required external validation of their knowledge and learning.

> I would recommend providing feedback on the weekly workbooks and eat the weeks. This is because I found it difficult to improve my original workbook submissions, as I did not know if I was on the right track.
>
> …more precise and individualistic feedback should be provided to each student after every workbook, task, assessment and quiz.

This misalignment in perceptions of feedback, which reflects broader experiences identified in the literature (Adcroft 2011), has been the source of considerable discussion and reflection by the teaching team. In the final section of this chapter, we briefly outline how we are responding.

16.5 Final Thoughts and Future Steps

The major revamp and revision of Health Systems and Policy was challenging, at times exhausting and overwhelming, but the level of student engagement and participation went beyond our expectations. Our students and their deliberations were often inspirational. It was a valuable educational experience for the whole teaching team. The assessment, particularly the workbooks, worked well in relation to establishing foundational knowledge that informed active class discussions; however, student critique of the lack of feedback on individual workbooks was an issue that has generated much team discussion. Providing students with feedback they can draw on to enhance further work is critical, but at a time of significant resource constraints extending the marking load is not feasible (we marked nearly 600 pieces of assessment). More importantly, students' reliance on feedback from an 'authority' figure does not support our broader efforts to help them develop self-authorising and self-evaluation skills. In line with these efforts, we are now developing a series of peer-based feedback sessions that aim to support students to develop self-evaluation skills through the evaluation of their peers (Nicol and Macfarlane 2006; Pearce et al. 2009). We are confident this process is consistent with our focus on collaborative and active learning.

A final point of reflection relates to the latest iteration of the course. It has not been possible to continue to replicate the changes made to HSP in 2014—the class has grown to nearly 300 (with further growth expected), and we do not have the physical space to accommodate the collaborative teaching model. However, our enthusiasm and commitment to the methods we employed have not been dampened. While we have had to return to lectures run in a large capacity theatre to manage the numbers, a new tutorial programme has been developed and is being run in accordance with the collaborative model to ensure active learning and critical debate continues in our classroom.

16.6 Conclusion

This chapter mapped the teaching journey and presented a discussion of a changed approach in delivery of The Health Systems and Policy undergraduate course. Through flipping the course, learning objectives, teaching activities and assessment were realigned, and activities were developed to establish foundational knowledge outside the classroom that would inform and support discussion, reflection, engagement and debate within collaborative classrooms. The teaching team and student reflections were presented to capture the lived experience and perceptions to the changed teaching and learning approach.

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Chapter 17
Implications for Pedagogy: Flipping the Classroom to Engage Pre-service Teachers

Linda-Dianne Willis

Abstract As noted by authors in previous chapters of this volume, the idea of flipping the classroom is not new. But the view that flipping the classroom just means students doing work at home that they once did in classrooms is simplistic, overlooking the imperative of new technologies and how these are revolutionising conventional teaching and learning. I have been a tertiary educator in Australia for almost a decade and began flipping my classroom two years ago to better engage pre-service teachers in learning to teach English and literacy. I first heard about a flipped classroom approach through a university-wide promotion (see Chap. 1). Subsequently, I joined my university's flipping the classroom community of practice to: learn more about what others were doing in their different settings and contexts; share experiences; gain practical ideas; discuss challenges; explore solutions; receive support; and contribute to ongoing research. In this chapter, I examine and reflect on my experiences of learning so far. In particular, I call on key concepts including community of practice, ethics of responsibility, and habitus as well as frameworks such as gateway, cornerstone, and capstone knowledge that have informed my teaching to highlight the pedagogical implications of the approach as well as the impact on student learning and achievement.

Keywords Ethics of responsibility · Community of practice · Habitus · Multiliteracies pedagogy · Pre-Service teacher · English and literacy

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17.1 Introduction

17.1.1 Flipping the Classroom and Multiliteracies Pedagogy

The concept of flipping the classroom initially appealed to me because of my previous work in teaching about *multiliteracies* pedagogy in pre-service teacher education English and literacy courses. Responding to unprecedented, rapid social change catalysed by the digital technology revolution over the past several decades, multiliteracies refers to the myriad ways individuals in modern society acquire literacy knowledge and practices (New London Group 1996). One response to the theory and philosophy of multiliteracies has been the Learning by Design model which focuses on active ways of knowing and text design (Kalantzis et al. 2005). Noticing alignment between these characteristics and the possibilities promised by flipping the classroom motivated me to investigate the approach. Given this apparent synergy between Learning by Design and the idea of flipping the classroom, I recognised possibilities for not only improving teaching and learning outcomes but also enabling my students to experience multiliteracies pedagogy first-hand by engaging in a flipped classroom approach.

17.1.1.1 Describing the English and Literacy Course

The focus of this chapter concerns an English and literacy course that I first taught in 2013. The course is a compulsory, year-long offering for fourth-year students in a Bachelor of Education, Middle Years of Schooling dual degree program, but also is offered as an elective to fourth-year students in a Bachelor of Education, Secondary, and to new students in either a Graduate Diploma of Education, Secondary, or Middle Years of Schooling program. Hence, students who enrol in the course: come from disparate backgrounds; have different motivations for undertaking the course as it is compulsory for some and not others; and identify as either beginning or in the final stages of their learning journeys in becoming professional teachers. Between 30 and 40 students usually enrol. There are 16 weeks in the course which are interrupted by two periods of professional experience totalling 15 weeks and vacation periods that make up another four weeks. The inherited structure of the course comprised weekly one-hour lectures followed by one-hour tutorials. Faced by similarly structured courses in the past, I felt that requisite course content best covered in lectures using direct teaching had compromised available time to produce quality English and literacy teaching for enabling students to become active participants in a multiliteracies classroom community of practice. I therefore considered that redeveloping the course to incorporate a flipped classroom approach would make it possible to deliver key content online, allowing me to re-structure allocated course time into weekly, two-hour, hands-on workshops. These changes would enable me to maximise active learning opportunities and customise my teaching to individual student needs, simultaneously taking advantage of multiliteracies pedagogy (Kalantzis et al. 2005) and a flipped classroom approach (Bergmann and Sams 2012).

17.2 Setting up and [Re]Conceptualising the Course

To learn about flipping my classroom, I attended professional development sessions at my university where I was introduced to desktop recording software, namely Echo 360, for pre-recording course content. In these sessions, I gained necessary knowledge, information, and technical skills to begin using the software. My involvement in the university's flipping the classroom community of practice enabled me to learn about further possible uses and benefits as well as avoid potential pitfalls of the technology. At the same time, this involvement heightened my awareness that to realise the potential of a flipped classroom approach in practice required critically re-thinking the content, pedagogy, and assessment for my new course.

Drawing on my PhD research into parent-teacher engagement using co-teaching (Willis 2013), my thinking for decision-making and subsequent implementation of the revamped course was guided by concepts such as *communities of practice* and the *ethics of responsibility*. The first concept, community of practice, is described by Lave and Wenger (1991) as comprising: "engagement in action, interpersonal relations, shared knowledge, and negotiation of enterprises" (p. 85). Lave and Wenger explain that participants in a community of practice view themselves as *belonging* to the community. Wenger (1998) adds that: "Such participation shapes not only what we do, but also who we are and how we interpret what we do" (p. 4). As simultaneously learners and teachers, participants are not only active but also proactive in the community, connecting with one another in ways that encourage mutual focus and shared goals. The process aligns with Vygotsky's (1978) notion of the *zone of proximal development* (ZPD) which describes how individuals at varying levels of knowledge in a community provide scaffolding for one another's learning. According to Vygotsky, the notion concerns the distance between an individual's actual compared with potential developmental levels where their ability to problem solve improves when they work collaboratively with more capable peers. Knowledge, skills, and language for participation exchanged among members thus enable everyone in the community to contribute to the emerging understandings of all others. Hence, participation in a community of practice is an ongoing, transformative process as each community is in a constant state of [re]generation (Lave and Wenger 1991). The second concept, the ethics of responsibility, is a theoretical and philosophical notion propounded by various philosophers such as Lévinas (1978 [1998]) to describe an implicit responsibility individuals have *to* and *for* one another's good (Joldersma 2014). This responsibility links everyone together, regulating social networks such as those in education. Individuals demonstrate ethics of responsibility in the classroom, for example, by adopting inclusive, respectful behaviours towards the participation and contribution of others irrespective of such factors as social standing, gender, race, age, or background. Allied to this notion is the sense of *co-responsibility* that develops in a community of practice where all individuals develop a sense of shared responsibility for the teaching and learning that occurs (see Willis 2013). So, in redeveloping the course, the overarching question I asked myself was:

> How can a flipped classroom approach enable me to create a community of practice in English and literacy teaching and learning where individuals develop a sense of responsibility for the good of all others?

17.3 Adapting Pedagogical Practices to Align with New Thinking Possibilities

To begin to answer this question, I needed to first decide on the online course content, keeping in mind requirements, standards, and attributes for graduate teachers at university, state, and national levels. As a flipping-the-classroom-first-timer, I also realised that developing and recording online lecture material presented a potentially labour-intensive and time-consuming exercise. Discussions in the university community of practice enabled me to develop an initial line of attack. I dismantled existing lecture and tutorial content to identify key English and literacy concepts and topics, applying a number of criteria I developed to then reorganise and refine the information into a series of mini-lectures. One criterion related to adapting the university's teaching and learning framework of gateway (compulsory introductory), cornerstone (compulsory intermediate), and capstone (compulsory advanced) knowledge. Using this framework, I decided that pre-recorded online lectures would provide initial access to core course content/concepts (gateway knowledge); hands-on activities in workshops would enable thorough exploration of key content/concepts (cornerstone knowledge); and longer-term project work in and outside workshops would enable students to enact knowledge and understanding of content/concepts (capstone knowledge). Hence, considerations about online content concerned choosing defining ideas, concepts, and theories that would pave the way for pre-service teacher learning in English and literacy. A second criterion concerned taking account of my audience needs. This entailed deciding what information would be valuable and interesting but not overwhelming, including readily relatable or practical examples to clearly illustrate ideas and connect with student experiences, and keeping online lectures to a reasonable length (e.g., no more than 30 min). Given the Echo 360 software involved producing audio recordings to accompany my teacher-made PowerPoint presentations, a chief consideration was making sure visual and audio information could be suitably married. Long-winded, oral explanations and visually cluttered or text-dense PowerPoint slides, for example, could compromise user-friendliness and hence possible student learning. A third criterion related to creating online content that could be re-used in subsequent course iterations. This involved choosing information such as a brief history of literacy education in Australia, describing recognised models of literacy education, and effective strategies for teaching reading and writing that I could reasonably predict would remain relevant for up to three years.

My next priority was actually producing the online content; something I recognised could neither be hurried nor left to the last minute. Having developed an overall course outline of concepts and topics, I adopted a systematic approach, scheduling time to create the online lectures over one or two sessions each week. I considered this would facilitate stockpiling of ideas and resources and critical sifting and sorting of information between times but also allow some flexibility in original planning should my teaching and learning needs change throughout the year. In preparing for the online recordings, I recognised the opportunity to reflect multiliteracies thinking by developing PowerPoint slide presentations that exploited linguistic, visual, gestural, and spatial modes. I paid particular attention, for example, to the use of white space, word economy, layout, colours, shapes, images, and vectors (e.g., arrows) as ways to explicitly and implicitly enhance meaning-making for students.

However, in developing the audio accompaniment, I initially experienced a sense of being in unfamiliar territory. I had not considered, for example, how the absence of a live student audience would disrupt my usual practice of adopting an interactive teaching style. To borrow from Bourdieu (1990), I suffered *habitus* breakdown. Habitus may be understood as a system of durable and transposable *dispositions* that an individual develops in response to operating in a range of different situations and contexts (Bourdieu 1990). Disposition refers to the tendency of an individual, upon encountering a particular context, to internalise the way it operates and subsequently externalise it through particular ways of thinking, speaking, and acting (Bourdieu 1990). Even in traditional lectures which rely heavily on direct teaching, the presence of listeners had always afforded me opportunities for verbal and non-verbal teacher-student interactions. This form of immediate, ongoing feedback not only provides point-in-time spaces to elaborate, correct, reframe, or expand on what is said but also builds teacher-student relationships. To develop the audio accompaniment, I therefore needed new habitus. After experimentation, I found the use of prepared notes helpful. These were not read from word-for-word like a script, but aided smooth, unbroken delivery of mini-lectures. One distinct advantage of this was that minimal post-recording editing was necessary. Of more significance was that, given my commitment to ethics of responsibility, it demonstrated respect for my prospective listeners by allowing me to maximise the amount of quality information I could communicate in the least amount of time.

Having established a system for selecting, organising, and recording online content, my attention shifted to the workshops. Using the university framework of gateway, cornerstone, and capstone knowledge, it was tempting to deliver cornerstone knowledge in the workshops by re-presenting some of the information contained in the gateway knowledge of the mini-lectures. My participation in the university's community of practice, however, had alerted me to the work of Bergmann and Sams (2012) about the need to create an expectation that all students would engage with the online learning materials before the workshops. Otherwise I would not only negate the point of adopting a flipped classroom approach but also undermine my goal of developing a community of practice which relied on building co-responsibility among the students for their individual and collective learning.

Having removed the need for lengthy direct teaching episodes, adopting a flipped classroom approach now effectively doubled available time for developing cornerstone knowledge through student activities in the workshops compared with my previous experiences of teaching similar courses. And although I relished the opportunity to teach in a more interactive, personal style, my habitus was yet again initially challenged. I needed to critically examine my knowledge and understanding about ways to build and sustain a community of practice among the students. At the same time, I returned to the idea of ethics of responsibility and how it could be infused throughout the course. I thus chose, adapted, developed, or rejected (as the case may be) teaching activities by asking a series of questions to interrogate their relative utility given my aims for redeveloping the course. These questions included: Would an activity encourage clear links for students between gateway knowledge contained in the mini-lectures and future capstone knowledge through project work to reinforce their experience of the teaching and learning cycle of curriculum, pedagogy, and assessment? Did an activity require active student participation by facilitating small-group work and/or integration of Information Communication Technologies (ICTs)? Was there potential for an activity to encourage co-responsibility for teaching and learning among the students?

To develop knowledge and understanding of multiliteracies pedagogy, for example, I adapted one activity where students worked in small groups to enact a well-known story such as the *Three Little Pigs* using only one mode namely linguistic, visual, audio, or gestural communication. This activity required students to engage with mini-lecture content not only to enable their active participation in small-group work but also to demonstrate developing responsibility for their individual and collective learning. At the same time, the activity linked to upcoming assessment work in which students needed to develop a long-term project for teaching English and literacy that also evidenced their ability to creatively deploy multiliteracies pedagogy. Hence, a number of pedagogical considerations flowed as a result of adopting a flipped classroom approach. More interactive, hands-on activities meant that I was encouraged to [re]consider use of classroom space (including outside), arrangements of furniture, groupings of students, ways to build productive student relationships, and incorporation of ICTs including the interactive whiteboard and personal digital devices.

Responding to the overarching question when redeveloping the course also challenged me to contemplate whether the activities I developed for students would encourage explicit understanding of the notion of the ethics of responsibility. I wondered, for example, how adopting a flipped classroom approach might enable me to go further than merely talking about the concept. My research work investigating co-teaching where two or more individuals work together in a classroom on all aspects of teaching including planning, enacting, assessing, and reflecting had highlighted the value of substantive conversations or co-generative dialogues to accompany co-teaching sessions (Willis 2013). These regularly scheduled conversations deepen knowledge and understanding of teaching and learning as participants engage in discussions to describe and explain what happens during their mutual work. A set of agreed-upon protocols form the basis of these conversations. These include: adopting a disposition of openness to learning from others; being willing to coordinate discussion by way of initiating dialogue, agreeing to 'gently' disagree, and providing evidence for ideas; and displaying inclusive and respectful practices such as attentive listening, inviting others to participate, and allowing each other equal talk time (LaVan 2004; Willis 2013).

Informed by these ideas, a flipped classroom approach enabled me to exploit the possibilities of different strategies for enhancing student understanding of the ethics of responsibility. One example, the *fishbowl strategy* (Scherer 1997), was adapted where each week a group of students was scheduled to discuss critical learning from and connections between the mini-lecture and set readings content. As each group talked unrehearsed and openly among themselves, the remainder of the class watched as 'memorable' observers who would later be invited to share their impressions, make comments, or ask 'burning' questions about what may have been (or perhaps not) discussed. Hence, the strategy multiplied opportunities for individual and collective student learning through more expansive and insightful analysis, interpretation, and reflection on course information. Simultaneously, the strategy provided opportunities for me to explicitly explore the concept of the ethics of responsibility with students by peeling back what we had observed to critically examine the implicit processes behind effective group work. Adopting a flipped classroom approach thus encouraged me to consider what and how such different strategies could be used to gainfully satisfy the course aims. Using the fishbowl strategy, for example, recognised that equal access to course gateway knowledge for all students could enable deeper learning about multiliteracies pedagogy. Although focused discussions made this possible, it was also because students experienced concepts such as the ethics of responsibility first-hand as the processes involved were modelled and explicated in situ. At the same time, such strategies paved the way for collaborative and longer-term project work through which students were expected to acquire course capstone knowledge. This included students successfully cooperating to co-plan and co-teach activities to demonstrate reading comprehension strategies and individually to develop English and literacy unit and lesson plans that relied on their knowledge of effective group processes for use in multiliteracies classrooms.

17.4 Acknowledging and Encouraging the Need to Develop New Habitus

Throughout the process of redeveloping the English and literacy course in the first and subsequent year, I made improvements to the offering based on my reflections and information provided by students about their flipping the classroom experience. This information has included verbal and written feedback garnered through informal conversations or invitations to students to participate in small focus groups as well as formal university course and teacher evaluations. At the same time, an additional mitigating factor emerged with the news that the course will be discontinued in 2016 given a decision to fold the Middle Years of Schooling program. I have therefore needed to deliberate on any such feedback by considering ways to improve the course without necessarily completely overhauling it.

My flipped classroom approach has received mostly positive student reviews over the last two years. Conversations in focus groups and written student feedback have indicated that carefully structured, practically oriented, collaborative workshops that complement the online mini-lectures have been key to the success of the flipped classroom approach in the course. This formula appears to have encouraged Lave and Wenger's (1991) ideas of mutual engagement and joint enterprise, assisting to develop a community of practice among the students. Students consider the workshops have not only supported their learning in interesting, enjoyable ways but also built their repertoire of suitable practices for effective English and literacy teaching using multiliteracies pedagogy. They report drawing on this repertoire, irrespective of subject area, when working in classrooms during their professional experience times. As well, they indicate that linking key English and literacy concepts to practical, relevant activities has enabled them to bridge the theory–practice gap more often than in their other courses and asserted their retention of this knowledge will endure beyond the course.

However, this is not to say that implementing my flipped classroom approach during the first two years of the course has been entirely smooth. Indeed, a number of important challenges with relevance to readers of this text have emerged. Of most significance is habitus breakdown on the part of some students. In the first year of the course, most students indicated that they had never heard of flipping the classroom. This meant that they were not only unfamiliar with the conceptual basis but also concomitant practices of such an approach. Some students even resisted the idea, indicating that: they had come to university for the usual lecture experience of being able to sit and listen passively while content was delivered; their attention was easily distracted when engaging with the online mini-lectures; and they did not enjoy having to physically move and work in groups with students other than their friends during workshops. However, I owe these students a great deal for sharing their experiences with me since their frank feedback has focused my attention on aspects of my flipped classroom approach for possible improvement.

I have consequently made a number of beneficial changes to the course since its first iteration. These concern providing explicit information about different aspects of my flipped classroom approach and rationale for teaching and learning. In addressing possible negative student experiences of my flipped classroom approach, for example, I was reminded of Cooney's (1985) study of a beginning secondary school teacher who adopted a more student-centred, problem-solving pedagogy to build a strong learning base for teaching mathematics (in Grossman and Stodolsky 1994). The students involved reacted negatively to the changes, finding them "threatening" and ultimately forced the teacher to return to a traditional teacher-centred transmission mode (in Grossman and Stodolsky 1994, p. 208). Just as habitus was evidenced in the form of these students' unconscious predispositions towards the teaching of mathematics, habitus was evidenced by some of my students' predispositions towards the teaching of university courses using traditional lecture styles.

Hence, since the first iteration of the course, I have been careful to explain the rationale for flipping the classroom from the beginning, adopting a more explicit tact. I have used specific language and concepts from the frameworks that have informed my decision-making. I have explained, for example, that the purpose of the mini-lectures is to provide the 'gateway knowledge' they need to participate meaningfully in the course and especially in the practical aspects of the workshops and the project work of collaborative and assessment tasks. Given that the nature of the mini-lectures is to provide pre-workshop online learning materials, I have noted that these teacher-made audio recordings with accompanying PowerPoint presentations cannot be compared with the possible entertainment experience of a Hollywood blockbuster film. I have therefore modelled specific strategies to use (or not) when engaging with the online information. In this case, the words of Bergmann and Sams (2012) have proven useful: "[students] shouldn't try to watch the video with Facebook open and the iPod in the ear while simultaneously texting and making dinner" (p. 79). Sharing successful strategies adopted by past students has also been worthwhile. These include suggesting that students: set aside a distraction-free time and place each week to engage with the mini-lectures; print out the PowerPoint slides to make notes about what they are learning while viewing and listening; and download the audio file to [re]listen to the information while travelling.

As well, I have more purposefully connected these strategies with the notion of the ethics of responsibility and the relationship between individual and collective learning. I have described, for example, how it is possible to conceive positive engagement with the online materials as a process that builds resources for individual student learning. And that when these resources are brought to bear during group workshop activities, a fertile environment for collective student learning is created that has the potential to expand individual resources. Hence, I have shared my thinking out-loud with students about how adopting a disposition of ethics of responsibility can generate an iterative process that enhances individual and collective learning. I have subsequently explained how conceiving the process as dialectic is valuable for pre-service teachers learning to use multiliteracies pedagogy in their future English and literacy classrooms. Having introduced these ideas, they have been reinforced using examples that manifest in practice throughout the course. Such examples have included: ways individuals build their resources by working with a range of different students apart from those in their usual friendship group; the benefits for individual and whole group learning given a basis of shared knowledge and understandings; and my ability as tutor to continually [re] distribute information from student to student compared with a traditional, didactic classroom. In the second year (2014), based on positive student feedback about teaching and learning throughout the course, these strategies appeared to minimise habitus breakdown while simultaneously encouraging the need for students to adopt new habitus when learning in a flipping the classroom context.

However, student feedback at the end of the second year signalled more areas for possible course improvement. Based on student focus group feedback after the first iteration of the course, I decided to set small, weekly tasks for assessment based on the online mini-lecture material. In the first year, similar activities were set but no marks were assigned. In the second year, students completed such tasks beforehand and submitted them in the weekly workshops as part of ongoing formal assessment. This decision aligned with similar pedagogies adopted by Bergmann and Sams (2012) in their Flipped-Mastery Classroom and Drinkwater et al. (2014) in their integrated approach to managing active learning processes in first-year Physics classes. Despite the feedback from the previous year and high overall achievement in the course, student feedback at the end of the second year about the value of these tasks was polarised. And while such divided feedback does not necessarily mean the course was unsuccessful (see Stark and Freishtat 2014), I wondered why students had experienced this aspect so differently. One half of the students, for example, considered weekly tasks to accompany the mini-lectures and readings an excellent way for keeping them engaged. The other half found that these tasks lost meaning because assigning marks made them feel compelled to spend considerable time on their completion, relegating them to a chore which they subsequently resented especially during heavy assessment periods.

To proactively respond to this feedback, I returned to my overarching question, asking: *How can a flipped classroom approach enable me to create a community of practice in English and literacy teaching and learning where individuals develop a sense of responsibility for the good of all others?* My analysis of comments in formal university course evaluations at the end of the second year confirmed that most students did not dispute the utility of flipping the classroom. However, the open-ended, reflective nature of accompanying weekly tasks and associated assessment requirements meant that students could expend more time and effort on their completion than was my intention. Student attention had therefore become more product than process focused, compromising my attempts to encourage new habitus. However, the feedback also contained constructive suggestions for possibly addressing this seeming contradiction. Students indicated, for example, that they would prefer to respond differently to the mini-lecture and readings content and that these responses could occur during workshops. Consequently, as I write this chapter during the third iteration of the course, I have [re]adjusted expectations pertaining to my flipped classroom approach and weekly assessment tasks. This year, for instance, instead of setting additional tasks for completion outside of class, a stimulus task for which five to ten minutes of independent writing time is allocated, is used to prompt students during workshops to apply their knowledge and understanding of a topic. An example of a stimulus task might be to explore the statement: *Extensive reading is the best way to promote comprehension*. Their reflective responses enable students to combine learning from the mini-lectures and readings with that of workshops. Subsequently, students are invited to share and discuss their contemplations and insights in small and whole class groups. Throughout the process, they may continue to make reflective notes. At the same time, students are encouraged to adopt protocols that reflect co-generative dialogues (e.g., adopting a disposition of openness to learning from others; displaying inclusive and respectful practices). At these times, I again take advantage of opportunities to make the iterative relationship between individual and collective learning explicit. In reading student reflections later, I am able to gain a picture of their point-in-time learning—individually and collectively—to gauge how they are making sense of the course as well as consider ways to provide appropriate scaffolding for future learning. Proactive adjustments to the course in light of recent previous feedback have thus enabled me to continue gathering evidence of student learning for ongoing formal assessment purposes. Yet, students are able to experience the potential benefits of a flipped classroom approach in ways that avoid being unintentionally onerous while simultaneously encouraging co-responsibility in a developing pre-service teacher English and literacy classroom community of practice.

17.5 Flipping the Classroom and Preparation for Teaching

My experience of flipping the classroom to teach the English and literacy course has afforded me fresh insights about how the approach aligns with preparing the students for their future work as classroom teachers. Flipping the classroom, for example, has created an imperative for students to engage with course content beforehand because they recognise that they will need to call on the information to participate effectively in workshop activities. Compared with the work of teachers, flipping the classroom has required my pre-service teachers to begin the process of thinking about learning in the same way that teachers do before their face-to-face classroom work. This is particularly significant when considered in light of the course structure designed to connect online (gateway knowledge), workshop activities (cornerstone knowledge), and longer-term projects (capstone knowledge) since flipping the classroom may be seen to facilitate student *reflectivity* and *reflexivity*. Speaking about reflectivity to promote student and teacher learning, Wilhelm (2013) explains that: “to build understanding, we must first activate prior reflections, then confront and build on prior experiences and knowledge” (p. 57). However, equally important is reflexivity which involves privileging the perspective of others by “suspending our own assumptions in order to understand what someone else brings to their understanding, learning, and practice” (Wilhelm 2013, p. 57). Attention to the nexus between individual and collective learning throughout the course, highlights how my flipped classroom approach may pave the way for such a cyclical reflexive process to occur. For example, the online materials stimulate reflective thought which opens up possibilities for not only action but also reaction through the collaborative work of sharing and exchanging knowledge, ideas, and information about teaching and learning during workshop and project activities. Ongoing collaboration enables the cycle to continue.

Part of this process is the role that the online mini-lectures play in developing student [co]responsibility for learning. My conversations with students have indicated that online mini-lectures create an expectation that they will engage with the materials. And this act of engaging encourages a sense of commitment to and for their own learning since they reason: "I've actually done the work, so why wouldn't I turn up to workshops?" Students are also cognisant that attending workshops depends on each one of them having shared in preparing for, and thinking about, learning. By providing an appropriate structure, a flipped classroom approach has thus assisted to inculcate the notion of ethics of responsibility among my students, subsequently generating a positive, professional learning climate in the workshops. Recognising how a flipped classroom approach can encourage a disposition of ethics of responsibility for participating productively in a community of practice is also valuable when considering how to effectively prepare preservice teachers for their future professional work.

As well, over the past two years of teaching the English and literacy course, students have consistently achieved high results with few recorded fail grades. One possible explanation is that the online materials enable students to revisit ideas by either stopping to replay parts of recordings if something at the time piques their interest or later replaying entire recordings to revise information for assessment purposes. Another reason relates to the increased number and quality of student-teacher interactions possible during workshops for clarifying and deepening understandings about course concepts and minimising potential student anxiety about assessment tasks. Flipping the classroom, for example, has made it more possible for me to seize teachable moments as well as provide immediate and targeted feedback to particular students. These observations, as previously indicated, reflect findings by Bergmann and Sams (2012). They also seem to elucidate, compared with my other courses, why I have experienced minimal email traffic from students seeking clarification or assistance about the course or assessment tasks. However, I have gained an impression from some students, particularly those who identify as English second language speakers, that previously they have found the subject of English challenging. These students have indicated that flipping the classroom has enhanced their confidence about learning by enabling them to pace their construction of knowledge of topics and concepts between times and allaying their concerns about perceived knowledge deficiencies being exposed during class. Hence, overall high academic student achievement may be attributable to more engaged time on task throughout the course made possible because of increased opportunities for *all* students to participate effectively. My experiences align with others who have used a flipped classroom approach in university courses to enhance inclusivity and embrace diversity (e.g., Smith et al. 2015). Given that flipping the classroom appears to enable students to experience the notion of ethics of responsibility in practice, the approach accords with multiliteracies pedagogy which seeks to build a repertoire of practices for acknowledging student differences, interests, and prior knowledge as valuable teaching and learning resources. This may have contributed to overall student success in the course while simultaneously providing an example of good practice in multiliteracies pedagogy for teaching English and literacy in their future classrooms.

17.6 Final Conclusions and Points of Significance

In this chapter I reflected on my learning experiences since 2013 of developing a flipped classroom approach to teach pre-service teachers English and literacy using multiliteracies pedagogy. In particular, this chapter explored the question: *How can a flipped classroom approach enable me to create a community of practice in English and literacy teaching and learning where individuals develop a sense of responsibility for the good of all others?* The chapter began by highlighting the synergies between the theory, philosophy, and goals of multiliteracies pedagogy based on the Learning by Design model (Kalantzis et al. 2005) and a flipped classroom approach (Bergmann and Sams 2012). In marrying these approaches, concepts such as community of practice, the ethics of responsibility, and the dialectical relationship between individual and collective learning together with frameworks such as gateway, cornerstone, and capstone knowledge proved useful in showing how flipping the classroom complemented multiliteracies pedagogy to provide a robust teaching and learning experience.

Key insights emerged about how flipping the classroom requires teachers and students to think and act differently. Hence, to cultivate new habitus, it is important for teachers from the outset to: describe and explain to students the nature and purpose of the approach in their particular context—including underlying theories, philosophies, frameworks, goals, and concepts; model appropriate skills and behaviours; and discuss possible challenges and limitations of the approach. What also emerged is that developing online content and materials needs to be augmented by thoughtful, well-structured workshop activities that encourage collaboration, engagement, and ongoing exchange—individually and collectively—among students. As I discovered, the benefits of aligning mini-lectures and workshop activities include more time and space for: richer student learning experiences through increased number and quality of teacher-student interactions; small and large group work; active learning opportunities especially hands-on practice of teaching skills and strategies; personalised, differentiated learning; creative integration of ICTs; and student discussion and sharing.

Flipping the classroom has also been well suited to multiliteracies pedagogy, providing a model of best practice especially concerning effective group processes and promoting equity for students. Greater opportunities for effective class participation by all students may therefore have contributed to high overall achievement in the course. As well, flipping the classroom encouraged students to contemplate aspects of learning before applying their developing knowledge and skills in practice. At the same time, purposeful observation of conversations and participating in co-generative discussions during workshops allowed individuals more opportunities to hear from others about how they were thinking from week to week about what they were learning. These aspects encouraged Lave and Wenger's (1991) notion of a community of practice as characterised by mutual engagement, a joint enterprise, and a shared repertoire in English and literacy teaching and learning among the students. The process was further explicated by conceiving the connection between individual and collective learning as dialectical. Hence, flipping the classroom encouraged reflectivity and reflexivity. These skills are considered essential for highly effective classroom teachers who need to conceive teaching, learning, and assessment as cyclical. Given the expectation of being prepared to participate and contribute constructively to individual and collective learning in workshops, the approach also cultivated co-responsibility among students. Flipping the classroom therefore invoked the idea of ethics of responsibility among students, signalling the further value of the approach when thinking about how university courses prepare pre-service teachers for their future, increasingly collaborative work in classrooms and schools.

My reflections on learning about a flipped classroom approach also point to the importance of persevering when issues relating to technical aspects or disrupting entrenched student culture can threaten successful implementation. For this reason, the value of teachers participating in a flipping the classroom community of practice to provide necessary ongoing support and assist with troubleshooting was highlighted. I also showed the value of garnering and responding proactively to student feedback to enable adjustments for improving their experience of the approach. This aspect is not only essential for enhancing teaching and learning but also for building trusting relationships with students over time to instil the ethics of responsibility as a way of thinking and operating generally in tertiary settings.

Flipping the classroom is an ongoing learning experience for teachers and students. While initially setting up a flipped classroom approach may take considerable time and effort, rewards for this investment such as more time to focus on what happens in the classroom are significant. However, it is important not to become complacent as aspects of the approach need continual review. These include, in my case, re-listening to mini-lectures before workshops from one year to the next to re-familiarise myself with the content and address any slippages in information over time to maximise my engagement with students. It also requires a shift in disposition for traditional teachers and necessary pedagogical changes. Part of which is recognising that students may need time and explicit instruction about aspects of the approach to nurture new dispositions and ways of working that encourage increased individual and collective responsibility for teaching and learning.

As a result of flipping my classroom, I am more open to trying other innovative approaches utilising existing and new technologies to enhance my university teaching and learning. I have also adopted a flipped classroom approach in other courses. Writing about flipping the classroom with pre-service teachers learning to teach English and literacy using multiliteracies pedagogy has enabled me to critically reflect on my learning experiences and the value of the concepts and frameworks used. This has deepened my knowledge of the approach and practice, expanding my capacity for exploring the power and potential of flipping the classroom in the future.

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Chapter 18
Flipped Tutorials in Business Courses

April Wright, Geoff Greenfield and Paul Hibbert

Abstract This chapter reports on a flipped classroom intervention in an undergraduate business course. We explore the role shifts for tutors and students that occurred when a flipped tutorial intervention was introduced in an introductory management course. The course is positioned in the first-year core of the undergraduate business management degree and has enrolments of up to one thousand students each semester. The chapter develops a model of tutor-student role combinations that create four different learning environments classified as: Instruction, Disconnection, Disruption, and Collaboration. We draw on vignettes from tutors and students to demonstrate how a Collaboration learning environment (the ideal for a flipped classroom) can be achieved through: 1. professional development practices that shift tutors from the role of King's (College Teaching 41(1):30–35, 1993) 'sage on the stage' instructor to learning facilitators; and 2. curricula and course design and assessment and feedback practices that encourage students to shift from passive knowledge recipient to self-managed learner.

Keywords Flipped classroom · Undergraduate business · Tutor-student roles · Collaborative learning · Socratic approach

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18.1 Introduction

The traditional Socratic approach to case study teaching works very effectively as a flipped classroom for business courses at the postgraduate and executive education level. Students in these courses are experienced managers with sufficient confidence to engage in vigorous debate, and instructors are disciplinary experts skilled at probing and challenging student reasoning (Garvin 2007). In contrast, Socratic case study teaching works much less effectively as a flipped classroom at the undergraduate level because teaching tends to become instructor-centric (Argyris 1980; Foster and Carboni 2009; Siciliano and McAleer 1997). Large undergraduate courses typically adopt a cost-effective format of mass lectures and tutorials, with case study debates conducted in tutorials. Undergraduate business students, especially first-year students, arrive to the tutorial unprepared and lacking confidence to engage in case discussion. At the same time, tutorial instructors, employed from a casual staff pool of research higher degree students, do not have the expertise and training to facilitate a Socratic case discussion. The outcome is an undergraduate business tutorial which resembles not a flipped classroom but instead a didactic mini-lecture reminiscent of King's (1993) 'sage on the stage'. The inexperienced tutorial instructor adheres rigidly to prepared case notes as students wait passively to receive the answers and a summary of relevant management theories and concepts (Lundberg and Winn 2005). Student resistance to completing the preparatory work required to 'flip' a classroom has been similarly reported by educators in other disciplines (Herreid and Schiller 2013).

However, all is not lost for undergraduate business teaching. Advances in thinking about the design of flipped classrooms mean tutorials do not have to regress to a level where, to paraphrase Mazur (2009), the case study notes of the tutor are transmitted to the notebooks of undergraduate business students without passing through the brains of either. In this chapter, we show how thoughtful design and implementation of a flipped tutorial class can transform (1) the tutorial instructor from sage-on-the-stage to learning facilitator, and (2) the undergraduate business student from passive knowledge recipient to self-managed learner. The chapter is structured into five sections. First, we describe our teaching context of an introductory management course in the first-year core of an undergraduate business degree. Second, we outline our design of a flipped classroom intervention for teaching case studies and the procedures we adopted for implementing it in tutorials. Third, we elaborate a model of different combinations of tutor and student roles. Fourth, we draw upon our model to explain the role shifts associated with flipped classrooms using illustrative vignettes and quotes sourced from tutors and students in our introductory management course. Finally, we conclude the chapter with a discussion of the broader implications of our experience with flipped classrooms in undergraduate business courses for reflective and reflexive practices of instructors and students more generally.

18.2 Teaching Context

Undergraduate business programmes are structured as an 'hour glass' model (Thompson et al. 1997) built around foundation stone and capstone courses. Foundation stone courses at UQ provide undergraduate students with knowledge about core concepts in the first year of that programme, while capstone courses allow for the integration of multi-disciplinary concepts in the final programme year. In business programmes, foundation stone and capstone courses provide for broad learning about business management at the degree's entry and exit points, between which students focus on building narrow discipline-specific knowledge and skills in areas such as marketing, human resources management, international business, entrepreneurship, and accounting. A key foundation stone is a course in introductory management, which covers concepts such as planning, control, leadership, ethics, and social responsibility as well as organisational strategy, structure, and culture. As Thompson and colleagues (1997) note, the introductory management course is 'critical to developing students schemas for management' by introducing them to key theoretical concepts and their application to practice as well as seeding early development of graduate attributes such as teamwork, communication, and critical thinking.

The particular introductory management course we focus on in this chapter is positioned in the core curriculum of the University of Queensland's undergraduate programmes in management and commerce and is also a popular elective for arts and engineering students. The course is structured weekly as a two-hour lecture conducted multiple times and a one-hour tutorial of about twenty students. The semester-long course is taught twice yearly. When the course was first flipped, enrolments were 800 students in Semester 1 and 450 students in Semester 2 each year. Enrolments have subsequently grown to 1200 and 700 students in Semesters 1 and 2, respectively. The majority of students are in their first year of university study following high school, and around 27% of students are international.

Prior to the flipped classroom intervention, instructor-led discussions of business case studies were conducted in tutorials by a team of around ten tutors employed on a casual basis and one Associate Lecturer employed full time. Tutorial attendances were low. Those students who did attend were underprepared, disengaged, and generally unwilling to participate actively in discussions of the assigned case studies. Although frustrated with students' lack of preparation, tutors—who were themselves doctorate and honours students—sometimes gained a self-esteem boost from appearing 'clever' and knowing the answers. This meant that tutors abandoned the role of facilitators of case discussions and became mini-lecturers consistent with King's (1993) notion of the 'sage on the stage', as illustrated in the quote below from a tutor in the course.

Box 18.1: Tutor Reflection
Before we 'flipped' the course, the tutorials were used to deliver content in a more relaxed environment than a lecture, with the tutor leading a structured discussion on the week's topic and questioning students' understanding by giving them the chance to participate. However, more often I was left standing in front of a group of students who had not prepared, did not understand or were unwilling to contribute as they were embarrassed that they may ask a 'stupid' question. Students came to the class generally lacking any preparation. As one student commented, 'I don't have to read the material as you will just tell me what it is about'. There was always a lot of silence when I asked students if they had read the week's case study and what they understood about it. So my role then became one of telling and not facilitating student learning. I guess it sometimes may have made us tutors feel like we had this power over the students' learning. However, it generally lacked motivation for me as a tutor. You can only hit your head on a brick wall for so long.

The outcome of these tutorial interactions was that student learning of the application of management theory to practice was limited, undermining the course's purpose as a foundation stone in the undergraduate business programme. Students did not fully comprehend the management discipline's 'ways of thinking and practising' as a foundation for their continued progress in their programme of study (Entwhistle 2005). First-year students typically entered the course with an everyday understanding of management as something people do in organisations that was common sense. The course tutorials were not facilitating movement from this common-sense understanding to a discipline-based understanding of management as theory which informs practice. Evaluation data indicated students perceived that the course focused on 'theory for theory's sake'. Moreover, examination responses to case study questions suggested students were ritually memorising concepts and had gained only a superficial understanding of the theoretical knowledge base for and of management and its application to business practice in 'real world' organisations. Finally, the course grade distribution was inferior to other introductory courses for the same student cohort, with a higher failure rate and a very low proportion of high-achieving students.

18.3 Flipped Classroom Intervention

To improve student learning in our introductory management course, we designed and implemented a flipped classroom intervention that sought to transform tutorial teaching by redefining the roles of tutors and students. Our approach involved flipping tutorials by designing interactive case study activities and progressive assessment in a way that reduced individual capacity and incentives to enact didactic roles of tutor as sage and student as passive content recipient. Instead, our flip sought to motivate tutors to identify with a role of learning facilitators and students to identify with a role of self-managed learners who arrived to class prepared and willing to participate and actively engage.

Our flipped classroom design was inspired by ideas from team-based learning, which has been recognised by educators as a useful method for flipping classrooms (Herreid and Schiller 2013). Developed by Michaelson and colleagues, team-based learning encourages development of high group cohesiveness through repeating phases of pre-class preparation, readiness assurance tests, application of course concepts and feedback (Michaelsen et al. 2004). The essential principles are that (1) groups are properly formed and permanent; (2) students are accountable for individual and group work; (3) group assignments do not require complex outputs that groups can divide and complete individually; and (4) students receive frequent and timely feedback (Michaelsen et al. 2004). The authors argue that these principles are best achieved when individuals and groups work on the same task, are required to apply course concepts to make a specific choice, and work on and report the choices simultaneously in class.

We adapted Michaelson's (2004) approach to design our flipped tutorials. Prior to the tutorial each week, students are required to pre-read a case study, analyse a set of four statements applying theoretical concepts introduced in the lecture and course readings to the case, and choose the most appropriate statement. The case studies, statements, and task descriptions are outlined in a Course Workbook, which we wrote for the course. During tutorials, class time is allocated as follows. For the first five minutes, students provide evidence of their individual preparation by writing a brief argument for or against each statement on a tutorial worksheet. For the next twenty-five minutes, students work in teams of four to discuss their positions on each statement and reach a team consensus on which statement they agree with most strongly, justifying the team consensus in writing on the team's worksheet. The tutor moves around the classroom talking to teams to probe and challenge their reasoning and understanding of the application of theory to management practice in the case. For the remainder of the tutorial, the tutor runs a whole-class debrief in which teams defend their consensus positions against other teams. Students are assessed on pre-class preparation and in-class discussion on five occasions, with the best three marks counted in their final course mark ($3 \times 5\%$).

The design of our flipped classroom fostered a role for students as self-managed learners guided by tutors playing a role of facilitators. Each student had to prepare to discuss every statement, preventing them from dividing up the task between group members. Assessment and non-assessment weeks were staggered to support students to manage their own learning through formative and summative feedback cycles (Norton 2009; Poulos and Mahony 2007; Ramsden 2003). Social loafing and free-riding were reduced by tutors observing individual contributions to group discussion as they moved around the class asking probing questions and posing 'devil's advocate' challenges, ensuring individual accountability for group output (Comer 1995; Mello 1993; Slavin 1988). Tutors were also tasked with assessing students against a criteria-based marking rubric (Sadler 2005), which allowed the tutor to adjust team marks up to reward a student who displayed superior individual preparation and/or insightful participation relative to their team and to penalise a student who was unprepared and/or not contributing to the team's discussion. Tutors were supported in shifting from the role of sage to facilitator through (1) a written tutor guide including detailed lesson plans, examples of probing questions for each case study and set of statements, and marking rubrics, (2) training prior to the start of semester, and (3) regular mentoring and peer review by the course coordinator and associate lecturer throughout the semester.

Overall, the flipped tutorial design was very effective in improving student learning. The overall pass rate for the course improved and the proportion of high-achieving students (Grade 7 or High Distinction) more than doubled. Student focus groups conducted by an independent researcher (who was a doctoral student who was not involved in teaching the course) reported that: (1) summative assessment initially motivates students to prepare, attend, and contribute, (2) positive group interactions then combine with assessment-feedback loops to create internal motivation, and (3) progressive and deep learning of the links between management theory and practice occurs in tutorials over the semester. Tutors reported higher levels of attendance, preparation, and participation in tutorials. Flipping the tutorial classroom was effective in shifting the role of students from passive recipients of content to self-managed learners and the role of the tutor from sage to leaning facilitator. We explore these role shifts in more detail in the following sections. We first present a model of the four possible tutor-student role combinations before explaining how our flipped tutorial design supported role transitions for the tutor and the student.

18.4 A Model of the Roles of Tutor and Student

The intended outcome of our flipped classroom design in terms of role shifts for both tutors and students is captured in Table 18.1. The model presents four different role combinations for tutors and students. Cell A captures the traditional classroom model of instruction, in which the tutor identifies as the 'sage on the stage' and students are passive receivers of knowledge. In Cell B, students continue to identify as knowledge recipients but the tutor now identifies as a learning facilitator or a 'guide on the side' and seeks to encourage student interaction and active learning. Thus, a disconnection occurs between how the tutor teaches and how students expect to learn. In contrast, in Cell C, the tutor attempts to play the role of sage but this preferred role enactment is disrupted by the student, who identifies as a self-managed learner. Rather than passively accepting the tutor's presentation of themselves as the source of knowledge authority in the classroom, the student disrupts by questioning and challenging. Finally, in Cell D, the tutor identifies with the role of learning facilitator and students behave as self-managed learners. This represents the ideal that flipped classrooms are seeking to create, where collaboration occurs between the tutor and students as co-participants in learning.

Table 18.1 Tutor and student roles in the classroom

	Tutor identifies as sage	Tutor identifies as facilitator
Student behaves as knowledge recipient	CELL A: instruction	CELL B: disconnection
Student behaves as self-managed learner	CELL C: disruption	CELL D: collaboration *Intended cell for flipped classrooms

To help ground the insights from Table 18.1 in concrete practice, we provide examples of the tutorial experience that emerges in each cell. In the four examples that follow, Lillian, who is an advanced-level student in the undergraduate business degree programme at our university, compares her experiences in the tutorial programmes of four different courses, including our flipped tutorials in Introduction to Management. In the first example below, Lillian describes a tutorial which fits Cell A's Instruction approach. The tutor played the role of an expert who knew all of the answers, which he wrote on the whiteboard, while students sat quietly and copied. Lillian notes the superficial learning that resulted when both the tutor and students conformed to the role expectations of this didactic and instructor-centred approach.

Box 18.2: Example Cell A: Instruction

In one of my courses, a tutorial session consists of us students sitting in rows facing the tutor who will stand at the front of the room. We have 10 questions to get through in 50 min. This results in the tutor rapidly writing out solutions on the whiteboard in front of us with very little time dedicated to understanding why we may have found a different answer. As the tasks are all closed questions, the fear of getting the answer wrong stops most students from responding. I do not learn in these tutorials. At best, I have successfully answered the questions using my lecture slides before class and am just ticking off my answers. At worst, I walk away with a sheet filled with crosses and feel like I know even less than before.

In the next example, Lillian outlines her experience in a tutorial associated with Cell B. Here, the tutor tried to establish a role for himself as a facilitator by stating, in the first week of the course, his expectations of pre-class preparation and in-class discussion. However, students were not sufficiently motivated to undertake the required preparation work. Thus, there was a disconnection between the tutor's role expectations—he wanted to facilitate informed discussion and well-reasoned debate—and students' enactment of their role—they behaved as passive knowledge recipients. The result of this disconnection for Lillian and her fellow students was a lost opportunity for student learning.

Box 18.3: Example Cell B: Disconnection
The first two weeks of tutorials in one of my courses were awkward. Students were supposed to have read the textbook and have answered a set of tutorial question before coming to class. The idea was that the tutor was going to allow us to give our opinion on the case along with our support/reasoning. He had stressed that there was no wrong answer to the tutorial questions as long as they followed correct logic and were supported with by course theory. This, of course, did not occur. Few students read the textbook, some had not yet had their lecture for the week, and an even smaller proportion had attempted the question. This stopped most learning from occurring, and people even declined to answer when asked by the tutor.

The example below presents Lillian's experience of Cell C disruption in a course tutorial. Many of the students in this tutorial enacted the role of self-managed learners by engaging deeply with the course materials, leading them to pose challenging questions to the tutor. The tutor, however, was not comfortable or confident in the role of facilitator and preferred to adhere to the prepared lesson plan. The tutor responded to behaviour of the students not as an emergent opportunity to work with highly engaged students and deepen their learning of the connection between theory and practice but instead, as a challenge to the tutor's role as content expert and as a disruption to scheduled classroom activities. For Lillian, the experience of disruption reduced her ability to learn in the tutorial to the point that she stopped attending. Fortunately, Lillian was able to switch to an alternative tutorial where the tutor was more welcoming of questions from students.

Box 18.4: Example Cell C, Disruption
For one of my courses, I attended an evening tutorial which was comprised of mature-age students as well as international students. The implication of this was that some of the mature-age students had industry experience and actively tried to make links between course work and their employment experience. The international students in my tutorial often did the pre-reading to understand the tutorial tasks and then would ask questions to see whether they had made correct conclusions. The tutor wanted to go through the questions in their way and did not appreciate a student asking questions. The disruptions meant we did not complete the questions in the given time. This continued for the first half of semester, and I stopped attending tutorials.

In the final example, Lillian reflects on her experiences with the flipped classroom model that we introduced in our Introduction to Management course. Lillian describes how, as a first-year student fresh from high school, she initially struggled with the role transition required of students in a flipped tutorial. Lillian and her classmates expected to be able to enact the role they were accustomed to performing—being a passive knowledge recipient while a teacher taught them. However, in keeping with the flipped tutorial model, the tutor did not behave as a sage but as a facilitator. As part of that facilitator role, providing summative and formative feedback on their performance in the tutorial activity proved pivotal in supporting Lillian and her group members to transition to the role of self-managed learners. The assessment-feedback cycle motivated students to prepare and participate in the flipped tutorial, leading to deep and active learning of course content, which was reflected in Lillian's demonstrated knowledge and analytical skills in her final exam.

Box 18.5: Example Cell D, Collaboration and the Flipped Classroom
The idea of a 'flipped classroom' was quite confronting for a first-year, first-semester student. Surely we were meant to be defining concepts, giving examples and identifying exceptions? Most of all, was not the tutor meant to teach us? What my group produced in the first week of the flipped tutorial activity was underwhelming but after receiving feedback, we agreed that reading the case study before the tutorial was probably a good start. After the first tutorial, however, our group knew what to do. We would even rearrange our tables and chairs into a tight group at the beginning of each session. The following week we all read the case study and brought a copy of the lecture slides—predictably, our results improved. This continued for the rest of the semester, and as we neared completion, we were on the top of our game. Our group would converse the night before to make sure that everyone, including English as Second Language students, understood the definitions. We all independently constructed a short paragraph on each topic and brought our resources (lecture slides, tutorial workbook, and textbook) to the tutorial. This resulted in our group reaching the highest grades and meant that we were well prepared for our final exam.

18.4.1 Role Shifts for Students and Tutors

Flipping the tutorials in our Introduction to Management course required both tutors and students to shift to new roles. As Lillian's example for Cell D illustrates, students who come into the course believing 'the tutor is supposed to teach us' have to be guided to behaving as self-managed learners. Similarly, tutors who are more comfortable with teaching through instruction have to be supported to play a role of learning facilitator. In this section, we outline the process of managing these role shifts by drawing on illustrative quotes and vignettes from students and tutors. We also describe some of the strategies that we used to design and implement our flipped tutorials to support the required role shifts.

18.4.1.1 Student Role Transitions: Cell A Instruction and Cell B Disconnection → Cell D Collaboration

For the flip to work successfully in promoting student learning, students who have role expectations inconsistent with the flipped tutorial must be transitioned from knowledge recipients to self-managed learners. The student vignette presented below highlights the student's initial discomfort with the role required of them in the flipped tutorial. The student admits their preferred approach was Cell A Instruction and they were confronted with a Cell B disconnection in the first weeks of the tutorial when the tutor adopted the role of facilitator. The student goes on to describe their increasing levels of confidence and motivation as the tutor helped to transition them into a self-managed learner who collaborated within a team inside a classroom of engaged learners in Cell D.

Box 18.6: Student Refection

I was out of my comfort zone at first with the flipped tutorials. I usually prefer tutorials where the tutor goes through the answers to questions at the whiteboard because—to be completely honest—they are just easier and it is less demanding in terms of having to think. So the first few tutorials for Introduction to Management were challenging. The tutorial model was so different from what we were used to that you can not really know what is expected of you until you have had a few practices at doing the tutorial that way. I remember being huddled around the desk with my group of four trying to figure out what we were supposed to write on the individual sections of the worksheet and then being told by our tutor that we had to stop writing so we could start discussing our individual positions to reach a team consensus.

When the tutor came around to our group in those first few tutorials, it was a bit intimidating because she challenged us to justify why we had chosen a particular statement and not another one. It made us realise that we were expected to have an opinion and be able to defend it. After our first assessment week, the tutor went through the marking rubric with us to show us where we could improve. We had one group member who was a bit too dominant with her opinions, and we got some feedback that we had to listen to everybody's arguments so that the group answer combined the best ideas from us all. This feedback was helpful because it gave the rest of us more confidence to speak up. The tutor also pointed out on the marking rubric that to achieve a mark in the excellent category we needed to come up with something novel or unexpected in terms of how we connected theory to the case. A couple of tutorials later we said something which made the tutor excited because she thought it was a good argument applying theory to the case but it had not been included as a suggested argument in the tutor guide.

She made a point of mentioning this in the class debrief which was motivating for us. As the semester went on, we got better at doing the flipped

> tutorial activity and we really started to enjoy working as a team and pushing each other to think of ways theory could apply to the case study. We got an excellent mark another week because we had done some additional research on the company in the case study to help strengthen our argument. The tutor liked that we had shown initiative in doing extra research relevant to the case. So in the end, I think the flipped tutorial made me learn a lot more and I got a lot out of going to the tutorials and I am still friends with one of my group members.

The vignette highlights three key elements in designing the flipped tutorial to promote the required shift in student roles. First, both the vignette and Lillian's illustrative quote for Cell D highlight the importance of an assessment-feedback cycle. Staggering assessment and non-assessment weeks in the course schedule, coupled with counting only the best three from five tutorial assessment towards the final course grade, provides students with risk-free opportunities to practice (1) how they should prepare for the flipped tutorial (*For example: What pre-reading should I do? What types of notes should I prepare on the case study? What resources do I need to bring along to class?*), and (2) how they should participate in the flipped tutorial both individually and as a group (*For example: Am I saying enough in the group discussion? Am I saying too much? How can we as a group make sure everyone has a voice and is listened to? How can we combine our individual ideas into the strongest argument about the case study that demonstrates how well we understand the course theory?*). Second, the marking rubric supports the student's role transition to self-managed learner. In the vignette, the student notes how the tutor used the marking rubric early in the tutorial programme as a tool to coach students about the behaviours they were expected to engage in. Finally, a key element in role transitioning is immediate and direct feedback from the tutor whenever students demonstrated behaviours of self-managed learners. The vignette highlights how the tutor provided both summative and formative feedback—including expressing excitement and providing public recognition—whenever students displayed behaviours such as initiative and critical analysis.

The tutor of the student featured in the above vignette provided additional elaboration of the techniques she uses in the classroom to help transition students from Cell C to Cell D. The tutor, Liz, uses the early tutorials in the semester to reinforce the kinds of behaviours that she wants students to adopt to manage their own learning. These behaviours include: reading the case study and thinking about the statements before coming to the tutorial; writing a few notes about each statement that can be quickly transferred to the worksheet as evidence of preparation; arriving on time and ensuring the group has brought along all of the necessary resources between them (e.g. textbook, lecture slides, tutorial workbook); not rushing to write the group answer onto the worksheet until it has been fully discussed; and self-policing the group to make sure everyone makes a meaningful and respectful contribution to discussion. Students who adopt these behaviours perform well in the assessment weeks. In the quote below, Liz describes her approach, including how she uses individual adjustments to a group mark to guide passive student behaviour in more active and collaborative directions. This is a powerful reinforcement that tutorial marks are not merely a reward for attending but rather are an evaluation of student's performance and engagement in the flipped tutorial.

Box 18.7: Tutor Reflection

The initial three or four tutorials work towards students realising the depth of discussion is dependent on their level of preparedness and willingness to engage with other students in the learning process. For example, when I go around each group, if they have all agreed on Statement A, I challenge them by asking why they did not choose Statement B. Or I might say, 'That is a really good point. Did you write that down?' I use the non-assessment weeks to talk with groups about what specific things they could do to improve on the marking rubric and to get them to compare the worksheet their group produced with the marking rubric and the example worksheet in the course workbook. I also use the individual section of the marking rubric to adjust a student's individual mark down from the team mark if the student has not come prepared or turns up late, which sends a powerful signal about what is required.

As the semester progresses, I can observe the students realising that their preparation is an important contribution to the team decision. The evidence is threefold with (1) students actively seeking to connect course concepts with the case information in detail, (2) students searching for additional information beyond the case information provided, and (3) the connecting together of topics that are taught in separate weeks. Students end up applying course theory in original and insightful ways and are actively engaged in the team discussion and the final debrief. My role becomes one of facilitating the learning by ensuring that the debate is rigorous and challenging and all students have the opportunity to voice their opinion. Students become actively engaged in the process of learning rather than focusing exclusively on the marks.

Another tutor in our course provided an illustrative example of a student who had an especially difficult time shifting to the role of self-managed learner. The student struggled to make sense of the flipped tutorial and was stuck in Cell B, waiting for the tutor to become the 'expert' and supply the right answer to the case study. The tutor, Geoff, enacted his facilitator role during the non-assessment weeks by coaching the student to question and experiment with course theory in the context of the case, rather than to search narrowly for a correct answer. Geoff also encouraged the student to listen to how other members of his group expressed their reasoning and justifications, and how other groups presented their ideas and insights during the class debrief, and to compare these approaches to his own. Through this coaching and reflective observation, the student began to approach the flipped tutorial as a process rather than as content and was able to manage his own learning and successfully transition into Cell D.

Box 18.8: Tutor Reflection

I had a student at the start of one semester who could not understand the flipped tutorial model. He just did not get it. The student looked to me as the person who would tell him all the information he needed to pass the course. By encouraging him to question what he was doing and why, rather than just looking for a 'right answer' from me and in the course content, the student changed as the semester progressed. Towards the latter half of the semester, he began to question how different management theories fit together in a more holistic and integrated understanding of business. The student sought to create a new and deeper understanding of the theory–practice connection from the additional theoretical knowledge and business case studies he was being exposed to each week. At the start of semester, the student was passive in the learning. With the help of my coaching and by actively listening and reflecting as other students in his group and other groups in the class presented their analysis, he became a self-managed learner. By the end of the semester, the student and his group members would challenge each idea in the case study by integrating theory across the course. Through this, the group achieved more than they would have by continuing to be passive learners.

18.4.1.2 Tutor Role Transitions: Cell A Instruction and Cell C Disruption → Cell D Collaboration

The majority of tutors in MGTS1301 are Research Higher Degree students (PhDs and Honours students) who lack classroom teaching experience and are often more comfortable playing the role of sage or instructor. Flipping the tutorials required that these tutors were supported to shift to the role of learning facilitators. We implemented four strategies to develop novice tutors into confident learning facilitators. First, we provided comprehensive support materials, including a tutor guide explaining the pedagogy underpinning the flipped tutorial, detailed lesson plans with suggested probing questions, marking rubrics, and sample worksheets. Second, we assigned experienced tutors to mentor inexperienced tutors and encouraged the latter to observe how their more experienced colleagues facilitated their flipped tutorials. By observing a flipped tutorial in action, the novice tutor gained insight into how to facilitate team discussion, conduct whole-class debriefs, and assess individual and group contributions. Third, we undertook peer review of all tutors as they facilitated their flipped tutorials and provided coaching and feedback on areas of strength and suggestions for improvement. Finally, we built a 'community of practice' within the teaching team where tutors shared—via face-to-face meetings and email—their suggestions, feedback, and reflections about their role as learning facilitators. The quote below from a novice tutor describes how being mentored by a senior tutor.

Box 18.9: Tutor Reflection

In my first semester of tutoring, Liz invited me to shadow her in one of her tutorials across a semester. By observing Liz, I learnt how to ask students questions that would lead them to deeper understanding of the course content, rather than just jumping in and explaining the content myself. It was great to be able to ask Liz questions in the context of a real tutorial. As a new tutor, this made me feel much more confident about my own teaching.

The most challenging role shift for inexperienced tutors was managing students who had already taken on the role of self-managed learners when the course began. As we indicated previously, the majority of students in our flipped tutorials initially enacted the role of knowledge recipients and required transitioning from Cell B to Cell D. Occasionally, however, students behaved and expected to be treated as independent learners. These students were often mature age and in the workforce or had delayed taking the course until their second or third year of university study. While these students were keen to bring their experiences into the classroom and to engage in debate, tutors who were not yet confident in their role as learning facilitators in the flipped tutorial may experience interactions with these students as Cell C disruptions. A tutor provided the following illustration.

Box 18.10: Tutor Reflection

I remember a mature-age student who had a very specific idea about what a mission statement was from his own experience in practice. He maintained that it was an extensive document rather than a short statement. This did not quite line up with what we were teaching in the course. I tried to bring him around to the course definition, but we ended up arguing with one another and excluding the rest of his group from the discussion. The student did not come to many tutorials after that, and I wondered whether it was because of this incident. I was not intending to impose a 'correct answer' on the student, but I think that is what I ended up doing. I think the learning outcomes could have been improved if I had asked the students to think about this example in terms of the relationship between practice and theory and encouraged them to discuss it as a group.

The above quote highlights how tutors develop a repertoire of strategies for shifting a Cell C disruption into Cell D collaboration as their experience with flipped tutorials grows. They may defuse the tension in the classroom, for example, by opening up the conversation to include other students or by 'parking' the issue for later discussion or elaboration in order to develop a more persuasive response. Another tutor strategy is to reframe a Cell C disruption as an opportunity to provide the class with a role model for being a self-managed learner in a flipped tutorial. An experienced tutor describes this particular transitioning strategy in the example below.

Box 18.11: Tutor Reflection

One of my flipped tutorials included an enthusiastic student who was taking the Introduction to Management course as part of a Health Science degree. By the second week, the student had carefully read all of the course material and was looking for additional content to read. She came along to the tutorial ready to debate the fact that Chap. 2 of the textbook brought up an historical perspective which was subsequently contradicted in Chap. 13. The rest of the class had barely read the first two chapters. I was able to use this student's questions to initiate a discussion about everyone's roles as participants in the flipped tutorial. I commended the student to the class as an excellent role model for how to arrive to class prepared, engaged, and having actively thought about what is being taught in the course and why. In terms of the student's specific question, I discussed how the theory underpinning the course had evolved over time as knowledge about management advanced through research and changes in practice, which gave the student a new lens to consider all of the subsequent course material in terms of how and why management theory changes. This kept the student's interest in the course by challenging her to think about theory differently and also provided an example for other students of what it means to be a self-managed learner in a flipped tutorial.

18.5 Reflection, Reflexivity, and Managing the Role Transitions for Students and Tutors

As we have discussed throughout this chapter, flipping the tutorials in our Introduction to Management course required role shifts for both tutors and students. In navigating the transformation from a didactic instructional environment to a flipped tutorial classroom, tutors and students need to modify their expectations and behaviours in order to enact different roles. Thus, managing these transitions in our flipped tutorial design connects to the practices of reflection and reflexivity raised previously in Chap. 5.

For tutors, the focus is on their *reflective* practices. Connecting with the work of Schön (1983), we can see that tutors taking on the task of enacting flipped classroom processes involve the two key aspects of his conceptualisation: reflection-*in*-action and reflection-*on*-action. Tutors need to deploy their repertoire of practice differently in the flipped classroom through the semi-intuitive adaptation to differences in behaviours that become apparent, as the examples in the previous sections have shown. This is the essence of reflection-in-action, as one decides how to handle each unfolding situation. An important aspect of the reflective practice required in making the transition from the role of sage to learning facilitator is to keep one's focus on *process* even if the *content* is not as precise as one might wish.

Tutors become used to managing both aspects, so this is really just a question of emphasis. Through reflection-on-action as experience with flipped classrooms grows, tutors can become more aware of their skills (or the need for them) in managing pedagogic processes and thus more adept in their deployment (see Ashwin et al. 2015, for much more on development as a reflective teacher). The quote below from a tutor in our course illustrates this process of reflection-in-action and reflection-on-action with regard to flipped tutorial teaching.

Box 18.12: Tutor Reflection

The first time I taught the course as a tutor I was learning the content week by week. My background was not in business and I had never tutored before, so most of it was new to me. I found that I was learning a lot by listening to student's discussions. I was definitely not as good at facilitating the discussion as I am now (after teaching the class over three semesters), but I think at that stage I was learning as much as the students. I made a point to say to the students that there are no right answers and that I learn from them as much as they learn from me. Even now, if a student gives a good example I sometimes use it in the next tutorial. I try to give credit by saying, 'Some students in another tutorial were talking about this, or that group mentioned that' so the students know that the examples came from other students and not from me.

Students, however, have an even more demanding transition to enact, through the deployment of *reflexive* practices. We are asking them to be more like adult learners, taking upon themselves Knowles et al. (2011) self-concept of being autonomous and self-directed in their learning. Students can be helped through this transition by connecting with the other aspects of Knowles et al. (2011) six-point framework, as discussed in Chap. 5. Perhaps the most important factor of the six for our flipped tutorial design is motivation. First, educators need to work with the immediate extrinsic motivation of the grade, and here we offer the only definite prescriptive advice: do not expect students to do anything that does not clearly lead to a grade, however, small the fraction of the overall class grade it is. *And you must be willing to allow students to fail (a low-stakes) assessment to make this motivator effective.* Some students will not need this extrinsic driver, but some definitely will.

Second, educators need to work with intrinsic drivers by taking the time to explain and stimulate reflection on how: the processes central to the flipped classroom develop stronger learning practices for other classes (students do care about their success in the overall degree, and what that 'says' about them); and how this pattern of learning prefigures future professional practice and thus works with their desire for a successful career in the long term. Through a combination of such interventions and explanations in the flipped tutorial, the ultimate goal is to help students to recognise in their overall educational careers and future professional practice that they are fully responsible for their own choices and development (c.f. Hibbert and Cunliffe 2015). To illuminate the importance of reflection for tutors and reflexivity for students, we conclude the chapter with a reflection from Alison, who is unique in having experienced our flipped tutorials both as a student and a tutor.

Box 18.13: Tutor Reflection

I have experience of the flipped tutorial model in the introductory management course as both a student and a tutor. In 2011 I was a student in the course. I found doing readings and preparations for class discussions at home gave me a deeper understanding of the lecture content—rather than simply rote learning theories to get through an exam, I found I was actually thinking about the course theory each week and how it might relate to real-life cases. Furthermore, discussing different theories relating to a case in diverse groups in class gave me an understanding of different perspectives that may be taken with regard to the same case—perspectives I might not have otherwise had access to. I found this worthwhile in how it also helped me understand how there is uncertainty in real-life business scenarios and no ‘one way’ to overcome issues. In 2013 I started tutoring for the course when I was an Honours student and I am now continuing tutoring as a PhD student. I still do readings and preparations at home for class but I find that there is ongoing mutual learning—I learn new perspectives from different students and offer my own experiences to elaborate on their discussion where I can. Instead of covering theory from the lecture and asking questions—which are often met with silence and a sea of blank faces, I find the discussions in class are deeper and every student participates. Similar to my own experience as a student in the course myself, students often approach me and say they enjoyed the course and learned a lot in the process.

18.6 Conclusion

This chapter reported on a flipped classroom intervention in an undergraduate business course. We explored the role shifts for tutors and students that occurred when a flipped tutorial intervention was introduced in an introductory management course. The chapter presented a developed model of tutor-student role combinations that created four different learning environments classified as: Instruction, Disconnection, Disruption, and Collaboration. We drew on vignettes from tutors and students to demonstrate how a Collaboration learning environment (the ideal for a flipped classroom) can be achieved through: (1). professional development practices that shift tutors from the role of King's (1993) 'sage on the stage' instructor to learning facilitators; and (2) curricula and course design and assessment and feedback practices that encourage students to shift from passive knowledge recipient to self-managed learner.

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Erratum to: Inclusive STEM: Closing the Learning Loop

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In the original version of the book, the sequence of the authors' order has to be changed to "Cindy O'Malley, Patricia McLaughlin and Pauline Porcaro" in Chap. 9. The erratum chapter and the book have been updated with the change.

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