Education Innovation

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Curriculum for High Ability Learners

Issues, Trends and Practices

Springer

Education Innovation Series

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Education holds the key to unlock human resources that a society needs to survive and flourish. This is particularly salient in a borderless knowledge economy. For the past decades, the sterling performance of economies such as Hong Kong, Finland, Japan, Singapore and Taiwan in international studies (e.g., TIMSS, PIRLS and PISA) has channeled much attention away from the traditional centers of education research in America and Western Europe. Researchers, policy makers and practitioners all over the world wish to understand how education innovations propel the emerging systems from good to great to excellent, and how different their trajectories were compared to the systems in America and Western Europe.

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The audience of the edited volumes and monographs published in this series includes researchers, policy makers, practitioners and students in the fields of education and teacher education, and public policies related to learning and human resources.

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Series Editors' Foreword

Learning and teaching are complex when we take into account individual differences as well as the interplay of social cultural contexts. High ability learners learn faster and understand abstract ideas more readily. A concept-based curriculum challenges the high ability learners to be adaptive thinkers. Moreover, in conceptualising and implementing the concept-based curriculum, teachers become the designer of learning experiences and environment. Since a concept-based curriculum requires teachers to teach for deeper understanding, it creates the curriculum space for pedagogical change on the part of teachers. Such innovation in curriculum design benefits not only the learner but also the teachers.

This book *Curriculum for High Ability Learners: Issues, Trends and Practices* is the 11th book in this Education Innovation Series. It is therefore an important addition to the series because inclusive education is a cornerstone of the Singapore education system. While the majority of the research literature on educating high ability learners focuses on person-oriented issues such as the identification and psychology of high ability learners and educational programmes to engage high ability learners, this book examines the quality of curriculum and instruction for this group of learners. With the widened conception of giftedness and talent development, Singapore's effort in nurturing the young to their fullest potential is in fact a relatively new endeavour. While major education initiatives such as *Thinking Schools, Learning Nation* (1997) and *Teach Less, Learn More* (2004) guide schools in providing quality learning experiences to all students within the existing educational framework, the recommendation of developing an Integrated Programme (IP) is a bold attempt to inject greater diversity into the education system. Since the 1990s, there is a steady increased participation rate in curriculum and programmes for high ability learners. The IP plays a pivotal role in shaping Singapore's prevailing facilitative learning contexts for diverse learners. IP schools are empowered to redefine their existing educational structures, redesign teaching and learning processes and reshape classroom practices. In Singapore, while the 'O'-level examinations serve as a valuable benchmark for the majority of students, they may not be necessary for students who are clearly university-bound and can benefit from a less structured approach. Without the 'O'-level examinations, the students will have more time and flexibility to immerse in a more broad-based education to nurture diverse talents. The pressures of increasing globalisation and competition for talent have led the government to nurturing the educational potential for all rather than for a few. The impetus of IP is to shift the emphasis of education from efficiency to diversity, from content mastery to learning skills and from knowing to thinking. At the secondary level, schools offering IP will optimise the time freed up from preparing for the 'O'-level examinations to intellectually stretch students and provide greater breadth in the academic and nonacademic curriculum. This book points to the quest for curriculum and pedagogy to provide appropriate intellectual challenges and stimulate learning, focusing on the four key areas of theories, competencies, practices and trends.

While Singapore's sociopolitical and historical contexts of educating high ability learners may be different from other systems around the world, we are certain that researchers, students, practitioners and policymakers of other countries will find the international and Singapore research and practitioner experiences exemplified in this volume to be relevant and useful. This volume's unique focus on curriculum for high ability learners, what curriculum models and pedagogical practices can do to enhance learning, what teachers believe, how they design and teach and how curriculum and pedagogical changes and innovations take place will provide the readers useful information to piece together and infer how circumstances might pan out in the classrooms of a different space at a different time, with similar aspirations. The book's focus on international and Singapore classroom practice takes into account the intellectual capacity of high ability learners. We therefore applaud the editors and authors of this volume for astutely capturing rich and detailed pictures of the journey undertaken by Singapore's classrooms. As all educational systems are dynamic in meeting the constant challenges of change, we encourage the authors to continue to study and research Singapore's diverse education system, so that high ability learners can have their learning needs met, work with people around them productively and become lifelong and life-wide learners.

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Wing On Lee
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Foreword

The editors of this international collection are to be congratulated for providing educators and researchers with answers to both fundamental and sophisticated questions regarding the nature and effectiveness of concept-based curriculum and instruction for gifted and high ability learners. The contributors provide rich illustrations of its nature, design and implementation in a variety of countries, school settings, subjects and grades. What is concept-based curriculum? Why is it a powerful pedagogy for gifted and high ability learners? What are its benefits and challenges? How should it be designed, implemented and evaluated when high ability learners are involved?

In the past, one of the distinguishing features of curriculum for gifted students was an emphasis on abstract concepts, theories and generalisations, rather than facts. Those days are gone. Now, concept-based curriculum is recommended for a range of learners so many educators of high-ability students wonder how it can and should differ from that intended for their more typical peers. Fortunately, the contributors to this volume address this need directly with each chapter presenting a complementary perspective from authors in a variety of roles: researchers, practitioners, policymakers and programme designers and evaluators. Their scholarship, wisdom and experiences enable them to offer potent insights into the value and complexities of concept-based curriculum when the goal is for highly able learners to develop enduring, authentic, flexible, conceptual understandings that prepare them well for their unpredictable futures.

No matter what a reader's role may be in the life of one or many gifted and high-ability students, she or he will find valuable insights in the authors' analyses and discussions of concept-based learning. They focus readers' attention on the complexities and benefits of this powerful and essential approach to the education of the most capable students while sharing and probing their own accomplishments and challenges in diverse settings in Singapore, Australia, South Korea and the United States.

That curriculum for gifted and high ability learners should be concept-based is one of the very few points of consensus among experts in their education. We have long known our brightest students distinguish themselves from their peers with the complexity of their thinking, their learning, their interests and their concerns. As readers will find in these pages, an expansive body of research findings, lived experience and common sense demonstrate the need for high ability learners to be provided educational experiences aligned with these characteristics as they are fundamental to the development of their extraordinary potentials. My gratitude goes to the editors for attracting the authors and to the authors for providing guidance to their colleagues in all countries who also endeavour to achieve this alignment. Although they may never read it, ultimately, those who will benefit most from this book are the students who will learn from those who have.

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We are also thankful to Ms. Lauren Kar Boon Koh for her efficient coordination and monitoring of the entire process of publishing this book. We would also like to thank Ms. Nadia Imran Ganesh, Ms. Jing Yi Tan and Ms. Sheryl Ong for their assistance in putting together the index of this book.

It is our hope that this book will enhance readers' understanding of concept-based curriculum in both the local and the international contexts and encourage practitioners to delve into curricular innovations that research has shown to be efficacious for learners with high ability.

Liang See Tan
Letchmi Devi Ponnusamy
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Reclaiming the Curriculum

Liang See Tan, Letchmi Devi Ponnusamy, and Chwee Geok Quek

In a climate of increasingly complex social and political issues, mired with competing perspectives and ideologies, and the overabundance of information, there is a growing realisation that curriculum that sees learners as mere receptacles of knowledge traditions will not equip them sufficiently to live and work in the future (Eisner, 2000). Brown (2005) argues that schools need to prepare learners to be conversant with knowledge and knowing – for learners to take an epistemic frame to learning. Adopting an epistemic frame to learning engages the learners to think conceptually. Hence, there is a need to promote high-quality education, with curriculum and pedagogies that prepare today's learners to live in and constantly adapt knowledge in an increasingly complex and changing future. There is now a mind shift amongst educators that curriculum needs to foster deeper thinking, flexibility and synthesising of thoughts and ideas.

In many parts of the world, the clarion call to maintain and improve educational standards has resulted in a drive to greater standardisation of curriculum and assessment in schools (Hargreaves, 2003). However, instead of enriching the intellectual opportunity for all learners, such standardisation has focused on merely covering the curriculum, through the transmission of facts and skills and on assessment processes with narrow conceptions of achievement and success (Darling-Hammond, 2010). Critical to the success of a system that seeks to engage high ability learners is the need for appropriate and challenging curriculum. Experts in curriculum development for high ability learners have pointed to the need for a qualitatively different curriculum for these learners, where more focus is placed on conceptual learning and teaching within the discipline (Avery & Little, 2003; Feldhusen, 1988;

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Jacobs & Borland, 1981; Maker, 1982; Perkins, 1993; Tannenbaum, 1983; VanTassel-Baska & Stambaugh, 2006; Ward, 1961). In her seminal work carried out more than 40 years ago, Hilda Taba (1962) pointed out the need to focus more on conceptual understandings rather than merely teaching facts. This view has now been echoed in the international literature on concept-based curriculum (Avery & Little, 2003; Erickson, 2002, 2007; Wiggins & McTighe, 2005) and, more recently, through the greater focus on conceptual understanding as a standard in curriculum documents (Milligan & Wood, 2010).

Conceptual learning deals with abstractions that require learners to function at higher levels of thinking in order to deepen understanding of ideas as well as to facilitate the reasoning processes. Learners are encouraged to use higher order thinking skills such as inductive, analogical and deductive reasoning to acquire increasingly sophisticated conceptual frameworks. Given the demand on intellectual capacity, concept-based curriculum requires teachers to provide opportunities for students to work with challenging, complex ideas and to apply these ideas to novel situations. Educational experiences that focus on conceptual learning are known to link the learner with the content and to other disciplines, thereby motivating high ability learners to make meaning of disconnected ideas so that there is deeper learning (Schack, 1989).

Even as concept-based curriculum is being recognised as engaging for the high ability learner, educational systems such as Singapore's, which have historically used centrally developed curricula, have now become aware that a one-size-fits-all curriculum does not meet the needs of high ability learners (MOE, 2006). Curriculum experts today refer to the need to include the diverse learning contexts in the development process and advocate multiple inputs by stakeholders (Pinar, Reynolds, Slattery, & Taubman, 2004; Skilbeck, 1984). Braslavsky (2005) postulates a network model of interaction which includes conversations and interactions, amongst curriculum writers, discipline experts and school teachers, and advocates for bottom-up and top-down approaches to curriculum development. In Singapore, the wider call to ensure schools nurture the abilities of every child on the back of greater global competition and the growth of knowledge-driven industries has seen schools looking to meet the curricular and pedagogical needs of high ability learners in the classroom (Gopinathan, 2007). There has been a paradigm shift away from an efficiency-driven educational system to an ability-driven one that places emphasis on quality teaching and learning experiences (Tan, 2005). This focal shift has resulted in a system-wide makeover where the authorities are 'reconsidering the past definitions of giftedness' (p. 1) and reconfiguring 'past provisions made for gifted children in Singapore to incorporate a larger pool of (the country's) brightest and best' (MOE, 2006). The educational landscape has been reconfigured into one that nurtures talents through 'multiple pathways' that 'seek to match the strengths and aptitudes of each student to help them achievement their potential' to achieve 'peaks of excellence' (Heng, 2012). Since 2007, several initiatives, such as the extension of the provision of a differentiated curriculum from the top 1 % to the top 5 % of the national primary school cohort, the introduction of 18 Integrated Programme (IP) schools at the secondary level and the establishment of the specialised schools in the areas of math, science, sports and arts have been put in place. Specifically, the Integrated Programme Schools have been afforded greater autonomy in curriculum-making processes through the creation and development of curriculum and programmes (MOE, 2002), an initiative that allows a seamless transition from the secondary to the high school level through the removal of the high-stakes General Cambridge (Ordinary Level) Examinations. This was intended to broaden the scope of curriculum so that teachers have more room to explore, experiment and develop curriculum that fosters deeper understanding and develops broader skills for high ability learners. Education Ministers have also emphasised that high ability learners need to be nurtured in ways which should benefit the economy and the individual whilst developing a sense of national rootedness and identity (Shanmugaratnam, 2004; Teo, 2000). Consequently, school leaders and teachers have heeded such calls to meet the educational needs of high ability learners through developing school-based curriculum. Such curriculum for high ability learners has also shifted away from focusing on generalised behavioural outcomes and high-stakes examination-based measures, to embrace a more child-centred one that focuses on rich learning experiences that emphasise greater intellectual engagement and conceptual thinking for the high ability learner.

With such autonomy, Singaporean schools are employing eclectic approaches in their selection of curriculum for high ability learners, with some adopting existing curriculum models for high ability learners, whilst others adapting them slightly to meet their own needs. VanTassel-Baska (1986) cautions against a recipe-like approach to the adoption of high-ability curriculum, stating that there is a need to consider the value of the adopted curriculum to the school's overall educational context. The development of appropriate curriculum for high ability learners is indeed a long-term process that requires large-scale investments in resources, closer collaboration and evaluation amongst teams of teachers as curriculum writers. Such development requires multiple conversations between school leaders, teachers and curriculum experts.

Concept-based curriculum development is an initiative that schools have undertaken to address Singapore's far-sighted policy initiative of ensuring curriculum development for high ability learners. Viewed as a crucial platform for promoting intellectual challenge to such learners, concept-based curriculum can provide an appropriate degree of engagement and sustained learning for such learners (Feng, VanTassel-Baska, Quek, O'Neil, & Bai, 2005; VanTassel-Baska, Avery, Little, & Hughes, 2000; VanTassel-Baska et al., 2008). Other studies have in fact found that well-written concept-based units have helped children in mixed-ability classrooms improve academically as well (Henderson, 2006; Little, Feng, VanTassel-Baska, Rogers, & Avery, 2007). These promising results, although gathered from research conducted overseas, have convinced and subsequently led several school leaders and practitioners in Singapore to adopt concept-based curriculum for their high ability learners. However, little is known about how concept-based curriculum is adopted, the benefits and the issues faced in these schools. Not much is also known about the scale of implementation in the Singapore context. The fledgling initiatives of schools implementing concept-based curriculum for high ability learners in the

Singapore context need to be highlighted to shed more light on curriculum development efforts and indirectly allow the educational system to be responsive and competitive.

'Concept-based curriculum for high ability learners' is a modest attempt to document and analyse the efforts, perspectives and conversations that relate to concept-based curriculum design and implementation processes. The book synthesises the ongoing efforts of the different curriculum stakeholders – those who design, implement and administer as well as those who evaluate and observe in their burgeoning drive to create pedagogies to meet the needs of high ability learners. This book also reflects Singapore's curriculum differentiation journey, documenting the transitioning of the educational system from one that is characterised by a centrally-controlled, standardised curriculum with high-stakes examinations to one that is customised through school-based curriculum and considers the needs of high ability learners. Throughout the book, the chapters portray the voices and experiences of the different stakeholders whilst drawing on the international perspectives of educators who contribute and comment in the field. The book also documents the opportunities and challenges that abound in Singapore's drive to provide appropriate curriculum in its efforts at ability-driven education. As Singapore's educational system is increasingly aware of the systemic inadequacy in preparing young learners to face the challenging twenty-first-century environment with our current high-stakes exam model, our system is currently undergoing change from one that is system-focused (e.g. emphasis on academic achievement in high-stakes exams) to one that is learner-centred (e.g. nurturing adaptive expertise of the learners). Similar to Singapore, many highly competitive Asian educational systems are experiencing the pressure and unknown forces of the twenty-first century. Singapore's experiences in transforming from a centralised curriculum system to one that requires teachers to make decisions in differentiating curriculum and instruction based on knowledge about the learners will receive attention from countries in the East and the West as they too are grappling with similar issues.

Differentiated curriculum and pedagogy is dynamic and flexible, more so when this is understood in the context of the diverse learning environments for HALs: from self-contained high ability learner classrooms to mixed-ability classrooms, especially in the high-stakes examination-oriented educational systems in Asia. This volume provides the much-needed analysis and discussion of current developments in this exciting field and contributes to new ways of thinking about instructional design and inclusive learning environments. In addition, it will add a fresh perspective to the international discourse on inclusionary practices for HALs.

This volume will be the first edited book to provide an overview of the latest developments related to customization of school-based curriculum and pedagogies for high ability learners after the implementation of the Integrated Programme in Singapore. As the role of making curriculum is a relatively new endeavour and rapidly evolving area, it is crucial that stakeholders keep abreast of the contexts, issues, challenges and processes of evolving teacher knowledge, beliefs and teacher learning in practice. This volume will provide a timely means of access to the latest developments in terms of ideas, research, policy and practice for international stakeholders in the field.

This volume creates opportunities to present curricular initiatives from both top-down as well as bottom-up perspectives. It can be seen as a form of curriculum theorising, in as far as it examines the interpretations and the debates in concept-based curriculum development and in that process it can 'bring about present new possibilities and bring about deeper understanding' (Huenecke, 1982, p. 290). This book presents the multiple perspectives and experiences of leading academics and practitioners from different parts of the world. It also provides a much-needed analysis of the lived experience of teachers and other practitioners in the field of high-ability studies that has been a part of the local educational system for the last 35 years. As such, this volume presents a layered and wide-ranging discussion of key issues, which will be useful in both local and global contexts.

Chapter authors, who are experts in their fields, are well positioned to contribute thoughtful and useful ideas, analysis of issues, research-based strategies and practice-oriented perspectives. They have structured their writing around the larger framework of themes which the editors have provided. Every chapter has been peer reviewed and cross-referenced to ensure consistency.

As this volume provides a range of perspectives relating to the latest developments in differentiating curriculum and pedagogies for high ability learners, we believe that it will broaden understandings and offer new insights to stakeholders, enabling them in turn to be innovators in their respective domains. The target readership for this book includes educational policymakers, researchers, educators, curriculum leaders and specialists, practitioners, and advocates who are interested in differentiating curriculum for high ability learners. Internationally, it will be a good resource for stakeholders in the field of high-ability studies as development and implementation of differentiated curriculum for high ability learners. In addition, the book will also have a wide readership locally amongst IP schools, specialised schools, TLLM schools and mainstream schools catering to high ability learners.

Each chapter provides a detailed account of the lived experience of different stakeholders in curriculum development. Essentially the chapters are divided into three general areas that address the different facets of curriculum development.

Chapter 2 aims to highlight the key findings, issues and debates in the field of curriculum and instruction for high ability learners. The chapter will justify curricular features that are suitable for high ability learners based on their key intellectual characteristics. The intended learner outcomes of developing concept-based curriculum will be discussed. Appropriate studies that compare traditional and concept-based curriculum in terms of engagement and outcomes will be discussed. It will also set the stage by providing useful definitions of the key terms used throughout this book, particularly terms such as 'high-ability' and 'concept-based' curriculum.

Chapter 3 explicitly examines the role of the teacher in the curriculum writing process and whether the role in curriculum development changes over time. It discusses the key empowering factors that shared curriculum leadership can have for the teacher and for the school and how best to allow for greater curriculum leadership to sustain the curriculum writing process. In essence, the chapter considers the role of the teacher as a change agent in curriculum development processes.

Chapter 4 explores issues in designing and implementing concept-based curriculum in schools. As schools are going through the renewal process in the twenty-first century, questions about the substance and organisation of curriculum are critical to consider, along with issues of teacher responsibility for curriculum innovation and implementation. Curriculum change requires consideration of key concepts at the core of learning in various disciplines and also attention to the knowledge and skills that teachers must have to accomplish the goals of the curriculum in the classroom. This chapter illustrates key elements and challenges involved in designing and implementing concept-based curriculum. It also makes some suggestions as to how these challenges can be handled within classrooms and schools to ensure quality in curriculum and its implementation.

As change and curriculum reform often do not happen in a vacuum, Chapters 5, 6 and 7 present scholarly contributions about the beliefs and philosophy of curriculum developers as well as issues and challenges in developing, implementing and assessing concept-based curriculum encountered in different continents and educational systems.

Chapter 5 emphasises the rationale of teaching for conceptual understanding. The author assesses the models of concept-based approaches in designing curriculum and delves into the mechanisms of designing a concept-based curriculum. The chapter closes with the support that the school and teacher leaders can provide for developing and implementing a concept-based curriculum for student learning.

Chapter 6 outlines experiences in Australian schools with concept-based curriculum. This chapter traces a brief historical perspective on how concept-based curriculum design has been perceived in the Australian context. The inquiry-based approaches introduced in the 1970s, the curriculum integration approaches of the 1980s and 1990s, and the more recent take-up of the transdisciplinary, concept-based International Baccalaureate (IB) curriculum, will be discussed. Opportunities within the different Australian state curriculum frameworks and also within the new national Australian curriculum will be identified. Here, the emphasis on cross-curriculum priorities as the basis for a curriculum designed to support twenty-first-century learning will be noted. Exemplar case study schools, such as inquiry-based integrated curriculum in primary and secondary schools, IB's transdisciplinary curriculum, play-based learning in the early years and digital designs, will be used to explore current approaches of interpreting concept-based curriculum in Australian schools. Drawing on Australian research studies, teachers' perceived benefits and the challenges involved in planning and implementing concept-based curriculum in Australian schools will be examined. Approaches to addressing assessment issues will be highlighted, including the backward design approach of front-loading assessment (Wiggins & McTighe, 2005) used by an increasing number of Australian schools. Key findings of Australian studies around the process of designing and implementing concept-based curriculum, including the author's own research in primary and secondary classrooms, will be drawn upon to qualify her stance on how concept-based curriculum is currently practised in Australian schools.

Chapter 7 offers a South Korean perspective on the development of concept-based curriculum for high ability learners. It begins with a brief discussion of the growing responsiveness of the South Korean school system at meeting the needs of high ability learners. Recent efforts and opportunities for the re-crafting of existing curriculum into a more concept-based one within the national and specialised schools systems are then explored. It is argued that such concept-based curricula assist in meeting the nation's plan of ensuring that its people are adept at meeting twenty-first-century learning demands and that such readiness is an imperative for the future of its globalised and knowledge-based economy and its burgeoning civil society.

Chapter 8 discusses the opportunities and challenges faced by school leaders as they set out to adapt curriculum to make it more concept-based. It traces the experiences of one school leader as the school embarked on the designing of the Integrated Programme that allows secondary school students to proceed to junior college without taking the 'O' levels. As the school set out to innovate and provide a more holistic programme, it had to deal with issues of autonomy to design and organise learning to add breadth and depth to the learning experiences of its students.

Chapter 9 documents the journey of a school's experience as they embarked on designing a concept-based curriculum, emphasising teaching for understanding so that students do not merely regurgitate facts, but instead become critical thinkers adept at meaning-making and dealing with abstraction. To facilitate a school-wide approach to this endeavour, the elements of the curriculum have been aligned to this purpose. This chapter explains the use of the curriculum map and the unit plan to organise facts using macroconcepts and the use of performance tasks as means to demonstrate learning outcomes. This chapter articulates the pivotal role of professional development programme in the curriculum implementation process. As in any curriculum initiative, the implementation of such a curriculum requires consideration of the context. This chapter describes the school's journey in applying the principles of a concept-based curriculum into actual practice, highlighting its contextual background, aspirations and challenges in meeting the needs of the students and teachers.

Chapters 10, 11, 12 and 13 provide first-hand subject-based perspectives in the design and implementation of concept-based curriculum. Chapter 10 calls for (re) visiting the place for concept-based instruction in English classes in Singapore as curricula continuously evolve to remain relevant. Having curricula that are relevant, engaging and motivating might sometimes appear to be secondary to notions of perceived rigour and key performance indicators in a system where high-stakes summative assessments continue to feature dominantly. Discipline-specific fundamentals remain core, especially in the formative years of education. With increasing calls to cater to a range of abilities in the classroom, we see the integration of higher order thinking, cross-disciplinary approaches and problem-solving skills playing a larger role in pedagogies and frameworks in curriculum development. There is an increasing awareness and drive to enhance conceptual thinking abilities and meta-subject understandings. Concept-based instruction premised upon a concept-based curriculum serves as a very real means of incorporating a relevant and current approach to enhancing the established discipline-specific imperatives of depth and breadth. Using the base consideration of a section of an English Language work plan, the chapter explores how a concept-based framework incorporates a Language Arts approach. It aims to indicate how it is not merely a feature for differentiation but also an approach applicable to all for skills attainment and performance enhancement. The question should not be whether concept-based instruction is relevant; it should be where and how we can smoothen the path to implementation.

Chapter 11 focuses on the relevance of concept-based curriculum for teaching Geography. This subject-specific chapter discusses the opportunities and potential in strengthening the intellectual capacities of high-ability students through a concept-based unit of instruction. The author of this chapter documents the thought processes involved in crafting a concept-based unit of instruction and reflects her personal experiences encountered in such processes as a teacher.

Chapter 12 illustrates the Singapore mathematics framework, which has been a hallmark feature of school mathematics in Singapore for well over two decades. Using problem-solving as a central focus, the framework stresses five interrelated components: conceptual understanding, skills proficiency, mathematical processes, attitudes and metacognition. In this chapter, from a curriculum perspective, the author describes how the key components of this framework undergird the content outcomes in the syllabus to provide opportunities for students to develop deep understanding of concepts. An example of how the curriculum is modified for high ability learners is also discussed. From an instruction perspective, using local data, the author discusses the extent to which classroom implementation provides students the opportunity to develop conceptual understanding. Finally, current and possible future approaches to strengthen a concept-based curriculum and instruction nexus are considered.

Chapter 13 affirms the potential opportunities in investigating and solving real-world complex scientific issues through concept-based science curriculum and instruction. The Concept-based approach emphasises and encourages learning through analysis, synthesis and evaluation. High-ability students become effective thinkers in the twenty-first century through manipulating the connections between or amongst scientific concepts. This chapter discusses specific examples of instructional strategies which could enhance conceptual teaching and learning of high-ability students. Such strategies allow students to acquire a better understanding of concepts and the interconnection of various concepts in explaining the phenomenon at hand. Instructional activities that relate well with the students and deepen conceptual understanding help students to clarify misconceptions. This chapter also discusses the challenges of assessing conceptual understanding in the context of high-stakes examination for science educators in Singapore.

Separately, Chap. 14 provides a comprehensive philosophy as well as rationales, objectives and goals for conducting curriculum evaluation in schools. Moreover, the author highlights the alignment of evaluation criteria and the intended outcomes of curriculum evaluation. This chapter also presents the curriculum evaluator's bird's-eye view on what to look out for in the evaluation process as well as provides valuable pointers on the pitfalls to avoid so as to ensure sustainable fidelity of curriculum interpretation and implementation.

Finally, the concluding chapter completes the book with an overview of the lessons learned from current practices and experimentation with concept-based curriculum in schools, explicating the insights about the ways such an experiment can benefit learners and stakeholders.

This book is pivotal in analysing and documenting efforts in creating concept-based curriculum and pedagogies for HALs. This is especially important in the context of the continued use of standards-based and high-stakes examinations in educational systems in Asia and other parts of the world. Contributors of this book discuss key concepts and trends in their curriculum development efforts for high ability learners, as well as the challenges and solutions in their work. By drawing on a wide group of stakeholders – practitioners, curriculum writers, administrators and researchers – this book collects a range of perspectives on the processes, outcomes and implications of using concept-based curriculum and pedagogies in a dynamic educational landscape. It is the editors' hope that these informed perspectives highlighted by the contributors will provide insight and inspiration to practitioners, policymakers and other stakeholders alike.

References

Avery, L. D., & Little, C. A. (2003). Concept development and learning. In J. VanTassel-Baska & C. A. Little (Eds.), *Content-based curriculum* (pp. 101–124). Washington, D.C.: National Association for Gifted Children.

Braslavsky, C. (2005). *The curriculum*. Retrieved May 20, 2011, from UNESCO: http://www.ibe.unesco.org/fileadmin/user_upload/archive/AIDS/doc/cecilia_e.pdf

Brown, J. S. (2005). *New learning environments for the 21st century*. Paper presented at the Forum for the Future of Higher Education. Retrieved November 16, 2012, from http://www.johnseelybrown.com/newlearning.pdf

Darling-Hammond, L. (2010). *The flat world and education: How America's commitment to equity will determine our future*. New York: Teachers College Press.

Eisner, E. W. (2000). Those who ignore the past … : 12 'easy' lessons for the next millennium. *Journal of Curriculum Studies, 32*(2), 343–357.

Erickson, L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.

Erickson, L. (2007). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.

Feldhusen, J. (1988). Developing units of instruction. In J. V. T. Baska, J. Feldhusen, K. Seeley, G. Wheatley, L. Silverman, & W. Foster (Eds.), *Comprehensive curriculum for gifted learners* (pp. 112–150). Boston, MA: Allyn & Bacon.

Feng, A., VanTassel-Baska, J., Quek, C., O'Neil, B., & Bai, W. (2005). A longitudinal assessment of gifted students' learning using the integrated curriculum model: Impacts and perceptions of the William and Mary language arts and science curriculum. *Roeper Review, 27*(27), 78–83.

Gopinathan, S. (2007). Globalisation, the Singapore developmental state and education policy: A thesis revisited. *Globalisation, Societies and Education, 5*(1), 53–70.

Hargreaves, A. (2003). *Teaching in the knowledge society: Education in the age of insecurity*. New York: Teachers College Press.

Jacobs, H. H., & Borland, J. H. (1981). In J. V. T. Baska (Ed.), *Curriculum for gifted and talented children*. Thousand Oaks, CA: Corwin Press.

Henderson, L. (2006). Reform and its impact on gifted students. *TalentEd, 24*(1), 33–44.
Heng, S. K. (2012). *Education for competitiveness and growth*. Paper presented at the Singapore Conference. Retrieved from http://www.moe.gov.sg/media/speeches/2012/02/08/speech-by-mr-heng-swee-keat-at-the-singapore-conference-washington-dc-usa.php
Huenecke, D. (1982). What is curriculum theorizing? What are its implications for practice? *Educational Leadership, 39*(4), 290–294.
Little, C. A., Feng, A. X., VanTassel-Baska, J., Rogers, K. B., & Avery, L. D. (2007). A study of curriculum effectiveness in social studies. *Gifted Child Quarterly, 51*(3), 272–284.
Maker, C. (1982). *Curriculum development for the gifted*. Rockville, MD: Aspen Systems Publications.
Milligan, A., & Wood, B. (2010). Conceptual understandings as transition points: Making sense of a complex social world. *Journal of Curriculum Studies, 42*(4), 487–501.
Ministry of Education (2006). Singapore- Moving beyond 1%. *The Exchange*.
MOE. (2002). *Government accepts recommendations for a broader and more flexible curriculum and a more diverse JC/Upper secondary education landscape*. Retrieved May 20, 2011, from http://www.moe.gov.sg/media/press/2002/pr15102002.htm
Perkins, D. N. (1993). The connected curriculum. *Educational Leadership, 51*(2), 90–91.
Pinar, W. F., Reynolds, W. M., Slattery, P., & Taubman, P. M. (2004). *Understanding curriculum: An introduction to the study of historical and contemporary curriculum discourses*. New York: Peter Lang.
Schack, G. D. (1989). Self-efficacy as a mediator in the creative productivity of gifted children. *Journal for the Education of the Gifted, 12*, 231–249.
Shanmugaratnam, T. (2004). *To light a fire: Enabling teachers, nurturing students*. Speech by Mr Tharman Shanmugaratnam, Minister for Education at the MOE Workplan Seminar 2004. Retrieved from http://www.moe.gov.sg/media/speeches/2004/sp20040929.htm
Skilbeck, M. (1984). *School-based curriculum development*. London: Harper & Row.
Taba, H. (1962). *Curriculum development, theory, and practice*. New York: Harcourt, Brace & World.
Tan, C. (2005). The potential of Singapore's ability driven education to prepare students for a knowledge economy. *International Education Journal, 6*(4), 446–453.
Tannenbaum, A. (1983). *Gifted children*. New York: Macmillan.
Teo, C. H. (2000, September 23). *Ability-driven education - Putting the system in place*. Paper presented at the Ministry of Education Workplan Seminar Nanyang Polytechnic Auditorium.
VanTassel-Baska, J. (1986). Effective curriculum and instructional models for talented students. *Gifted Child Quarterly, 30*(4), 164–169.
VanTassel-Baska, J., Avery, L. D., Little, C. A., & Hughes, C. E. (2000). An evaluation of the implementation: The impact of the William and Mary units on schools. *Journal for the Education of the Gifted, 23*, 244–272.
VanTassel-Baska, J., Feng, A., MacFarlane, B., Heng, M. A., Teo, C. T., & Wong, M. L. (2008). A cross-cultural study of teachers' instructional practices in Singapore and the United States. *Journal for the Education of the Gifted, 31*(3), 214–239.
VanTassel-Baska, J., & Stambaugh, T. (2006). *Comprehensive curriculum for gifted learners* (3rd ed.). Boston, MA: Pearson.
Ward, V. S. (1961). *Educating the gifted: An axiomatic approach*. Columbus, OH: Charles Merrill Company.
Wiggins, G., & McTighe, J. (2005). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Theory, Research and Conceptions of Curriculum for High Ability Learners: Key Findings, Issues and Debates

Liang See Tan and Keith Chiu Kian Tan

Introduction

The intense global competition for talents and the development of the knowledge economy as well as advancements in learning sciences and instructional methods have brought about tremendous changes and possibilities in using and designing innovative curriculum and pedagogies in classrooms. Thus, ensuring school curriculum meets the needs of learners living in an increasingly complex, fast-changing and interactive world is a major concern for educators in almost all countries.[1] In Singapore, curriculum initiatives such as the Thinking Schools, Learning Nation (TSLN) and Teach Less, Learn More (TLLM) attempt to strengthen teacher capacity to customise curriculum and instruction to engage the learners. Two major changes took place involving the high ability learners. In 2004, the Ministry of Education (MOE) implemented the Integrated Programme (IP) at the secondary level to enable schools with high ability learners to focus less on preparation for high-stakes examination and instead spend the time on opportunities that broaden their learning experience. Three years later, the MOE announced the extension of the Gifted Education Programme (GEP)-like curriculum to the next 4 % at the primary level (refer Neihart & Tan, 2016 for review). These initiatives require teachers to widen the scope of curriculum for high ability learners and provide classroom experiences that build deeper conceptual understanding and broader skills. Thus, a curriculum innovation such as the IP is arguably "a programme that is intentionally designed to engage learners in activities or events that will have educational benefits

[1] In the most recent *International Handbook of Curriculum Research* (2014), Pinar (William F Pinar, 2014) brings together curriculum change efforts in at least 34 countries that accordingly reflect "the localised and reconstructed character" of curriculum across unique histories and culture (p.1).

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for them" (Eisner, 2001, p. 31) beyond the requirements of the high-stakes examination. Even as changes are taking place in differentiating curriculum to meet the needs of learners, with the increasing speed of change and the information explosion around the world, teaching with an emphasis on thinking (Alexander, 2001; Paul & Elder, 2003) and for building conceptual understanding has been heralded as an effective approach within many curriculum frameworks (Erickson, 2002; Tomlinson et al., 2002; VanTassel-Baska & Stambaugh, 2006). There is therefore value in analysing and documenting the efforts in creating concept-based curriculum and pedagogies for high ability learners (HALs), both in the Singapore context and around the world. This is particularly important in the context of the continued use of standards-based and high-stakes examinations in educational systems in Asia and in other parts of the world.

This chapter aims to highlight the key findings, issues and debates in the field of curriculum and instruction for high ability learners, specifically in four key areas. Firstly, we explain the relations among the key elements that dictate curriculum development: (1) the intellectual characteristics of the high ability learners; (2) the curriculum principles, theories and models for high ability students; and (3) the intended student outcomes. Secondly, we explore the idea that concepts are fundamental to learning, how and why teaching for conceptual understanding results in deeper learning and how teaching for conceptual understanding is different from teaching concepts. Thirdly, we look at the complexities of understanding what a concept is across different disciplines. Finally, we focus on the tensions and challenges involved in designing and implementing concept-based curriculum. This first chapter also sets out useful definitions of the key terms such as "high ability" learner and "concept-based" curriculum that are used throughout this book.

Concept-Based Curriculum and Meeting the Needs of High Ability Learners

High ability learners need challenges in learning experiences (Passow, 1982). They have the capacity to learn fast (Colangelo, Assouline, & Gross, 2004) and to manipulate conceptual schemata (Sternberg, 1985), for in-depth learning (Renzulli, 1977), and have the intellectual sophistication to make connections conceptually (Gallagher & Gallagher, 1994). Ward (1961) advocated differential education to maximise student growth by beginning teaching with what learners know, how much further they can go and how best they learn. Subsequently, Passow (1982) suggested seven guiding principles in differentiating curriculum for high ability learners:

- Curricular content to focus and organised to include more elaborate, complex and in-depth discussion of big ideas, issues and themes within and across systems of thought
- Application of productive thinking and enable learners to reconceptualise existing knowledge and/or generate new knowledge

- Exploration of constantly changing knowledge and information to develop attitude that knowledge is worth pursing in an open world
- Exposure to, selection of and the use of appropriate and specialised resources
- Promotion of self-initiated and self-directed learning and growth
- Development of self-understanding and one's relationship to persons, societal institutions, nature and culture
- Emphasis on higher-level thinking, creativity and excellence in performance and products

Based on these principles and theories, several curriculum models emerged in the field of high ability studies for differentiating the core curriculum and enrichment programmes. In this regard, the Integrated Curriculum Model (ICM) (VanTassel-Baska & Stambaugh, 2006) is a framework that aids in designing rigorous curriculum for high ability learners. At its core, the ICM draws attention to the issues, themes and concepts in the content in order to challenge high ability learners, which in turn becomes a conduit for promoting inquiry learning and conceptual understanding. Similarly, Tomlinson et al.'s (2002) Parallel Curriculum Model (PCM) highlights the associations among the core curriculum, the curriculum of connections (i.e. conceptual understanding), the curriculum of practice and the curriculum of identity as a means of increasing depth, breadth and complexity while learning a discipline. The concept-based curriculum framework championed by Lynn Erickson (2001, 2002) emphasises the need to identify and connect concepts, both macro- and micro-concept, that are present in a unit of instruction and use these to form enduring understandings to direct teaching and learning activities. In these three models, the essential commonality is the consistent emphasis on teaching for conceptual understanding and thinking. While the curriculum orientation of the ICM and Erickson's concept-based curriculum have its roots in academic rationalism with an emphasis on developing cognitive processes, the PCM approaches the curriculum as precursor to a professional career (Eisner, 1985; Greene, 2003) and as personal relevance (Eisner, 1985; Renzulli, Gentry, & Reis, 2003). Despite these differences in their orientations, we contend that it is their collective emphasis on teaching conceptually and stimulating conceptual thinking that allows these frameworks to achieve deeper and more connected learning for high ability learners.

Furthermore, the notion of differentiating curriculum and instruction for high ability learners by focusing on conceptual understanding capitalises on the innate, intellectual strengths of such learners. The desired student learning outcomes in the curriculum would therefore require open-ended learning tasks that allow learners to discuss multiple perspectives or engage in mathematical and scientific investigative processes. Open-ended discussions will be needed to create a learning environment that encourages risk-taking behaviours and promotes self-directedness. Hence, when the emphasis on advanced concept-based content learning, higher order thinking and productive creativity is anchored in the four curricula elements of content, process, product and environment (Maker, 1982), the curriculum that results is richer, connected and more layered, thus providing a broader learning experience for the high ability learner.

Knowledge: Concepts, Forms and Processes

What knowledge is and how it should be taught are two persistent questions in the field of learning sciences. In the literature, the research focuses not only on questioning the nature of knowledge but also attempts to address the questions about the form of knowledge (Margolis & Laurence, 1999; Medin, Lynch, & Solomon, 2000), structure of knowledge (Erickson, 2001) and dimensions of knowledge (Airasian et al., 2001), as well as whether knowledge should be transmitted or co-constructed with the learners (Scardamalia & Bereiter, 2002). Moreover, proponents of concept-based curriculum provide the following contrast: deep conceptual understanding rather than a shallow or surface knowledge (Bennet & Bennet, 2008; Biggs, 1999).

The basic building block of cognition and knowledge is known as a concept. The classical view of concepts dates back to Aristotle (384–322 BCE) and is defined by a list of rules or characteristics. However, this view is challenged by the prototype theory (Rosch, 1999; Rosch & Mervis, 1975). They viewed that people do not hold lists of attributes when categorising experiences and information. Instead, they contend that people have a mental picture or belief about what makes up an example of a category. In addition, besides the prototype theory, the exemplar theory states that people are constantly engaged in comparing novel items or examples they observe to those that are stored in their memory instead of generalised or prototypical examples or a list of specific required characteristics. All these views, however, do not tell us how large the mental storage is and how the information or experiences are being stored, and so such a representation becomes problematic when defining concepts or when teaching learners about a concept.

Nevertheless, there are some commonly accepted characteristics of concepts. Concepts are universal and timeless within and across cultures. They help us to simplify and make sense of vast amounts of information and categorise observations and experiences (Martorella, 1986, 1990). Concepts are abstract because a concept "constitutes a generalised mental image of the characteristics that make items examples" (Ehrenberg, 1981, p. 37). Concepts are made up from a few concrete facts and become abstract. Also, concepts can be found in a continuum of well-defined conjunctive (i.e. having two to three attributes remains the same across examples, e.g. island, mountain) and disjunctive (i.e. having two or more sets of criteria attributes, e.g. strike) forms to relational concepts (e.g. freedom and justice) that need to be understood by comparing the contexts. In addition, concepts are essentially hierarchical: (1) the subordinate level (e.g. butterflies, spiders), (2) the coordinate level (i.e. concepts at the same level, e.g. insect, arachnid) and (3) the superordinate (i.e. the overarching concept, e.g. arthropod) level. In constructing mathematical and scientific knowledge, there is a general concern with general truths about the observable physical world, and therefore rigorous experiments and proofs are valued in an effort to achieve scientific or mathematical precision.

In terms of processes, the act of categorising facts according to concepts is therefore a process in which the learner notes the significant similarities and differences of attributes, observations and experiences. To enable learners to be conversant with this process requires specific teaching strategies, where the teacher would skillfully lead the learners to a better elucidation of the elements that make up the concept and therefore a mastery of concepts and ultimately allow them to become more sensitive, accurate and precise in their ability to distinguish new ideas (Bruner, Goodnow, & Austin, 1999). Additionally, this mastery would allow learners to better make connections across different fields and manipulate, test, predict and generate ideas. The cognitive capabilities that come with having such a deep conceptual understanding allow for powerful knowledge (Young & Lambert, 2014) that can generate diverse perspectives and encourages creative behaviours among learners.

Knowledge and Disciplinarity

While the above-mentioned features provide a basis for understanding what a concept is, there are complexities in viewing what constitutes a concept in different subject domains and disciplines. In science education, scholars are concerned with scientific misconceptions. There are two reasons for such misconceptions to occur: (1) when learners are exposed to scientific explanations without adequate instruction (Vosniadou, 2012; Vosniadou, Vamvakoussi, & Skopeliti, 2008) and (2) when learners are constrained by prior knowledge in the context of lay culture before they are exposed to school science (Vosniadou, Skopeliti, & Ikospentaki, 2005). School science can often lead learners to greater internal inconsistency and fragmentation in ways that are not often recognised by the science education community. Thus, science education researchers advocate the need for learners to develop an understanding of the nature and function of models, involve themselves in the processes of scientific reasoning through hypothesis testing and falsification and acquire experience in model construction and revision (Vosniadou, 2012). According to Posner, Strike, Hewson and Gertzog (1982), there are four fundamental conditions that need to be fulfilled before conceptual change can happen in science education: (1) there must be dissatisfaction with existing conceptions; (2) there must be a new conception that is intelligible; (3) the new conception must appear to be plausible; and (4) the new conception should suggest the possibility of a fruitful programme. Also, conceptual change is a slow process not only because it involves a complex network of interrelated concepts (Smith III, Disessa, & Roschelle, 1994) but also because it requires the construction of new representations that involve radical changes in ontology and epistemology (Chi, 1992; Hatano & Inagaki, 1997). Hence, it is necessary for educators to be aware of the need to develop scientific reasoning in students in order to achieve conceptual change in the initial conceptual system of novice science learners (Vosniadou et al., 2005).

Meanwhile for the languages, humanities and social sciences, curricular specialists discuss the importance of concept development and consider conceptual learning as the key element of curriculum, especially among curricular advocates for high ability learners (Avery & Little, 2003; Taba, 1966; VanTassel-Baska & Stambaugh, 2006). They maintain that concept development capitalises on high-ability learners' deep and complex cognitive abilities and that it allows learners to recognise how concepts in such fields are socially constructed and are therefore highly contextualised and dynamic in nature. Learning in such fields involves the establishment of conceptual understandings drawn from discussions of experiences of the phenomena in the real world. Therefore, recognising the complex individual and social constructions of various concepts across contexts, time periods and cultures can bring to consciousness the reasoning processes that underlie concept construction (Avery & Little, 2003; Lyle, 2008). Besides the cultural elements and communication skills involved in learning a language, there are structured grammar rules in languages that can be taught by using concept attainment strategy (Bruner et al., 1999). Although this results in paramount differences in acquiring knowledge in these two broad domains of knowledge, there are well-defined and fuzzy concepts in most subject domains (Kazak, Wegerif, & Fujita, 2015; Lyle, 2008). The challenge is to help teachers develop pedagogical expertise in deciding on the appropriate instructional strategy to teach for conceptual understanding.

Conceptual Thinking and Achieving Deeper Learning

In their consideration of teaching and learning activities, Airasian et al. (2001) argue that lesson experiences should focus on two dimensions, the cognitive dimension, as illuminated by Bloom's taxonomy, and the knowledge dimension, consisting of four different types of knowledge – factual, conceptual, procedural and metacognitive – to achieve deeper understanding of the discipline. Factual knowledge is defined as the specific details and terminology present in a discipline, whereas procedural knowledge refers to the skills, algorithms and specific criteria determining the use of such knowledge. They define conceptual knowledge as the more abstract ideas in a discipline, such as the classifications, principles and generalisations, and indicate that metacognitive knowledge refers to the individual's knowledge of self, cognitive and strategic tasks (Airasian et al., 2001).

Despite such advancement in our understanding about cognition and learning, Airasian et al., (2001) contend that development of conceptual knowledge, which leads to depth of understanding, does not happen because "many students do not make the important connections between and among facts and the larger system of ideas reflected in an expert's knowledge of a discipline" (p. 70). Schools are alleged to promote fragile knowledge and poor thinking (Airasian et al., 2001; Perkins, 1992) and have inadequate capacity to foster in learners the competencies to learn for the future (Voogt & Roblin, 2012). Instead of educating the minds, frontal teaching is often used which leads to missing, inert, naïve and ritual knowledge, thereby hampering good understanding and active use of knowledge among learners. Zirbel (2006) cited Mazur (1992, 1997) as well as Schneps and Sadler's (1998) work to highlight three areas that prevent teachers from achieving deep learning in students: (1) what teachers teach and what students learn are actually two different things; (2) many teachers still hold on to the same misconceptions they had prior to teaching; and (3) even when students are able to solve advanced problems, their comprehension of the most basic concepts is flawed. This is in contrast to the deep learning that can happen if students are encouraged to think conceptually, that is, organise and relate facts and information according to prior knowledge, use visual associations, quiz themselves and elaborate and extrapolate the information using examples, among many other strategies that are often not being employed in the classroom (Perkins, 1992). This issue has also been raised by other researchers across multiple disciplines (Bell, 2010; Biggs, 1999; Boaler, Williams, & Confer, 2014). In fact, Biggs (1999) argues for all learners to be encouraged to use the kinds of "higher order learning processes which "academic" students use spontaneously" (p. 57) in order to keep them engaged.

Deep understanding means that the concepts are well represented and connected (Zirbel, 2006). As such, deep understanding of a subject involves the ability to recall many connected concepts at once, where every single concept has a deep meaning in itself. Conceptual thinking then involves being able to make further connections between the webs of concepts. Such thinking also involves the construction of new concepts and is almost always based on what the student already knows. Thus it is very important to ensure that students properly understand the basic concepts and can make connections between them, i.e. are taught to think and learn conceptually.

It follows therefore that to achieve deep learning in the learners, it is beneficial to design curricula that focus on the in-depth exploration of a few key concepts in one subject matter rather than to cover a great deal of material in a superficial way. Short units on specific topics do not give students enough time and disciplinary depth to achieve the deeper, qualitative understanding of the concepts being taught. On the contrary, it encourages the memorisation of facts and it is likely to lead to logical incoherence and misconceptions. Hence, designing concept-based learning in units of instruction is a preferred mode of curriculum planning and implementation.

In their paper, Vosniadou and her colleagues (2001) share another design feature that can enhance concept-based learning. They emphasised designing curricula to distinguish between two types of new information: (1) information that is consistent with what learners already know or believe and (2) information that runs contrary to learners' conceptions. They explain that when the information is consistent with what learners already know, it can be easily incorporated into existing knowledge structures and the student readily makes sense of the new information. However, for contrary information, the curricula should be designed to provide especially clear explanations, experiments, observations and models that would help learners to restructure their prior knowledge. While Vosniadou, Ioannides, Dimitrakopoulou and Papademetriou's (2001) insights arose in the field of science education, such features are applicable in other disciplines as well, wherever students are learning concepts, so that determining the kinds of activities and assessments that would accompany a lesson is crucial to enable conceptual thinking.

Dialogic Teaching and Knowledge Co-construction for Conceptual Thinking

The authors of subsequent chapters in this book explicate the theoretical and practical knowledge of their experiences with the conceptualisation and implementation of concept-based curriculum in different educational contexts. They address several important questions such as how is concept-based curriculum different from other types of curriculum and why is it superior? When does conceptual understanding take place? How is concept-based curriculum organised? These questions bring us back to the debate of whether we educate students to simply be knowledge receivers or to be knowledge producers. Thus, in this opening chapter, we argue that the design of concept-based curriculum has great potential for developing good thinking in the learners and enabling them to be knowledge producers.

Empirical studies from Singapore (Hogan et al., 2014; Hogan, Rahim, Chan, Kwek, & Towndrow, 2012) and the West (Myhill, 2006; Myhill & Fisher, 2005; Nystrand, Gamoran, Kachur, & Prendergast, 1997) have found limited dialogic discourse happening in the classrooms. The dominant classroom practice privileges teacher instruction over student learning (Lyle, 2008). Teaching concepts didactically are different from teaching for conceptual understanding. For example, researchers in science education have asserted that mental representation cannot be created simply by didactic teaching or by presenting information (Vosniadou et al., 2001). Such teaching jeopardises student learning because it does not engage the learners with adequate background information, the necessary mental or cognitive tools and discussions to acquire an understanding of complex, conceptual models in science. A dialogic classroom engages students to think purposefully, deeply and critically at the conceptual level by asking probing questions, taking students' views into account and helping students to build relations with new information (Alexander, 2001; Paul & Elder, 2003). Teachers need to be knowledgeable about learners' prior knowledge in making substantial reorganisation of existing conceptual structures and the extent to which new knowledge needs to be introduced in order for the learner to make conceptual change. Only when teachers are aware of and understand the development of epistemological sophistication and the role of conceptual models in science and hypothesis testing and falsification in the learning process (which involve a complex network of interrelated concepts) can they be able to help learners to construct new representations and make radical ontological and epistemological changes (Smith III et al., 1994). Hence, a teacher's knowledge and understanding of a conceptual model is also an essential element in teaching for conceptual understanding. By considering learners' prior knowledge, the teacher can then engage the learners through a process of reasoning to achieve conceptual understanding of theoretical models and how such models relate to experimental evidence (Vosniadou, 2012; Vosniadou et al., 2005; Vosniadou et al., 2008). Similarly, in the humanities and the social sciences, didactic teaching often leads to learning without sufficient conceptual depth and complexity resulting in students only being able to regurgitate information and unable to connect with new knowledge when they see it. Hence, when concept-based curriculum is utilised together with pedagogies where teachers consciously connect facts together to form concepts, learners are shown how to use higher order thinking to generate the concepts, generalisations and principles which lead to a deeper and abstract understanding of the discipline, thereby allowing longer retention and transfer (Erickson, 2002).

For many scholars, the epistemological aspect of knowledge – how concepts can be understood, developed and retained – is a key feature of the curriculum and instruction (Bereiter, 2002; Passow, 1982; VanTassel-Baska & Stambaugh, 2006). Associated with such pedagogy are the relevant instructional strategies that facilitate concept attainment and concept development, where teachers are required to activate cognitive demand as well as engage the learners in discussions. Specifically, Bruner et al. (1999) argue that concept attainment sharpens the mental representation by actively formulating and testing hypothesis with the information at hand. This strategy allows learners to generate rules by differentiating similarities and differences of examples and non-examples which in turn refines the critical accuracy and precision of an idea. While concept attainment is a strategy to formulate precise and well-defined ideas, Taba (1966) developed a strategy that seeks to develop conceptual understanding which incorporates multiple perspectives. This method seeks to facilitate a systematic acquisition of concepts. Using a dialogic approach, it builds learners' initial understanding of the concept by testing, reinforcing, refining and then revising it.

Dialogic approaches have their roots in the Socratic tradition of using questions to challenge students to think for themselves. The questioner, in this case, the teacher, uses prompts or questions to help students achieve higher order thinking and creates opportunities for dialogue with others (Alexander, 2001; Cazden, 1988; Corson, 1988; Paul & Elder, 2003). Dialogic teaching allows teachers to better facilitate the exploration of relations between or among new concepts and those already learned. Ultimately, this helps to create enduring understandings.

Despite the advantages of dialogic teaching and knowledge co-construction for conceptual thinking, it is rare to observe such lessons in today's classrooms. One of the key issues could be the way lesson time is structured. Nevertheless, more dialogic interaction could happen in classes when teachers begin to ask open-ended questions that require learners to think, rather than expecting learners to merely provide answers to the questions posed in class. Ultimately, dialogic interactions would redirect learning and teaching experiences into opportunities to nurture the dispositions of all learners to be thinkers.

Students' Views About Knowledge and Learning Concepts

Concept-based curriculum not only requires teachers to know how to plan for student learning; it also requires learners to change the mode of their thinking and learning from that which they have been used to. This can be difficult as is reflected by research findings across multiple subjects that show that student beliefs about epistemology can affect how they respond to concept-based teaching and learning. For example, among science learners, those who believe that science provides a true picture of the state of affairs about the world (Driver, Asoko, Leach, Mortiner, & Scott, 1994) are less likely to develop critical thinking, engage in hypothesis testing or look for alternative explanations and instead rely on the authority of the teacher or of the text among language learners. It has been found that those who believe that knowledge is stable and consists of pieces of information are more likely to adopt superficial rather than deep study strategies, and they are less likely to achieve conceptual change in mechanics (Manson, 2003; Manson & Gava, 2007).

These findings suggest that even high ability learners need guidance and scaffolds to learn to think logically and systematically. The concept-based curriculum leverages on learners' questioning their prior experience and therefore brings logical and systematic thinking to student learning. Hence, rather than promoting rote learning, teaching and learning conceptually uses dissonance to further students' learning. This zone of learning dissonance can propel students' inner desires to know how the world works and lead them to deeper engagement in generating hypotheses and problem-solving (Cremin, Burnard, & Craft, 2006; Schwartz, Bransford, & Sears, 2005). This way of learning and teaching creates a learning environment that nurtures student dispositions in critical and creative thinking. However, such enculturation is possible only when learners and teachers feel comfortable with dissonance in their learning. This will take time, even with high ability learners, as they may have been habituated in educational systems to value the "what" of learning rather than the "how and why". This requires not only the restructuring of learners' naïve theories but also the restructuring of their modes of learning and reasoning, the creation of meta-conceptual awareness and intentionality and the development of epistemological sophistication (Pinar, Reynolds, Slattery, & Taubman, 2004; Sinatra & Pintrich, 2003). Clearly, both teacher and learners' attitude to learning needs to change so that conceptual understanding and thinking become prevalent in the classrooms.

Conclusion

This chapter has drawn attention to the strong conceptual focus that has directed current thinking about curriculum for high ability learners and sought to argue that this is necessary if we are serious about preparing such learners for the future. It has also discussed the key research findings and issues around what teaching and learning concepts mean and how this affects the work of teachers and learners in the classroom. Teachers' and students' views of a subject and its discipline have an impact on the way in which they approach learning in the domains. This implies there is a need for teachers to be knowledgeable in employing strategies that will inductively lead to conceptual change and understanding in the learner.

In the following chapters, this book will examine scholarly contributions about the beliefs and philosophies of curriculum developers, as well as issues and challenges in developing, implementing and assessing concept-based curriculum in different continents and education systems (Chapters 4, 5, 6 and 7). The role of the teacher in the curriculum writing and development process will be explored in Chapter 3. Meanwhile, Chapters 8, 9, 10, 11, 12 and 13 provide perspectives from teachers and school leaders as they set out to design and implement concept-based curriculum in English language, Geography and Mathematics. Chapter 14 provides a comprehensive philosophy as well as rationales, objectives and goals for conducting curriculum evaluation in schools. Finally, we conclude with an overview of the lessons learnt from current practices and experimentation and articulate the insights for the benefit of future learners and stakeholders in Chapter 15.

References

Alexander, R. (2001). *Towards dialogic teaching* (3rd ed.). New York: Dialogos.

Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). In L. W. Anderson & D. R. Krathwohl (Eds.), *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Longman.

Avery, L. D., & Little, C. A. (2003). Concept development and learning. In J. VanTassel-Baska & C. A. Little (Eds.), *Content-based curriculum for high-ability learners* (pp. 101–124). Washington, DC: Prufrock Press.

Bell, T. (2010). Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education*, *32*(3), 349.

Bennet, D., & Bennet, A. (2008). The depth of knowledge: Surface, shallow or deep? *NIVE Journal of Information and Knowledge Management Systems, 38*(4), 405–420.

Bereiter, C. (2002). Education in a knowledge society. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 11–33). Chicago: Open Court.

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *High Education Research and Development, 18*(1), 57–75.

Boaler, J., Williams, C., & Confer, A. (2014). Fluency without fear: Research evidence on the best ways to learn math facts. Retrieved from http://youcubed.org/teachers/wp-content/uploads/2014/10/FluencyWithoutFear.pdf

Bruner, J., Goodnow, J., & Austin, G. (1999). The process of concept attainment. In E. Margolis & S. Laurence (Eds.), *Concepts: Core readings* (pp. 101–123). Cambridge, MA: The MIT Press.

Cazden, C. B. (1988). *Classroom discourse: The language of teaching and learning*. Portsmouth, NH: Heinemann.

Chi, M. (1992). Conceptual change within and across ontological categories: Examples from learning and discovery in Science. In R. Giere & H. Feigl (Eds.), *Cognitive models of science* (pp. 129–186). Minneapolis, MN: University of Minnesota Press.

Colangelo, N., Assouline, S. G., & Gross, M. U. M. (2004). *A nation deceived: How schools hold back America's brightest students*. Iowa City, IA: Belin-Blank Centre.

Corson, D. (1988). *Oral language across the curriculum*. Clevedon, UK: Multilingual Matters.

Cremin, T., Burnard, P., & Craft, A. (2006). Pedagogy and possibility thinking in the early years. *Thinking Skills and Creativity, 12*, 108–119. doi:10.1016/j.tsc.2006.07.001.

Driver, R., Asoko, H., Leach, J., Mortiner, R., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23* (7), 5–12.

Ehrenberg, S. D. (1981). Concept learning: How to make it happen in the classroom. *Educational Leadership, 39*(1), 36–43.

Eisner, E. W. (1985). Five basic orientations to the curriculum. In *The educational imagination: On the design and evaluation of school programmes* (pp. 61–86). New York: Macmillan.

Eisner, E. W. (2001). *The educational imagination: On the design and evaluation of school programmes* (3rd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.
Erickson, L. H. (2001). *Stirring the head, heart and soul: Redefining curriculum and instruction* (2nd ed.). Thousand Oaks, CA: Corwin Press, Inc.
Erickson, L. H. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press, Inc.
Gallagher, J., & Gallagher, S. (1994). *Teaching the gifted child* (4th ed.). Boston, MA: Allyn & Bacon.
Greene, M. J. (2003). Gifted adrift? Career counseling of the gifted and talented. *Roeper Review, 25*, 66–72.
Hatano, G., & Inagaki, K. (1997). Qualitative changes in intuitive biology. *European Journal of Psychology of Education, XII*, 111–130.
Hogan, D., Kwek, D., Towndrow, P., Rahim, R. A., Tan, T. K., & Chan, M. (2014). Visible learning and the enacted curriculum in Singapore. In Z. Deng (Ed.), *Globalization and the Singapore curriculum: From policy to classroom* (pp. 121–149). Dordrecht, The Netherlands: Springer.
Hogan, D., Rahim, R. A., Chan, M., Kwek, D., & Towndrow, P. (2012). Understanding classroom talk in secondary three mathematics classes in Singapore. In B. Kaur & T. L. Toh (Eds.), *Reasoning and communication and connections in mathematics* (pp. 169–197). Singapore, Singapore: World Scientific.
Kazak, S., Wegerif, R., & Fujita, T. (2015). The importance of dialogic processes to conceptual development in mathematics. *Educational Studies in Mathematics, 90*, 105–120. doi:10.1007/sl0649-015-9618-y.
Lyle, S. (2008). Dialogic teaching: Discussing theoretical contexts and reviewing evidence from classroom practice. *Language and Education, 22*(3), 222–240.
Maker, C. J. (1982). *Curriculum development for the gifted*. Rockville, MD.: Aspen Systems Publication.
Manson, L. (2003). Personal epistemologies and intentional conceptual change. In G. M. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 199–236). Mahwah, NJ: Erlbaum.
Manson, L., & Gava, M. (2007). Effects of epistemological beliefs and learning text structure on conceptual change. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Reframing the problem of conceptual change in learning and instruction* (pp. 165–196). Oxford, UK: Elsevier Science.
Margolis, E., & Laurence, S. (1999). Concepts and cognitive science. In E. Margolis & S. Laurence (Eds.), *Concepts: Core readings* (pp. 3–81). London: The MIT Press.
Martorella, P. H. (1986). Teaching concepts. In M. C. James (Ed.), *Classroom teaching skills*. Lexington, MA: Healty and Company.
Martorella, P. H. (1990). Strategies for aiding students in comprehending social studies subject matter. *The Social Studies, 81*(3), 131–134.
Mazur, E. (1992). Qualitative vs. quantitative thinking: Are we teaching the right thing? *Optics and Photonics News, 2*(38).
Mazur, E. (1997). *Peer instruction: A user's manual*. Upper Saddle River, NJ: Prentice-Hall.
Medin, D. L., Lynch, E. B., & Solomon, K. O. (2000). Are there kinds of concepts? *Annual Review Psychology, 51*, 121–147.
Myhill, D. (2006). Talk, talk, talk: Teaching and learning in whole class discourse. *Research Papers in Education, 21*, 19–41.
Myhill, D., & Fisher, R. (2005). *Informing practice in English: A review of recent research in literacy and the teaching of English*. London: Her Majesty's Inspectorate.
Neihart, M. F., & Tan, L. S. (2016). Critical assessment of gifted education in Singapore. In Y. D. Dai & C. C. Kuo (Eds.), *A critical assessment of gifted education in Asia: Problems and prospects* (pp. 77–96). New York: Information Age Publishing.
Nystrand, M., Gamoran, A., Kachur, R., & Prendergast, C. (1997). *Opening dialogue: Understanding the dynamics of language and learning in the English classroom*. New York: Teachers College Press.

Passow, A. H. (1982). *Differentiated curricula for the gifted/talented.* Paper presented at the first national conference on curricula for the gifted/talented, Ventura, CA.

Paul, R., & Elder, L. (2003). *A miniature guide for students and faculty to scientific thinking*. Tomales, CA: Foundation for Critical Thinking.

Perkins, D. (1992). *Smart schools: From training memories to educating minds*. New York: The Free Press.

Pinar, W. F. (2014). *International handbook of curriculum research*. New York: Routledge.

Pinar, W. F., Reynolds, W. M., Slattery, P., & Taubman, P. M. (2004). *Understanding curriculum: An introduction to the study of historical and contemporary curriculum discourses*. New York: Peter Lang.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211–227.

Renzulli, J. S. (1977). *The enrichment triad model: A guide for developing defensible programs for the gifted*. Mansfield, CT: Creative Learning Press.

Renzulli, J. S., Gentry, M., & Reis, S. M. (2003). *Enrichment clusters: A practical plan for real-world, student-driven learning*. Mansfield, CT: Creative Learning Press.

Rosch, E. (1999). Principles of categorisation. In E. Margolis & S. Laurence (Eds.), *Concepts: Core readings* (pp. 189–206). London: The MIT Press.

Rosch, E., & Mervis, C. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7*, 573–605.

Scardamalia, M., & Bereiter, C. (2002). Knowledge building. In J. W. Guthrie (Ed.), *Encyclopedia of education* (2nd ed., Vol. 4, pp. 1370–1373). New York: Macmillan Reference.

Schneps, M. H., & Sadler, P. M. (1998). *A private universe*. New York: Annenberg/CPB.

Schwartz, D. L., Bransford, J. D., & Sears, D. (2005). Efficiency and innovation in transfer. In J. Mestre (Ed.), *Transfer of learning: Research and perspectives* (pp. 1–51). Greenwich, CT: Information Age Publishing Inc.

Sinatra, G. M., & Pintrich, P. R. (2003). *Intentional conceptual change*. Mahwah, NJ: Erlbaum.

Smith, J. P., III, Disessa, A. A., & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Science, 3*(2), 115–163.

Sternberg, R. (1985). *Beyond IQ*. Cambridge, UK: Cambridge University Press.

Taba, H. (1966). *Teaching strategies and cognitive functioning in elementary school children (Cooperative research project)*. Washington, DC: Office of Education, U.S. Department of Health, Education, and Welfare.

Tomlinson, C. A., Kaplan, S. N., Renzulli, J. S., Purcell, J., Leppien, J., & Burns, D. (2002). *The parallel curriculum: A design to develop high potential and challenge high-ability learners*. Thousand Oaks, CA: Corwin Press, Inc.

VanTassel-Baska, J., & Stambaugh, T. (2006). *Comprehensive curriculum for gifted learners* (3rd ed.). Boston: Pearson Educaiton, Inc.

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competencies: Implications for national curriculum policies. *Journal of Curriculum Studies, 44*(3), 299–321. http://dx.doi.org/10.1080/00220272.2012.668938

Vosniadou, S. (2012). Reframing the classical approach to conceptual change: Preconceptions, misconceptions and synthetic models. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second international handbooks of science education* (pp. 119–130). Dordrecht, The Netherlands: Springer.

Vosniadou, S., Ioannides, C., Dimitrakopoulou, A., & Papademetriou, E. (2001). Designing learning environments to promote conceptual change in science. *Learning and Instruction, 11*, 381–419.

Vosniadou, S., Skopeliti, I., & Ikospentaki, K. (2005). Reconsidering the role of artifacts in reasoning: Children's understanding of the globe as a model of the earth. *Learning and Instruction, 15*, 333–351.

Vosniadou, S., Vamvakoussi, X., & Skopeliti, I. (2008). The framework theory approach to the problem of conceptual change. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 3–34). New York: Routledge.

Ward, V. S. (1961). *Differential education for the gifted*. Los Angeles: National/State Leadership Training Institute for the Gifted and Talented.

Young, M., & Lambert, D. (2014). *Knowledge and the future school: Curriculum and social justice*. London: Bloomsbury Academic.

Zirbel, E. L. (2006). Teaching to promote understanding and instigate conceptual change. *Bulletin of the American Astronomical Society, 38*, 1220.

Concept-Based Curriculum and the Teacher: Galvanising Teacher Agency

Letchmi Devi Ponnusamy

Introduction

With the current understanding about the teacher's critical role in the learning process (Barber & Mourshed, 2007; Hattie, 2009; Mourshed, Chijioke, & Barber, 2010), educators are now increasingly looking to involve teachers in ensuring greater customisation of learning. Educational systems are exploring more bottom-up approaches to curriculum development, as they seek to ensure that schools are equipping learners for the post-modern economy whilst at the same time deal with persistent achievement gaps and manage greater stakeholder involvement in education (Braslavsky, 2002; Darling-Hammond & Friedlaender, 2008; Garner, 2015; Kalantzis & Cope, 2006). School-based efforts have become test-beds to change instructional practices that have traditionally relied on centrally controlled, linear models of curriculum development (Brady, 1995; Gopinathan & Deng, 2006; Law & Nieveen, 2010). Teachers' role in curriculum has become important in leading the bottom-up approach to curriculum, and factors such as teachers' curricular expertise in selecting and conveying content suited to the learner in particular contexts (Ennis, 1994), professional learning opportunities (Cochran-Smith & Lytle, 1999; Timperley, Wilson, Barrar, & Fung, 2007) and teacher agency (Campbell, 2012; Fenwick & Edwards, 2010; Priestley, 2011; Priestley, Edwards, Priestley, & Miller, 2012) have become significant considerations in school-based curriculum development efforts. Specifically, given that such change depends on the active and reflexive engagement of teachers in their curricular contexts for action, teacher agency has become a critical determinant for the ongoing development and refinement of curriculum.

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This chapter therefore discusses the role that teacher agency plays in teachers' efforts at curriculum development, specifically in designing concept-based curriculum. The first part of the chapter explores teachers' efforts at curriculum development and how it plays a role in building teachers' capacity to address twenty-first-century learning needs. This is followed by a discussion of how teachers' involvement in concept-based curriculum, with a particular focus on ensuring deeper learning, can affect teacher agency, and explores this line of thinking in current conceptualisations of teacher agency in the literature. In the second part of the chapter, utilising a Deleuzian (Deleuze & Guattari, 1987) perspective of learning, knowledge and concepts, I argue that the development of concept-based curriculum galvanises teacher agency as it supports teachers' efforts at educational customisation to meet the needs of all learners and prepare them for the twenty-first century. In the final part, teachers' efforts at developing concept-based curriculum are considered in light of data gathered from a 6-year single site case study. The implications of such efforts for teacher expertise development and developing richer and transformative student learning experiences in teacher-developed curriculum will also be discussed.

Teacher-Developed Curriculum, Deeper Knowledge and the High Ability Learner

Teacher's efforts at curriculum reform are now seen as a viable way to help learners deal with the challenge of becoming life-long learners in today's complex, interconnected world (Fullan, 2000). In the literature, the term curriculum development can refer to both deliberate and unplanned curricular adaptions, triggered by larger policy changes or by smaller requirements such as accommodating the needs of learners (Cohen & Ball, 2007). However, in this chapter, curriculum development refers to the *planned* changes that are conceptualised and undertaken by classroom teachers *to meet learners' needs*. Even as teachers are the main drivers in such efforts, it must be noted that they often depend on and utilise wider networks that stretch across the classroom (Marsh, Day, Hannay, & McCutcheon, 1990), and these include researchers and experts working with learners with special needs.[1]

Traditionally, curriculum has been developed by subject specialists and disciplinary experts, with a clear focus on the rigour and depth of the discipline, whilst schools have acted as the implementers of the curriculum (Skilbeck, 2005). This process has continued in most educational systems which are centrally controlled and has been the case in most Asian contexts (Kennedy & Lee, 2008). When designing the curricula, experts tend to answer the question about what learning experiences

[1] Both curriculum development and innovation are used interchangeably in this chapter. Furthermore, the term curriculum development is used in its widest sense and refers to the appropriate selection and use of content as well as instructional strategies to achieve disciplinary learning and meet learners' needs in specific contexts.

in public education are significant to the cohort by selecting one of four main learning orientations, namely: the academic, experiential, technological or pragmatic orientation[2] (VanTassel-Baska & Stambaugh, 2006; Walker & Soltis, 2004). Most centralised education curricula have adopted the academic approach (Herschbach, 1989), which focuses on the significance of the rich academic and cultural knowledge heritage to the discipline, the whole society and to the individual (Tyler, 1949). In the academic rationalist orientation, disciplinary experts adopt a generalised, ideal picture of an archetypal learner in a typical school (Carl, 2009). Such an ideal profile of the learner is usually derived from psychological development and teaching theories such as those of Piaget, Maslow and Kohlberg. Disciplinary experts place a heavy focus on aspects of the subject discipline, setting up predetermined objectives for rigour in the curriculum, which ultimately requires the learner to know the facts and concepts that are deemed significant to the field. However, this strong focus on getting students to achieve a predetermined understanding of the key facts and concepts in the academic approach is argued as being inflexible as such lessons can lead to a one-size-fits-all format. Hence, even when the academic approach generates an appreciation of the key ideas and structures in the discipline, it is clear that taking only one of the four approaches to curriculum is unlikely to achieve parity in learning for all learners (Walker & Soltis, 2004).

In fact, Cheung and Wong (2002) have found that adopting different curriculum orientations alone does not result in greater learner engagement. Bottom-up curriculum approaches where teachers are involved in the design of curricula can offer significant bridges between the subject matter and the learner and can be more fruitful in creating meaningful engagement for the learner (Bolstad, 2004; Brady, 1995; Kärkkäinen, 2012). To this end, Kärkkäinen's meta-study of curriculum efforts in several OECD countries highlights how a very prescriptive central-level curriculum guidance may not allow teachers to bridge students' experiences and learning goals, as teachers lack ownership and commitment to change. In Asian societies, teacher's efforts at curriculum development are encouraged in a variety of ways in the hope that schools are able to offer learning experiences that are broader than that offered by the existing curriculum (Law & Nieveen, 2010). In the Singapore context, the 'Teach Less Learn More' policy was introduced to advocate instructional differentiation to meet learners' needs, so that teachers are able to teach the centrally developed curriculum to prepare students for high-stakes national examinations (Lee, 2004). However, meeting learners' needs using a top-down policy has indeed proved to be difficult and is stifled by several factors such as teacher commitment, competence and autonomy (Leong, Sim, & Chua, 2011). More bottom-up curriculum

[2] Curriculum orientations reflect decisions made about what knowledge is of most worthy in public education and are derived from the original five orientations set out by Eisner and Vallance (1974). Briefly, the four approaches are as follows: (1) academic rationalism approach promotes the ideas and structures within each discipline; (2) experiential approach promotes the development of a student's ability to think; (3) the technological approach aligns curriculum with how to assess and provide appropriate prescription of instruction and activities to students; (4) the pragmatic orientation focuses on developing students to solve social problems and participate in society.

efforts that are embedded in schools are now being called on and supported by the Ministry (Deng, Gopinathan, & Lee, 2013), but there is an inherent fear of loss of academic rigour when more control is ceded to the teacher, so the recurrent message has been one of ‘decentralised centralism’ in order to better manage change (Leong et al., 2011, p. 59).

Nevertheless, rigour and sustainability are perhaps more achievable if teachers, in designing curricula, can deliver broader learning outcomes than what can be achieved in the centrally developed curriculum. Teacher efforts therefore have to evolve from modifying the centralised curriculum to that of adopting content, concepts, sequencing and pedagogy to focus on the learner’s experience in the discipline, placing less emphasis on factual learning and providing space for the growing understanding of abstract concepts (Skilbeck, 2005). The curriculum development processes therefore should be directed at transforming learners into autonomous thinkers with a deeper understanding of the discipline. It is this outcome that experts point to when they stress the need to design curricula that develop the learners’ insights of the knowledge offered in the various disciplines (Dewey, 1902; Schwab, 1973; Stenhouse, 1975; Taba, 1962).

In doing so, teachers need to heed Reid’s (1999) imperative of taking up a fundamental shift in the conception of curriculum from that of ‘things to be learned’ to that of curriculum as practice. Viewing curriculum as practice emphasises interpretation and meaning-making by the teacher (Grundy, 1987), which involves curriculum to be deconstructed and reconstructed as a vehicle for shaping of the meaning, insights and identities of the learner. Clearly teachers need to have the depth and breadth of knowledge that connects the learners’ different cognitive processes with the structure of knowledge in the discipline (Erickson & Lanning, 2014). Current lesson experiences tend to focus so much on factual and procedural knowledge that learners do not make the ‘important connections between and among facts and the larger system of ideas reflected in an expert’s knowledge of a discipline’ (Airasian et al., 2001, p. 70), an observation that has been raised in multiple disciplines (Bell, 2010; Boaler, Williams, & Confer, 2014). Specifically, in meeting the needs of high ability learners, the lessons need to be focused on what such learners do ‘spontaneously’—their use of higher order thinking processes (Biggs, 1999, p. 57). Focusing learning experiences on conceptual connections can engage such learners better as it requires high ability learners to play an active and intentional role by requiring them to question, restructure and re-contextualise facts and skills to the larger concepts. The result is therefore more engagement for high ability learners in the short term and academic rigour and deeper understanding in the long term. Hence, for a high ability learner curriculum to provide transformational learning experiences and develop deep disciplinary knowledge, teacher-developed curriculum needs to stress concept-focused learning.

Concept-Focused Learning and the High Ability Learner's Needs

Erickson points out that concept-focused learning allows the learner to actively restructure their knowledge, develop autonomous thinking and acquire key twenty-first-century dispositions and skills (2002) such as self-directedness and life-long learning. Concepts are defined as 'sets of specific objects, symbols, or events which are grouped together on the basis of shared characteristics and which can be referenced by a particular name or symbol' (Merrill & Tennyson, 1977, p. 3). This learning conceptually involves incrementally connecting and re-representing the disparate facts acquired in the course of learning into a form that learners can call their own. Learning concepts is a thoughtful, engaging process because learners access and apply higher order thought processes, so that there is greater complexity, rigour, and integration of knowledge in the discipline (VanTassel-Baska, 1989; VanTassel-Baska & Brown, 2007). Transmission-based, content-focused curricula do not provide enough of such opportunities for learners, and therefore what is learned tends to be fossilised.

The incremental, thoughtful process in concept-focused learning is highly important for high ability learners as such learners often have a wider knowledge repertoire and exhibit faster thought processes. Often educators who work with such learners have to keep these fast thinkers engaged, and this is better done by getting the learners to exercise their own discretion through the use of a wider conceptual approach. For this reason, teachers working with high ability learners leverage on existing curriculum models such as the Integrated Curriculum Model (ICM) and the Parallel Curriculum Model (PCM),[3] as is apparent in the practitioners' accounts in the later chapters of this book, as these models are fundamentally concept focused to ensure a more engaging and customised learning experience. However, even as concept-based curricula have the potential of encouraging learning at a far greater depth and complexity for high ability learners, the teacher's agentic behaviour makes a strident contribution to developing and implementing such curricula.

Developing Concept-Based Curriculum Galvanises Teacher Agency

Teachers' involvement in the curriculum development process inspires deeper commitment and meaning-making in the teaching and learning process (Ben-Peretz, 1990; Connelly & Clandinin, 1998; Doyle, 1992). However, teachers' commitment and meaning-making process become more evident when they emphasise concept-focused learning in the discipline, both during the development and implementation

[3] For description and comparative review of these curriculum models, please see VanTassel-Baska and Brown, 2007 and VanTassel-Baska and Stambaugh, 2009.

stages. When teachers develop concept-focused curricula, they are personally faced with the task of retracing how the facts in the discipline are aligned together with the abstract concepts. They then actively experiment with instructional strategies, determining how they can get at the learner's background knowledge, tacit understanding and misconceptions in the discipline. At the same time, teachers would need to consider a wider range of affective, cognitive and metacognitive skills and dispositions amongst their learners as they select instructional practices and formative assessment tools to ensure that learners make conceptual links in the discipline. In short, by designing concept-based curriculum and adopting concept-focused learning, the teacher can help to nurture a broader and deeper appreciation of the discipline. This moves teachers away from being transmitters of curriculum (Brady, 1995), and instead they become the meaning-makers of the discipline. Furthermore, a focus on conceptual understanding ensures that the technical, practical (interaction) and emancipatory knowledge—interests that should guide fundamental human learning (Habermas, 1972)—are realised, so that teachers can realistically and reasonably prepare learners for life-long learning.

However, whilst concept-based curriculum can offer a more realistic way of preparing learners for life, traditionally, teachers have acted as curriculum implementers and knowledge transmitters. This lack of acceptance of the curriculum developer and learning facilitator roles is compounded by the depth of deliberation and work that is needed to develop concept-based curricula. Moreover, teaching conceptually may sometimes mean that the learner will leave the lesson with more questions than answers. Leaving learners in a place of doubt is often seen as the antithesis of good teaching and can put teachers in an uncomfortable place, especially if the existing social and cultural norms of education rest on giving learners the right answer. Given such complexities and the daily grind of working with so many learners, teachers will need to find the mental and physical energy to exercise their knowledge authority and thought freedom and feel confident about teaching the discipline conceptually whilst meeting the needs of the prescribed curriculum.[4] When teachers *do* exercise their knowledge authority and freedom to develop concept-based curricula, they arguably exercise agentic behaviour to become active advocates for how to (re)represent the discipline to their learners' in situ. Teachers' work in concept-based curriculum development is therefore dependent on the delicate relationship that arises when teachers become active agents of learning, and I briefly look at how this emphasis on teachers developing concept-based curricula interacts with teacher agency.

[4] It might be useful for teachers to become used to distinctions between two kinds of curricula- one which is prescribed and fixed, and a fluid one, where they have space for deliberation and experimentation of key ideas. This idea is taken up again later in this chapter.

Conceptualisations of Teacher Agency: Focusing on Promoting Deeper Learning

In current conceptualisations, professional agency is seen to be situated within the individual, who has the capacity to exercise free action based on his or her beliefs and values, and accomplish independent actions. Specifically, agency tends to focus on the individual's capability of carrying out action and not merely intentions (Giddens, 1984), and how the agentic action is free from social constraints (Calhoun, 2002). However, there is also an extant debate about the primacy of structure over agency and how structure affects agency by shaping social realities.[5] In elucidating the links between structure and agency, Emirbayer and Mische (1998) describe agency as being organised by three constitutive elements: iteration, practical and projectivity, and evaluation, which consecutively relate to time-specific orientations of the past, the present, and the future. Thus a chordal triad of agency is espoused, where all three dimensions resonate but not always harmoniously. This triad also sheds more light on the subjectivities of agentic action in the real world. Hence, at any point in time, an actor's action or agency is seen as 'a temporally embedded process of social engagement, which allows actors to critically shape their own response to a problematic situation' (Emirbayer & Mische, 1998, p. 963). Another recent theory posits a professional's agentic work as temporally embedded, so that the past training and background, current conditions and the future expectations are all considered and contribute to professional work (Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013). Thus whilst agency lives within the individual, each professional's practice happens in the midst of the socio-cultural conditions of the workplace as well as the professional identity, knowledge and competencies, and experience that make up professional practice.

However, despite the debates about the primacy of structure or agency in human behaviour, the power of individuals is still a necessary condition for agency. Biesta and Tedder (2007) extend this line of thinking to regard teacher agency as something that is achieved, rather than possessed, and draw on current ecological understandings of agency to describe the active engagement of teachers within their contexts for action. In further explorations of teacher agency, Priestley, Robinson and Biesta (2011) theorise an ecological view of teacher agency where teachers' agentic action is affected by the teachers' past experiences, current school and learner needs and future stakeholders' expectations. Drawing on studies of teachers' work with new curriculum, the teachers' agentic action has been found to be affected by factors such as the beliefs, values and attributes that the teacher calls on in a particular situation (Priestley et al., 2012). However, they also note that current conceptualisations of teacher agency are relatively under-theorised in the specific context of curriculum development (Priestley et al., 2012).

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[5] Recent theories have made efforts at finding a "middle ground" and to blur the dichotomy between structure and agency as can be seen in arguments made by Archer (2003), Bourdieu (1984) and Giddens (1984) as well as the arguments made about the holistic and individualistic strategies used to explain agency (Hollis, 1994; Levine, 2005).

In arguments about professional agency in education, teachers are seen alternatively as agents of socialisation or as change agents (Campbell, 2012; Fullan, 1993). However, reform efforts such as school-based curriculum development can affect the teachers' identity as much as they call on more agentic action (Lasky, 2005). Given the multiple roles that each professional has to play, each identity of the teacher is referenced to the parts of the self that are attached to the roles that he or she plays in society. Teachers involved in curriculum development therefore would have to contend with a new professional identity, that of being a curriculum developer and a meaning-maker of the discipline. It follows then that in designing curriculum, the teacher's professional agency will manifest itself in at least two distinct ways—in maintenance of existing curriculum practices *and* in being an advocate of curriculum change. However, given that the professional identity can change according to the different circumstances (Stryker & Burke, 2000), even amidst this tension, there is constant shaping and renegotiation of the teachers' professional identity as they go about their work, and this affects the teachers' agentic action. When the teacher is going about changing curriculum to ensure that it is more concept focused, the teacher becomes an advocate for deeper learning and therefore calls on specific beliefs, values and attributes in order to achieve agentic action.

Two important questions arise when we look at how teacher agency is spurred on by teachers' work in developing concept-based curricula: (1) What are teachers change agents of? and (2) what is the teachers' purpose of change? Campbell (2012) pointed out that in curriculum contexts, teachers' agency can be framed by the essential question of 'agency for what?' and how the answer to this essential question frames the multiple actions of the teacher during curriculum implementation, interpretation, change and subversion. In traditional transmission-based models of teaching and learning, teacher agency is called on when teachers refine externally developed curriculum in order to socialise the learner into understanding the concepts that are the norm of the discipline. However, teacher agency in concept-based curricula emphasises the teacher's role in facilitating deeper understanding by questioning current mindsets and conceptions and in the process inviting the learner to create fresher links in the subject that was not seen hitherto. Whilst this facilitation of deeper understanding can happen sometimes in fact-based curricula, in concept-focused curricula, both facts and concepts are pushed to the foreground. Hence, when considering teacher agency in the curriculum development effort, the perspectives that teachers have towards the inadequacies of an existing curriculum in meeting current and future needs will have to be considered as well.

Additionally, Priestley et al. (2012) point to the iterative, practical and projective dimensions of teacher agency. This means that agency in the teacher's curriculum efforts is at least related to the ways that the teacher values teaching and learning, and this can help in investigating how teachers design curricular experiences that are compatible with these values that engage students. Teachers therefore become active agents of change in understanding the discipline, firstly at the personal level and then at the individual learner and classroom levels. In this sense, curriculum development, particularly, that of concept-based curricula, becomes a concrete handle by which theoretical constructs such as teacher agency and identity transcend into the teacher's practice in the school. It is profitable to consider how teaching and learning conceptually change the teachers' view of what happens in learners and the outcomes that are expected, and this is explicated next using the Deleuzian post-structuralist theory (Deleuze & Guattari, 1987).

Teaching and Learning Conceptually: A Deleuzian Perspective

Concept-based curricula development brings to the fore the teachers' thought processes and the gestalt shifts that happen in their everyday practices as they work with different learners to achieve conceptual clarity. To do this well, I turn to Deleuze and Guattari (1987), contemporaries of post-structuralists such as Foucault and Derrida, and employ Deleuzian[6] philosophy to gather fresh insights into the role that concepts have in teaching and learning, how they engage the learner and the resultant changes in teachers' thinking and the curriculum development processes. Central to the Deleuzian perspective is the view that thought is dynamic and evolving and of life as creative and engendering diverse 'becomings' (Deleuze, 1995). Most significantly, this Deleuzian perspective allows us, educators and students, to visualise a transformation of modern life from the disciplined and controlled, to one in which one can seize opportunities to become inventive, creative and experimental (Colebrook, 2002). Using a Deleuzian perspective to look at learning and teaching offers important insights about what learning is, and more importantly, it problematises the role of concepts in engaging the learner. Three insights offered by the Deleuzian perspective of learning and its connections to the world of concepts are discussed in turn to understand how this can affect teacher agency in concept-based curricula.

An important insight offered by Deleuzian thinking is its notion of learning as being rhizomatic and of knowledge as being networked. The rhizomatic structure of learning is envisaged to be interconnected and, like never-ending biological rhizomatic roots, is seen to have planar and trans-species connections; the opposite arborescent model views learning as hierarchical with vertical, linear connections (Sotorin, 2011). In fact, the Deleuzian networked view of knowledge for teaching and learning is visible in current perspectives of knowing as being situated, embodied and distributed (Putnam & Borko, 2000; Rogers, 1997). Teaching conceptually requires teachers not to 'follow models of arborescent descent going from the least to the most differentiated, but instead as a rhizome operating immediately in the heterogeneous and jumping from one already differentiated line to another' (Deleuze & Guattari, 1987, p. 31). It then follows that in concept-focused teaching and learning, the task of facilitating the learners' search for knowledge and meaning-making is paramount and requires teachers to rethink their own ways of making meaning of knowledge. Hence, concept-based curricula signals the teacher to focus on the

[6] Deleuze and Guattari published together, and so in this chapter the reference to Deleuze is used to refer to their collective work.

active process of getting learners' to think about links within ideas in a discipline as well as across them, which is an important goal of classroom interaction. This way of thinking about learning offers parallels to post-modern proclivity for knowledge creation over knowledge transmission, therefore stimulating self-driven inquiries and connections.

The second insight stems from Deleuze and Guattari's position (1987) that a concept is more than simply a name attached to a subject or object. According to them, a concept is a way of approaching the world or, put differently, a way of *creating* a world through the active extension of thinking the possible and an extension to what it is not (Wallin, 2010). In this way, concepts extend experience through an affirmation of difference. Hence, what a concept *is* is of lesser significance than what it *does*, as concepts have a way of linking different things and feelings together. This therefore draws the focus in teaching and learning concepts to the conceptualisation process where 'the teacher and the learner co-respond, co-laborate and co-construct the territories of teaching and learning that they inhabit' (Gale, 2010, p. 306) so that concepts are re-examined and reframed together. Rather than a tool that purports to reflect an a priori reality, conceptualisation is seen as a core learning process that creates connections across premature understandings gained from multiple settings, allowing us 'to consider … a new way of conceiving being, the world, or what there is' (May, 2005, p. 116). Concepts are not ready-made or immutable structures beyond experience. Instead, concept-driven curricula require curricular material that is widened, in terms of depth, breadth and complexity, so that there is scope for the learner to form ideas and conceptualisation within the frames of reference in the field and in other lived experiences. Once again, the Deleuzian articulation of a concept as involving the conceptualisation process provides a more complex but realistic twenty-first-century relevant guide for managing the speed and complexity of learning. In this respect, it is free from the tensions of predefined disciplinary concepts that exist in the traditional curriculum and process of teaching. Instead, concept-based curricula provide teaching and learning spaces where ideas are actively created and recreated in the in-between spaces or cracks between crystallised discipline-specific ideas from thinking, discussion and experimentation.

The third insight pertains to the Deleuzian articulation of thought processes as experimentations that give rise to diverse 'becomings' rather than as (re)productions of the status quo. Learning in the Deleuzian perspective is not viewed as static but fluid. The creative effort is emphasised as each learner's trajectory is unique and requires connections that are wholly different. This articulates a view of learning that is consistent with twenty-first-century ideals, which has in Singapore been put forth via the Teach Less Learn More (TLLM) policy that has pressed for content reduction in the syllabus to create more spaces for innovation and experimentation. However, even as TLLM has been put in place to bring greater focus on processes rather than content in classroom practices, why should concept-based curricula be chosen? Putting concepts at the centre of curriculum and teaching allows for experimentation and thinking for both the teacher and the learner and therefore places the emphasis on the process rather than on acquisition of fixed understandings of the concepts. Furthermore, if the Deleuzian perspective of building ideas and connections that pre-exist in the field is accepted, then using concept-based curricula can give rise to diverse 'becomings' rather than (re)productions of the status quo. Curriculum therefore needs to provide learning pathways that are co-constructed with learners (as individuals and as a class), an instructor, and external ideas that learners manage to pick up during the process of learning. This would relieve the pressure for teachers to ensure that there are opportunities to build self-directed and creative capacities in the lesson.

Enhanced Teacher Agency in Concept-Based Curriculum Development

The preceding discussion of the insights gained from the Deleuzian perspective of learning and knowledge has important implications for the nature of teachers' work in concept-based curricula. It points to enhanced teacher agency as the teacher figures out how to extend and transform learners' concepts for deeper disciplinary knowledge. Developing concept-based curriculum presupposes the notion of a common desire and labour at promoting discovery and meaning-making, inherent in any creative activity, but which is now directed at classroom learning. Each teacher in developing competence in promoting conceptual understanding therefore must direct and facilitate the learners' search for knowledge and meaning-making. Each teacher needs to accept and appreciate that developing conceptual understanding is less about arriving at a destination and more of 'becoming'. Agency is called on when teachers work in a space that is between the poles of knowledge authority and thought freedom. Thus there is a credible change expected in the role of the teacher in designing and implementing the concept-based curricula.

Furthermore, using a concept-based approach to curriculum rests on teachers making the rhizomatic links in the subject matter and acting in the 'experimental' mode in the classroom. When developing concept-based curricula, each teacher and team will go through a detachment and reattachment process, whether psychological or cognitive, as they work through their own conceptualisation process. Such attachment and reattachment processes require the teacher to be actively connected to their learners and the discipline, which calls on deeper teacher agency. To be better proponents of concept-based learning, teachers must themselves be ready for thinking and acting in 'experimental' modes. In such an experimental mode, the teacher will focus on 'becoming' rather than merely (re)producing current states of understanding, both in themselves and the learner. Hence, in developing concept-based curricula, the teacher needs to think about how to keep learning 'open' rather than 'closing up' learning by expecting learners to simply accept the teachers' knowledge authority. The concept-based curriculum development process therefore stimulates teacher agency as it calls on deeper considerations of their own disciplinary knowledge and greater teacher autonomy in providing spaces for learners to constantly interact with conceptualisations. The teacher agency in such a context also requires more networks and rhizomatic, rather than arboreal, connections. Hence, teacher agency itself transforms from one that is static to one that stimulates the people in the field of action—the students, other teachers and experts—through constant interaction.

Concept-Based Curricula Development Sparks Teacher Agency: A Case Study

The Deleuzian insights about how teaching conceptually changes the teacher's view of classroom learning extrapolate well to the real-world situation as in this case study of curriculum work taking place in a specialised school in Singapore (L. S. Tan & Ponnusamy, 2013). This case involves a school offering a 6-year programme for 13–18-year-old pupils - the first independent, pre-tertiary school that focuses on both arts and academic learning (MICA, 2004). The school's leaders and teachers' vision of a connected curriculum (Perkins, 1993) requires learning to be connected, so that lessons engage and stimulate deeper thought. The Singapore curriculum is commonly described as highly centralised (Ng, 2008), driven by high-stakes examinations (Hogan, 2014) and politically and pragmatically forged to meet nation-building needs (Kennedy, 2013). However, recent decentralisation efforts have spurred ground-up school-based initiatives to build capacity in schools and teachers for curriculum innovation (Koh, Ponnusamy, Tan, Lee, & Ramos, 2014; Tan & Ng, 2007). Hence, the curriculum in this case study school was spurred by the school's and teachers' aspirations to meet the specific developmental needs of aspiring students intending to develop their artistic and academic passions and trajectories. In specific units, teachers chose a concept-focused approach where they had to think deeply about the what, why and how of curriculum and how this heightened teacher agency is described next.

Firstly, teacher agency was visible when teachers had to design learning as conceptual and rhizomatic. The teachers in the units that were studied began to work in experimental modes, so that classroom learning was seen to lead to diverse 'becomings' for both learners and the teachers. Tan and Ponnusamy (2013) argue that in negotiating the accountability demands brought on by Singapore's high-stakes examination system and ensuring learning was connected, teachers in their case study school created two kinds of curricula, the fixed and the fluid curriculum, and in this way resolved the pressures of constant experimentation. The teachers indicated that they had to focus on the fixed curricula, defined as that which contained the codified subject knowledge determined by the examining board. However, the school and its teachers also created a fluid curriculum defined as curricula that emphasised linkages and interactions between the learners' specialised needs, current interests and the academic subject matter, so that learning activities were primarily focused on interpretation, meaning-making and the expression of originality. Thus, whilst the fixed curricula directed the what, how and when of classroom learning for students, teachers also created specialised units of learning to allow for the constant exploration of novel connections between the different disciplines. Hence, Tan and Ponnusamy (2013) describe teachers' accounts of lessons that require connections of ideas across different disciplines. The fixed and fluid curricula were used by the teachers iteratively in different contexts to address varying needs and they anchored the larger school curriculum vision of connectedness. More importantly, the iterative use of the fixed and fluid curricula featured greater integration of diverse knowledge. This favoured meaning-making and reinterpretation of concepts and ideas by both students and teachers - a case of experimentation and diverse 'becoming'. Hence, the development and implementation of the units called on agentic behaviours such as conducting lesson as 'experiments' with different permutations of concepts and thought processes, both within and across different disciplines.

The case study also found that in designing concept-based curriculum units, teachers needed to be able to work in interdisciplinary teams and envisage learning as happening beyond the traditional boundaries of subject matter that dictate classroom instruction. The teachers' actions of creating curricula were therefore focused on producing abstract and interdisciplinary conceptualisations in the minds of the learners and counter the emergence of fragile forms of knowledge (Perkins, 1992). Teachers proceeded to look beyond a single curricular experience for students and to use concepts as a way to constantly frame and reframe learning. Using Actor-Network Theory (ANT) (Callon, 1986; Mol, 2010) as a framework to guide the analysis, the study found that a complex web of networks between human and non-human actors resulted in and affected teachers' agentic behaviours. Actors in each network were found to actively convince other members so that there were common definitions of concepts at the heart of the designed curriculum unit. Hence, as the Deleuzian ideal of using the concept is seen as a way of understanding the world, teachers work on the concept-focused curriculum units and take the learners' present and future understanding and 'becomings' into consideration. For the teachers, concept focus of the curricula allowed teachers to traverse their own limiting and demotivating beliefs about the nature and importance of their own subject knowledge (Meirink, Meijer, Verloop, & Bergen, 2009). Such a change provided opportunities to review teachers' current and longer-term aspirations for learning, drawing on the practical and projective aspects of Priestley, Biesta and Robinson's (2013) ecological model of teacher agency. Clearly, developing concept-based curricula catalysed deeper changes to the teachers' actions and attitudes towards student learning and galvanised teacher agency.

Implications: Improvements in Teacher Expertise and Student Learning

If concept-based curricula can have the effect of galvanising teacher agency, then using a conceptual approach has important implications for teacher expertise development and student learning. As argued, concept-based curriculum development calls on the teacher to be a reflexive practitioner, to become a researcher in the field (Ben-Peretz, 1980). These teachers would make teaching itself a focus of inquiry, laying open preconceptions and becoming aware of situational dynamics. They would have developed insights about how and when learners are jointly involved in knowledge production during concept-based teaching. Current research has found that experts rely on routine and adaptive expertise to achieve excellence when compared to novices in the same field (Bransford, Brown, & Cocking, 2000; Hatano & Inagaki, 1986). Whilst routine expertise relates to accuracy and efficiency, adaptive expertise focuses on innovation and creativity. Adaptive expertise is an important quality that teachers need so that they think outside the box to solve challenging problems or address atypical situations - a crucial part of meeting learners' needs. Clearly, when the development of concept-based curricula galvanises teacher agency, then there is a case for studying the kinds of expertise that teachers develop in the design and practice of concept-based curricula.

Teachers today hold different views and have different levels of expertise with regard to curriculum development. If concept-based curricula galvanises teacher agency, then more teachers will begin to question the role of curriculum in bringing about deeper learning and thus be empowered as they propagate new and revolutionary ideas to optimise teaching and learning experiences in the classroom. At the same time teachers will realise that such empowerment is not about unrestrained or unstructured action but about working collaboratively with other teachers and learners to enhance learner potential. They would move away from viewing the syllabi as fixed recipes and instead see them as key areas that they should experiment and change to make the learning more relevant and meaningful. To do this requires specific knowledge, skills and dispositions, and this is a level of expertise that is developed in such a process. Concept-based curricula development can be used to better understand how teaching expertise develops in the field, as it involves the cognitive and affective features or characteristics held by expert teachers, such as extensive pedagogical content knowledge (Shulman, 1986; Turner-Bisset, 2001), which includes deep representations of subject matter, knowledge and a greater sensitivity to the context (Berliner, 2001).

Lastly but more importantly, galvanising teacher agency through developing concept-based curricula will have especially vital implications for student learning. In fact, learning using a concept-based curriculum can alter the current tight coupling that exists between instruction and assessment in education today (Hogan, 2014). When students are constantly exposed to experimental ways of thinking and learning, they move out of the transmission-based mode of learning into a knowledge co-creation mode. Learning conceptually demands higher levels of intellectual involvement and questioning, which in turn is especially useful for keeping high ability learners engaged. Rhizomatic conceptual linking of knowledge offers powerful ways of thinking about knowledge, both within the discipline and between disciplines, thus reducing the fragile knowledge syndrome (Perkins, 1992). A concept-based curriculum also provides new ways of thinking about classroom learning for the high ability learner. Learning conceptually invokes the influential metaphors about what it is to learn, (un)learn and relearn in the post-modern world, which suits the complex and sophisticated ways of knowing that high ability learners prefer. Clearly, the gains made on teacher agency by concept-based curricula will have significant short- and long-term benefits for teachers as well as learners, keeping them engaged as life-long inquirers and knowledge producers.

References

Archer, M. (2003). *Structure, agency and the internal conversation*. Cambridge, UK: Cambridge University Press.

Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). In L. W. Anderson & D. R. Krathwohl (Eds.), *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Longman.

Barber, M., & Mourshed, M. (2007). *How the World's best-performing school systems come Out on Top*. Dubai, United Arab Emirates: McKinsey & Co.

Bell, T. (2010). Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education, 32*(3), 349.

Ben-Peretz, M. (1980). Teachers' role in curriculum development: An alternative approach. *Canadian Journal of Education / Revue canadienne de l'éducation, 5*(2), 52–62.

Ben-Peretz, M. (1990). *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts*. Albany, NY: SUNY Press.

Berliner, D. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research, 35*(5), 463–482.

Biesta, G., & Tedder, M. (2007). Agency and learning in the lifecourse: Towards an ecological perspective. *Studies in the Education of Adults, 39*(2), 132–149.

Biggs, J. B. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development, 18*(1), 57–75.

Boaler, J., Williams, C., & Confer, A. (2014). *Fluency without fear: Research evidence on the best ways to learn math facts*. youcubed. Retrieved from http://youcubed.org/teachers/wp-content/uploads/2014/10/FluencyWithoutFear.pdf

Bolstad, R. (2004). *School-based curriculum development: Redefining the term for New Zealand schools today and tomorrow*. Paper presented at the New Zealand Association of Research in Education (NZARE), Wellington, New Zealand. Retrieved from http://www.nzcer.org.nz/pdfs/13514.pdf

Bourdieu, P. (1984). *Distinction: A social critique of the judgement of taste*. Cambridge, MA: Harvard University Press.

Brady, L. (1995). School based curriculum development and the national curriculum: Can they coexist? *Curriculum and Teaching, 10*(1), 47–54.

Bransford, J., Brown, A., & Cocking, R. (2000). *How experts differ from novices*. Washington, D.C.: National Academy Press.

Braslavsky, C. (2002). *The new century's change: New challenges and curriculum responses*. Proceedings of COBSE-international conference, New Delhi.

Calhoun, C. (2002). Agency. In C. Calhoun (Ed.), *Dictionary of the social sciences* (p. 7). Oxford, UK: Blackwell.

Callon, M. (1986). The sociology of an actor-network: The case of the electric vehicle. In M. Callon, J. Law, & A. Rip (Eds.), *Mapping the dynamics of science and technology* (pp. 19–34). London: Macmillan Press.

Campbell, E. (2012). Teacher agency in curriculum contexts. *Curriculum Inquiry, 42*(2), 183–190.

Carl, A. E. (2009). *Teacher empowerment through curriculum development: Theory into practice* (3rd ed.). Cape Town, South Africa: Mills Litho.

Cheung, D., & Wong, H.-W. (2002). Measuring teacher beliefs about alternative curriculum designs. *The Curriculum Journal, 13*(2), 225–248. doi:10.1080/09585170210136868.
Cochran-Smith, M., & Lytle, S. L. (1999). Relationships of knowledge and practice: Teacher learning in communities. *Review of Research in Education, 24*, 249–305. doi:10.2307/1167272.
Cohen, D. K., & Ball, D. L. (2007). Educational innovation and the problem of scale. *Scale up in Education: Ideas in Principle, 1*, 19–36.
Colebrook, C. (2002). *Gilles Deleuze*. London: Routledge.
Connelly, F. M., & Clandinin, D. J. (1998). *Teachers as curriculum planners: Narratives of experience*. New York, NY/Toronto, ON: Teachers College Press/OISE Press.
Darling-Hammond, L., & Friedlaender, D. (2008). Creating excellence and equitable schools. *Educational Leadership, 65*(8), 14–21.
Deleuze, G., & Guattari, F. (1987). *A thousand plateaus* (B. Massumi, Trans.). Minneapolis, MN/London: University of Minnesota Press.
Deleuze, G. (1995). *Negotiations 1972–1990*, (trans: Joughin, M.). New York, NY: Columbia.
Deng, Z., Gopinathan, S., & Lee, C. K.-E. (2013). The Singapore curriculum: Convergence, divergence, issues and challenges. In Z. Deng, S. Gopinathan, & C. K.-E. Lee (Eds.), *Globalisation and the Singapore curriculum* (pp. 263–275). Singapore, Singapore: Springer.
Dewey, J. (1902). *The child and the curriculum*. Chicago: University of Chicago Press [reprinted in L. A. Hickman & T. M. Alexander (Eds.) (1998). *The essential Dewey, Vol. I*. Bloomington, IN: Indiana University Press].
Doyle, W. (1992). Curriculum and pedagogy. *Handbook of Research on Curriculum, 5*, 486–516.
Eisner, E. W., & Vallance, E. (1974). *Conflicting conceptions of curriculum*. Berkeley, CA: McCutchan Publishing Corp.
Emirbayer, M., & Mische, A. (1998). What is agency? *American Journal of Sociology, 103*(4), 962–1023.
Ennis, C. D. (1994). Knowledge and beliefs underlying curricular expertise. *Quest, 46*(2), 164–175. doi:10.1080/00336297.1994.10484118.
Erickson, L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.
Erickson, L., & Lanning, L. A. (2014). *Transitioning to concept-based curriculum and instruction: How to bring content and process together*. Thousand Oaks, CA: Corwin Press.
Eteläpelto, A., Vähäsantanen, K., Hökkä, P., & Paloniemi, S. (2013). What is agency? Conceptualizing professional agency at work. *Educational Research Review, 10*, 45–65.
Fenwick, T. J., & Edwards, R. (2010). *Actor-network theory in education*. Abingdon, UK: Routledge.
Fullan, M. (1993). The professional teacher: Why teachers must become change agents. *Educational Leadership, 50*(6), 12.
Fullan, M. (2000). The return of large-scale reform. *Journal of Educational Change, 1*(1), 5–27. doi:10.1023/A:1010068703786.
Gale, K. (2010). An inquiry in to the ethical nature of a deleuzian creative educational practice. *Qualitative Inquiry, 16*(5), 303–309. doi:10.1177/1077800409358869.
Garner, R. (2015, March 20). Finland schools: Subjects scrapped and replaced with ‘topics’ as country reforms its education system. *The Independent*. Retrieved from http://www.independent.co.uk/news/world/europe/finland-schools-subjects-are-out-and-topics-are-in-as-country--reforms-its-education-system-10123911.html?cmipid=fb
Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*. Cambridge, UK: Polity.
Gopinathan, S., & Deng, Z. (2006). Fostering school based curriculum development in the context of new educational initiatives in Singapore. *Planning & Changing, 37*(3), 93–110.
Grundy, S. (1987). *Curriculum: Product or praxis?* London: Falmer Press.
Habermas, J. (1972). *Knowledge and human interests* (J. Shapiro, Trans.). London: Heinemann.
Hatano, G., & Inagaki, K. (1986). Two courses of expertise. In H. A. H. Stevenson & K. Hakuta (Eds.), *Child development and education in Japan* (pp. 262–272). New York: Freeman.

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.
Herschbach, D. (1989). Conceptualizing curriculum change. *Journal of Epsilon Pi Tau, 55*(1), 19–28.
Hogan, D. (2014). Why is Singapore's school system so successful, and is it a model for the West? *The Conversation Media Trust*. Retrieved from http://theconversation.com/why-is-singapores-school-system-so-successful-and-is-it-a-model-for-the-west-22917
Hollis, M. (1994). *The philosophy of social science—an introduction*. Cambridge, MA: Cambridge University Press.
Kalantzis, M., & Cope, B. (2006). On globalization and diversity. *Computers and Composition, 23*(4), 402–411.
Kärkkäinen, K. (2012). *Bringing about curriculum innovations: Implicit approaches in the OECD area*. Paris: OECD.
Kennedy, K. J. (2013). Singapore's school curriculum for the future: Beyond national development? In Z. Deng, S. Gopinathan, & C. K.-E. Lee (Eds.), *Globalisation and the Singapore curriculum: From policy to classroom* (pp. 205–224). Singapore, Singapore: Springer.
Kennedy, K. J., & Lee, J. C.-K. (2008). *The changing role of schools in Asian societies: Schools for the knowledge society*. Abingdon, UK: Routledge.
Koh, E., Ponnusamy, L. D., Tan, L. S., Lee, S.-S., & Ramos, M. E. (2014). A Singapore case study of curriculum innovation in the twenty-first century: Demands, tensions and deliberations. *The Asia-Pacific Education Researcher, 23*(4), 851–860.
Lasky, S. (2005). A sociocultural approach to understanding teacher identity, agency and professional vulnerability in a context of secondary school reform. *Teaching and Teacher Education, 21*(8), 899–916.
Law, E., & Nieveen, N. (Eds.). (2010). *Schools as curriculum agencies: Asian and European perspectives on school-based curriculum development*. Rotterdam, The Netherlands: Sense Publishers.
Lee, H. L. (2004). *Speech by Prime Minister Lee Hsien Loong at the Teachers' Day Rally 2006*. The Max Pavilion, Singapore Expo, Singapore, Singapore.
Leong, K. L., Sim, J. B.-Y., & Chua, S. H. (2011). School-based curriculum development in Singapore: Bottom-up perspectives of a top-down policy. *Curriculum Perspectives, 31*(1), 51–61.
Levine, C. (2005). What happened to agency? Some observations concerning the postmodern perspective on identity. *Identity, 5*(2), 175–185.
Marsh, C., Day, C., Hannay, L., & McCutcheon, G. (1990). *Reconceptualising school-based curriculum development*. London: The Falmer Press.
Meirink, J. A., Meijer, P. C., Verloop, N., & Bergen, T. C. (2009). Understanding teacher learning in secondary education: The relations of teacher activities to changed beliefs about teaching and learning. *Teaching and Teacher Education, 25*(1), 89–100.
Merrill, M. D., & Tennyson, R. D. (1977). *Concept teaching: An instructional design guide*. Englewood Cliffs, NJ: Educational Technology.
MICA. (2004). *Report of the committee on specialised arts school*. Singapore, Singapore: Ministry of Information, Communications and the Arts.
Mol, A. (2010). Actor-network theory: Sensitive terms and enduring tensions. *Köllner Zeitschrift für Soziologie und Sozialpshychologie, 50*(1), 253–269.
Mourshed, M., Chijioke, C., & Barber, M. (2010). *How the world's most improved school systems keep getting better*. Retrieved from http://ssomckinsey.darbyfilms.com/reports/schools/How-the-Worlds-Most-Improved-School-Systems-Keep-Getting-Better_Download-version_Final.pdf
Ng, P. T. (2008). Educational reform in Singapore: From quantity to quality. *Educational Research for Policy and Practice, 7*(1), 5–15.
Perkins, D. N. (1992). *Smart schools: From training memories to educating minds*. New York: The Free Press.

Perkins, D. N. (1993). The connected curriculum. *Educational Leadership, 51*(2), 90–91.
Priestley, M. (2011). Schools, teachers, and curriculum change: A balancing act? *Journal of Educational Change, 12*(1), 1–23. doi:10.1007/s10833-010-9140-z.
Priestley, M., Biesta, G., & Robinson, S. (2013). Teachers as agents of change: Teacher agency and emerging models of curriculum. In M. Priestley & G. Biesta (Eds.), *Reinventing the curriculum: New trends in curriculum policy and practice* (pp. 187–206). London: Bloomsbury Academic.
Priestley, M., Edwards, R., Priestley, A., & Miller, K. (2012). Teacher agency in curriculum making: Agents of change and spaces for manoeuvre. *Curriculum Inquiry, 42*(2), 191–214. doi:10.1111/j.1467-873X.2012.00588.x.
Priestley, M., Robinson, S., & Biesta, G. (2011). *Mapping teacher agency: An ecological approach to understanding teachers' work*. Paper presented at the Oxford ethnography and education conference, Oxford, UK.
Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4–15.
Reid, W. A. (1999). *Curriculum as institution and practice: Essays in the deliberative tradition*. Mahwah, NJ: Psychology Press.
Rogers, B. (1997). Informing the shape of the curriculum: New views of knowledge and its representation in schooling. *Journal of Curriculum Studies, 29*(6), 683–710.
Schwab, J. J. (1973). The practical 3: Translation into curriculum. *School Review, 81*(4), 501–522.
Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.
Skilbeck, M. (2005). School-based curriculum development. In A. Lieberman (Ed.), *The roots of educational change* (pp. 109–132). Dordrecht, The Netherlands: Springer.
Sotorin, P. (2011). Becoming woman. In C. J. Stivale (Ed.), *Key concepts (2)*. Durham, UK: Acumen.
Stenhouse, L. (1975). *An introduction to curriculum research and development*. London: Heinemann.
Stryker, S., & Burke, P. J. (2000). The past, present, and future of an identity theory. *Social Psychology Quarterly, 63*, 284–297.
Taba, H. (1962). *Curriculum development, theory, and practice*. New York: Harcourt, Brace & World.
Tan, C., & Ng, P. (2007). Dynamics of change: Decentralised centralism of education in Singapore. *Journal of Educational Change, 8*(2), 155–168. doi:10.1007/s10833-006-9016-4.
Tan, L. S., & Ponnusamy, L. D. (2013). Weaving and anchoring the arts into curriculum: The evolving curriculum process. In C. H. Lum (Ed.), *Contextualised practices on arts education: An international dialogue on Singapore* (pp. 219–249). Dordrecht, The Netherlands: Springer.
Timperley, A., Wilson, A., Barrar, H., & Fung, I. (2007). *Teacher professional learning and development: Best evidence synthesis iteration*. Wellington, New Zealand: Ministry of Education.
Turner-Bisset, R. (2001). *Expert teaching*. London: Fulton Books.
Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. Chicago: University of Chicago Press.
VanTassel-Baska, J. (1989). Appropriate curriculum for the gifted. In J. Feldhusen, J. VanTassel-Baska, & K. Seeley (Eds.), *Excellence in educating the gifted* (pp. 175–191). Denver, CO: Love Publishing.
VanTassel-Baska, J., & Brown, E. F. (2007). Toward best practice: An analysis of the efficacy of curriculum models in gifted education. *Gifted Child Quarterly, 51*(4), 342.
VanTassel-Baska, J., & Stambaugh, T. (2006). *Comprehensive curriculum for gifted learners* (3rd ed.). Boston: Pearson.
VanTassel-Baska, J., & Stambaugh, T. (2009). *What works: 20 years of curriculum development and research for advanced learners, 1988–2008.* Center for Gifted Education, College of William and Mary (p. 40). Retrieved from http://eric.ed.gov/PDFS/ED506369.pdf
Walker, D. F., & Soltis, J. F. (2004). *Curriculum and aims*. New York: Teachers College Press.
Wallin, J. J. (2010). *A Deleuzian approach to curriculum: Essays on a pedagogical life*. New York: Palgrave Macmillan.

Designing and Implementing Concept-Based Curriculum

Catherine Little

Introduction

In the media, in the educational literature, and in the general public discourse today, there is a wide awareness of the information overload to which we are currently subject. Given our accessibility to information and the ever-increasing capacity of the informational tools close to our fingertips, the role of schools becomes much more a responsibility of helping students find and make sense of information than of delivering it.

Within this context, an approach to curriculum and instruction that focuses on the delivery and retention of facts is neither practical nor productive. Yet as Erickson (2002, 2007) noted, many standards documents continue to maintain an emphasis on a fact-based and topic-based structure. Moreover, in many classrooms and schools, instruction continues to reflect an approach focused on delivery of content rather than on building understanding.

A concept-based approach to curriculum and instruction organises the learning experience more around meaning-making and the learner's ability to sort, integrate, and transfer understanding in multiple contexts (Erickson, 2007; Partington & Buckingham, 2012). Such an approach may also increase overall meaningfulness and students' sense of connection to what they are learning (Jacobs, 1989). Several research studies comparing conceptually oriented curriculum with more traditional approaches have demonstrated that students working with a conceptual focus learn the content just as well as or better than their peers in comparison classes, while outperforming those peers in measures of critical and conceptual thinking (Chappell & Killpatrick, 2003; McCoy & Ketterlin-Geller, 2004; VanTassel-Baska & Stambaugh, 2008).

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This chapter briefly addresses some of the rationale and benefits of a concept-based approach to curriculum and then turns to consideration of some of the issues and challenges presented by such an approach, along with some recommendations for ways of addressing these issues and challenges.

Rationale for a Concept-Based Curriculum

Concept-based curriculum is organised around big ideas and essential points of understanding about those big ideas, rather than around more discrete topics and facts (Erickson, 2007). Ideally, concept-based curriculum promotes authentic learning and understanding, because it is linked to the ways that we make sense of information and communicate it to one another—through processes of classification, association, and evaluation of how what we know may or may not apply or fit within different contexts. Wiggins and McTighe (1998) recommended that curriculum focuses around ideas, topics, or processes that (a) represent a "big idea" with enduring value beyond the classroom, (b) reside at the heart of the discipline, (c) require explication, and (d) offer potential for engaging students. Concept-based curriculum encourages learners to focus on constructing meaning from the world around them and from the information they confront by relating new information to what they already know, thereby reexamining and reorganising the structures of their understanding.

As Jonassen (2006) noted, "By partitioning the world into classes, concepts decrease the amount of information that we must learn, remember, communicate, and reason about" (p. 178). Therefore, within a concept-focused structure, the attention can be given to reasoning and meaning-making rather than to what Brophy and Alleman (2006) called a "parade of facts" (p. 449). In an era defined by information overload with limited regulation of quality, it is more urgent than ever that students develop stronger understandings that allow them to organise facts and analyse them within larger conceptual contexts.

Concepts are both individually and socially constructed. As individuals, we develop concepts and conceptual understandings to organise the huge amount of information we perceive around us; learning involves the establishment of conceptual understandings based on experiences of the world (Seiger-Ehrenberg, 2001). Within groups, including cultures, societies, and disciplines, we organise concepts and conceptual understandings within the context of the values and interests of the group, testing and evaluating to build stronger bases for shared understandings. Such shared understandings, with testing and evaluation over time, become the fundamental generalisations and principles of a discipline and therefore important tools for learners within each major subject area. Partington and Buckingham (2012), exploring several different students' ways of developing and refining their conceptual understanding in media studies, applied Vygotsky's (1962) notion of "spontaneous concepts" and "scientific concepts" to distinguish between those that learners might hypothesise as part of the learning process and those that have been defined as critical to study within particular disciplines. Through concept-based curriculum, we guide students in developing and examining both kinds of understanding, addressing misconceptions within the process.

Erickson (2007) highlighted the many skills involved with conceptual thinking, including aspects of seeing patterns and relationships, evaluating understandings based on supportive evidence, and transferring conceptual understanding, sometimes in the effort to solve a problem or create a new product. She stated that "there will not be a significant improvement in education until teachers understand the importance of concepts and conceptual understanding to intellectual development, deeper understanding, and motivation for learning" (p. 78). Student engagement with concepts and conceptual understandings through the curriculum should include emphasis on the properties that make something a member of a conceptual category or exclude it, the characteristics that make something an exemplar or prototype of a concept, and the ways that conceptual understandings guide our interpretation of the topics and facts in the subject area (Gallagher, 2012; Seiger-Ehrenberg, 2001; Taba, 1962). Such examination also promotes closer examination of those understandings themselves and their use as tools for understanding rather than facts set in stone; it is the examination, application, and refinement of conceptual understandings that contribute to deeper learning, not an unquestioning acceptance of the understandings as immovable statements (Jonassen, 2006; Milligan & Wood, 2010).

Research on how people learn has emphasised the connections between concept learning and metacognition (National Research National Research Council, 2000). Learners construct new understandings based on their current knowledge, and in order for teachers to assess misconceptions in student understanding, they must "make students' thinking visible and find ways to help them reconceptualise" erroneous understandings (National Research Council, p. 71). For example, Coll, France, and Taylor (2005), discussing the role of models and analogies in science education, suggested that in order for students to develop conceptual understandings accurately and comprehensively, they need to be able to reflect on and discuss these understandings as they are in the process of developing them. Similarly, Barton and Levstik (2004) emphasised the importance of encouraging students to express their understandings of key ideas in history, highlighting several types of misconceptions likely to develop unnoticed by teachers unless students were given opportunities to share their understanding in their own words.

Beyond the general benefits that concept-based curriculum can provide in the classroom, it also has potential to be supportive of learners with a wide range of needs. Erickson (2007) noted that teachers who fail to structure the curriculum around concepts and essential understandings tend to differentiate by varying the *quantity* and not the *quality* of expectations for student work, whereas a concept focus provides richer differentiation opportunities. Educators who specialise in working with culturally and linguistically diverse learners have noted that a focus on meaning-making and the use of concepts as key organisers of curriculum allow students to access and interpret key understandings, despite the limits that might be presented by language differences (Twyman, Ketterlin-Geller, McCoy, & Tindal, 2003). In special education, again educators have emphasised the importance of focusing on scaffolding and making meaning, using graphic organisers and other approaches to emphasise meaning and connection (McCoy & Ketterlin-Geller, 2004). Educators who focus on advanced learners also emphasise the value of concept-based curriculum and its potential to increase the depth, complexity, and challenge of the curriculum for advanced learners (Kaplan, 2009; VanTassel-Baska, 1994, 2011; Ward, 1981). Many resources targeting the needs of gifted learners are organised with a concept focus, and curricular specialists in gifted education emphasise the value of the complex thinking and abstract reasoning involved in deep conceptual understanding. In addition, concept-based curriculum offers both an advanced focus within particular disciplines and advanced interdisciplinary connections that encourage systematic exploration of the world with particular conceptual lenses from different disciplinary stances.

Key Issues and Challenges

Concept-based curriculum reflects many recent recommendations regarding giving students tools for interpreting the vast array of information available to them and for developing their skills across varied types and levels of thinking (Anderson & Krathwohl, 2000; Erickson, 2007; Marzano & Kendall, 2007). Yet the development and implementation of concept-based curriculum also present a number of issues and challenges for educators. These challenges reflect the complexity of conceptual study within and across disciplines, the constraints on curriculum and implementation that classroom circumstances and educational policies present, and the particular characteristics, behaviours, and choices among teachers that influence the application of concept-based curriculum in practice.

This section highlights four key issues faced by curriculum developers[1] and teachers in the development and implementation of concept-based curriculum:

- The selection of concepts around which to organise the curriculum
- The development and interpretation of key conceptual understandings linked to intended curricular outcomes
- Assessment of conceptual understanding
- Teacher perceptions, expectations, and behaviours

Each of these issues, while presenting challenges for curriculum developers and teachers, also provides an opportunity for careful consideration of how we conceptualise the curriculum and how we might enhance the learning experience for students.

[1] The term “curriculum developers” is used in the chapter to refer to all those involved in the process of writing curriculum, *including teachers* who are engaged directly in the process. Generally, the term “teachers” is used to refer to those individuals who will be implementing curriculum but were not necessarily directly involved in its development.

Choice of Concepts

One of the first complex challenges of developing concept-based curriculum is the choice of concepts around which the curriculum development effort will focus. This choice requires consideration of which concepts are most useful in illuminating key understandings in the discipline under study, as well as potentially which are most likely to foster effective transfer of conceptual understanding to other disciplinary contexts.

The notion of a "concept" (or the concept of a concept!) covers a wide range of possible choices that vary in their level of abstraction and universality. Taba and her colleagues (Taba, Durkin, Fraenkel, & McNaughton, 1971) distinguished between "key concepts" as the larger, more universal, abstract concepts (e.g., truth, systems, change) and the more "everyday" concepts that are somewhat more concrete and tend to be more specifically tied to particular disciplines and contexts. Erickson (2002, 2007) similarly classified "macroconcepts" and "microconcepts." Erickson recommended taking topical focus areas within the subject area and applying a relevant macroconcept as a conceptual lens, followed by identification of additional macroconcepts and more subject-specific microconcepts as key organisers for the curriculum. Both experts cautioned against defaulting to using only the macroconcepts to organise curriculum and instruction. Instead, they emphasised working with the *depth* that microconcepts can provide within a discipline, while also helping students to build understanding of the relationships of those ideas to the macroconcepts. This kind of approach requires thorough expertise in the discipline by the curriculum development team (Erickson, 2007).

VanTassel-Baska (1994) described two different approaches to developing concept-based curriculum. In the first approach, the curriculum developer starts with identifying a concept and conceptual understandings for focus and then applies varied disciplinary content; in the second approach, more akin to Erickson's recommendation, the curriculum developer starts with particular content and then identifies major concepts and conceptual understandings that will guide, illuminate, and strengthen the content study. Concepts provide a strong basis both for specific disciplinary study and for interdisciplinary study and connections. The question of whether a given curriculum should have a specific disciplinary focus or broader interdisciplinary focus depends on the context and purpose of the curriculum, though most of the scholars writing about concept-based curriculum have emphasised a central focus on applications within disciplines and a secondary focus on applications across disciplines, as a way to promote depth and effective transfer. Indeed, "interdisciplinary work is only as strong as the content, concepts, and approaches of the various disciplines brought into the study" (Erickson, 2007).

There are several sources for identification of the larger and smaller concepts that may be effective guides or supports for the curriculum. Feldhusen (1994) drew on Adler's (1952) *Syntopicon* addressing great ideas and great books of the Western world to list several dozen of the major concepts framing human life, learning, and interaction. Among these concepts, several that have been applied in specific curricular contexts include *change*, *signs and symbols*, *reasoning*, and *truth.* Several professional associations in education and in the major content areas have documented critical concepts within their subjects, with attention to how to apply those concepts in educational practice (American Association for the Advancement of Science, 1990; Heffron, Gallagher, & Downs, 2012). Erickson (2002) established a set of criteria for reviewing standards for conceptual focus and has highlighted the science standards in the United States as an effective model for building key conceptual understandings from concepts critical to the disciplines in ways that enable productive curriculum development.

The linkage between concept and content is a critical focus for curriculum developers. The macroconcepts that have broad application across a wide range of human experiences nevertheless illuminate some content more effectively than other content. For example, in the curriculum development work at the Centre for Gifted Education at The College of William and Mary, the developers found that the concept of *systems* was much less useful in building understanding in some components of social studies content than others. Therefore, they altered the conceptual focus for some units to the more directly applicable concept of *cause and effect* to increase the degree to which concept and content informed one another productively within the subject area.

As noted above, some standard documents can be supportive for curriculum developers in identifying important concepts and conceptual understandings within the content areas. At the same time, whether such standards are conceptually organised or not, curriculum developers must consider standards and related educational policies to promote alignment and coherence for teachers and learners. In this way, standards may present both an opportunity and a barrier for curriculum developers, because of the degree to which the standards complement and promote a conceptual orientation in the curriculum. In mathematics, for instance, aspects of the recently developed Common Core State Standards in the United States (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) are an effort to improve perceived conceptual weaknesses in many mathematics textbooks in use.

Conceptual Understandings

The individual concepts selected to guide curriculum development are not, in and of themselves, sufficient as a basis to guide the overall development process, curriculum product, and related instruction; rather, the key understandings about the concept are the tools that will underscore quality concept-based curriculum. The conceptual understandings that underlie the curriculum present two key issues for consideration: the first is the importance and the challenge of articulating those understandings, and the second is the challenge of how the understandings themselves are viewed within the context of curriculum implementation.

The conceptual understandings that are critical to curriculum development go by several different names in the literature. In Erickson's (2002, 2007) model, conceptual understandings reflect and are grounded in the generalisations and principles about particular concepts and their applications to topics. Taba (1962; Taba et al. 1971) emphasised the importance of working with key generalisations—and helping students to develop generalisations—about the concepts under study. The curriculum developer has a responsibility to articulate key conceptual understandings as they relate to any particular unit of study, to explain those understandings clearly for teachers, and to build the structure for experiences in which students will develop and work with these big ideas. Key conceptual understandings, including the major generalisations and principles about a given concept, rely on solid content knowledge within the discipline and awareness of the ways concepts may serve as focal points within networks of knowledge and the ways key concepts connect to one another (Brophy & Alleman, 2006; Erickson, 2007).

Erickson (2002) cautioned curriculum developers about the assumption that "teachers know and are drawing out the key conceptual understandings … from a topic. In fact, this is usually not happening" (p. 5). Similarly, Milligan and Wood (2010) noted that despite an emphasis on conceptual understanding and conceptual complexity in standard documents and some curricular materials, such levels of complexity and understanding do not always translate to the classroom.

On a related point, careful articulation of conceptual understandings may unfortunately relate to another problem with the translation of concept-based curriculum in the classroom. Several scholars have raised concerns about the degree to which conceptual understandings may become "reified" as destinations in and of themselves and as unmovable content statements to be learned, rather than representing tools for understanding concepts through application and testing against different contexts and situations (Jonassen, 2006; Milligan & Wood, 2010). In the outcome-oriented and objective-focused educational environment in which we currently work, it is tempting to view conceptual understandings as targets, but this view may limit the degree to which these understandings can truly become tools. Partington and Buckingham (2012) presented this issue as a key question for curriculum developers and instructors: "How do we avoid reifying concepts, teaching them as if they were a fixed body of facts or techniques?" (p. 8). Milligan and Wood (2010) also emphasised the risk of allowing conceptual understandings to become destinations instead of tools within the instructional process.

Jonassen (2006) asserted the value of exploring conceptual patterns and "concepts in use" rather than concepts in isolation, guiding students to recognise the ways they engage in building their conceptual understanding: "The most legitimate study of concepts should focus on changes in meaning of concepts with conceptual frameworks resulting from conceptual change, because concepts are the cognitive tools for representing ideas and testing relationships, not the object of instruction" (p. 193). This "concepts in use" focus emphasises the application of conceptual understanding within particular topics and content areas and also encourages students to be questioning and reflective. Concept-based curriculum, as well as implementation in instructional practice, loses its richness and rigour if the view of the concept is reduced to information to be transmitted without thought and questioning from the teacher and the students; thus, the impetus on curriculum developers is to ensure that the curriculum presents the concepts and conceptual understandings as points of departure and not as destinations (Milligan & Wood, 2010).

Assessment

Another challenge for concept-based curriculum results from questions of appropriate assessments of students' conceptual understanding. This is linked in part to the point above about conceptual understandings as points of departure or as destinations. Assessments for student understanding in the context of concept-based curriculum must provide opportunities for students to demonstrate the conceptual understandings in use, rather than just recall of those understandings, or the assessments will not reflect the spirit of the understandings themselves (Jonassen, 2006). Moreover, assessments that do not probe the depth of student understanding will not reveal the critical misconceptions that may emerge in their learning process. As explained above, there is a temptation to turn statements about conceptual understanding into hard and fast rules so that we may assess whether students can repeat them, rather than to encourage students to demonstrate their understanding through application of those understandings in varied contexts.

The way that we assess students needs to involve actual use of conceptual understandings, not merely repetition of them. Partington and Buckingham (2012) demonstrated examples of the ways four different students demonstrated their conceptual understanding but with varied levels of use of specific "academic terminology": "scholars and educators need to take care not to confuse conceptual understanding with the ability to mobilise academic terminology for the purpose of assessment" (Partington & Buckingham, 2012, p. 17). The language of concepts within a discipline is important in student learning, but the application of key understandings is perhaps a stronger foundation than any specific terminology. According to Jonassen (2006), "In order to engage and support learners in meaningful concept learning, students should learn how to use a variety of tools to build models of what they are learning and to engage in solving complex and ill-structured problems" (p. 193).

Teacher Implementation

The teacher who implements concept-based curriculum is, in certain respects, at the centre of all these challenges. The teacher's interpretation of the concepts and the key conceptual understandings has a powerful influence on how the curriculum looks in practice, no matter how detailed the resources and lesson plans may be. In their implementation of curriculum, teachers bring their own experiences, beliefs, preferences, attitudes, and conceptualisations to the process, including the way that they read the curriculum and the way they translate it into practice.

This is not the context for extensive discussion of curriculum theory and the different definitions of the written curriculum and the enacted curriculum, but it is nevertheless important to consider the perspective that in implementing curriculum, teachers are themselves involved in a curriculum development process, whether or not they were involved in the original writing of the materials (Ben-Peretz, 1990; Remillard, 2005). Remillard in an extensive review of the literature on how teachers conceptualise reform-based curriculum in mathematics, emphasised the interaction of the teacher with the curriculum and the impossibility of separating the teacher's individual influence from substantive and complex curriculum.

Teachers' interpretation and use of new curricular materials are influenced by their personal level of comfort or discomfort with the curriculum across a variety of domains. If the curriculum represents unfamiliar or especially challenging content, if it reflects unfamiliar pedagogical approaches, or if the content and pedagogy differ from teachers' own beliefs about the way something should be taught, then there is likely to be a negative effect on the quality and depth of implementation (Frykholm, 2004; Lloyd & Wilson, 1998; Remillard, 2005). On the other hand, a teacher with a high level of content knowledge and conceptual understanding about the material covered in the curriculum, as well as greater comfort with teaching practices in that subject area, may be more likely to explore the concepts more deeply with students and to model and invite greater engagement with conceptual complexity (Remillard, 2005; Spillane, 2000). Indeed, individual teachers may show distinct differences in the degree to which they will implement concept-based challenging curriculum successfully in different subject areas just based on their different levels of comfort with complexity in those areas (e.g., Spillane, 2000).

Further issues related to teacher comfort with the curriculum relate to development of misconceptions and to teachers' expectations of their students. If teachers do not themselves have a strong content understanding and a strong grasp of the conceptual basis of the curriculum, they might fail to recognise and address misconceptions that emerge from students—or even in some cases foster those misconceptions themselves. For example, Spillane (2000) described an elementary teacher whose level of discomfort with reform-based mathematics curriculum led her to reduce the curriculum to a very procedural and algorithmic approach and to lose opportunities to strengthen students' conceptual understanding and counter misconceptions—yet the same teacher was quite comfortable working with complex conceptual understandings in language arts. Anticipation of misconceptions is a key part of curriculum development and of planning for instruction, particularly with this concept-based focus (Borko, 2004; Gallagher, 2012), and when teachers themselves are uncomfortable working with the concept and its relationships within the content area, that anticipation and management of misconceptions are likely to be less effective.

The kinds of adaptations teachers make to lessons relate not only to their own comfort level with the materials but also their expectations of students and how students are likely to respond, as well as their own perceptions of the time and resources they have available to them (Ball & Cohen, 1996, cited in Drake & Sherin, 2006). Researchers have observed in studies of implementation of reform-based mathematics curriculum that sometimes teachers actually decrease the cognitive demands of the tasks in the way they implement them because of concerns that the students will not be able to access the tasks as presented (Remillard, 2005).

On the other hand, some teachers may resist concept-based curriculum because of concerns that a focus on concepts, over expressed practice of specific procedures/memorisation of facts, will water down the rigour of the content. This has been a point of debate, for instance, in discussion of the curriculum for college calculus (Chappell & Killpatrick, 2003). Teachers are also presented with the pressures of trying to implement concept-based curriculum within a context that may place heavy responsibility on them for students' scores on tests that are more fact- and topic-focused. Yet evidence suggests that in multiple studies, across content areas and student age levels, in which traditional, topic-focused instruction was compared with concept-based instruction, students in concept-based instruction tended to perform at least as well as their traditionally instructed peers on measures of content. Furthermore, these students tended to outperform those peers on various measures of conceptual understanding or critical thinking (Chappell & Killpatrick, 2003; McCoy & Ketterlin-Geller, 2004; VanTassel-Baska & Stambaugh, 2008). VanTassel-Baska and her colleagues have conducted extensive work on the implementation of curriculum for high ability learners with a strong focus on conceptual thought along with advanced content, demonstrating effective influence on student learning across a variety of content areas and thinking skills (Bracken, VanTassel-Baska, Brown, & Feng, 2007; Little, Feng, VanTassel-Baska, Rogers, & Avery, 2007; VanTassel-Baska, Bracken, Stambaugh, & Feng, 2007; VanTassel-Baska & Stambaugh, 2008).

However, trusting to such results—especially in the context of curriculum that might present discomfort for teachers in its unfamiliarity anyway—may add to teachers' discomfort because of the pressures of accountability combined with the general discomfort around the content, concepts, and pedagogical approaches (Remillard, 2005). Therefore, the teacher's interpretation of the curriculum in the classroom remains a key variable in the effectiveness of the curriculum in promoting student learning.

Considerations and Recommendations

The issues and challenges described above centre around the initial development and refinement of concept-based curriculum and then around the interpretation and implementation of the curriculum by individual teachers within the context of schools. Given these issues and challenges, some key considerations and recommendations emerge from the literature and from specific experience with both parts of the endeavour. These considerations are grouped in this section into three interrelated categories: (a) aspects of the curriculum development process, specifically regarding how conceptual understandings are developed and communicated;

(b) exploration and communication of fidelity of implementation with regard to concept-based curriculum; and (c) professional development.

Conceptual Understandings

As explored extensively above, concepts and conceptual understandings are most effective in the curriculum when they are presented and reinforced as tools for interpreting the world around us and the disciplines from which our school subjects emerge. This is not to say that all concepts and conceptual understandings are relativistic; there are key principles and generalisations fundamental to different disciplines that guide the development and implementation of the curriculum, but these too should be viewed as vehicles for building, testing, and evaluating understanding more than as specific points of content to be memorised.

Milligan and Wood (2010), in commenting on concept-based curriculum in social studies in New Zealand, raise some key points about conceptual understanding that should guide the curriculum development process. They emphasised that the conceptual understandings we select necessarily bring some aspects of our world into the forefront and leave others in the background; therefore, the very process of selecting and interpreting conceptual understandings for the purpose of curriculum development is inherently value-laden. They also argued that concepts themselves are contestable and that their defining characteristics may vary depending on the context. This relates to Jonassen's (2006) claim that the most defensible approach to learning concepts is to focus on concepts in use, on patterns of concepts, their relationships, and how we examine essential characteristics as we work to classify new information and to reshape understanding.

All of the perspectives discussed here on concepts and conceptual understanding underscore the point that the purpose of concept-based curriculum is to promote students' abilities to *use* conceptual understanding in making meaning of the world, which requires that they hone these understandings as effective tools in context. Successful concept-based curriculum relies on expertise both in curriculum development and in the specific content under study to build those understandings as supports for the curriculum. Curriculum developers should have experience in understanding the ways that teachers and students think and respond in particular contexts and in considering how the curriculum can talk *to* and *with* the teacher rather than attempting to talk *through* the teacher (Remillard, 2005). Content specialists provide deep knowledge of the concepts most critical to the discipline and the guiding principles and generalisations that are most important for learners to understand, and they also know the likely misconceptions about said concepts. Together these two groups or individuals can anticipate misconceptions on the part of both teachers and students, consider how to make the concepts at once rigorous and accessible for teachers and students and think about assessment approaches that encourage demonstrations of deeper understanding of concepts and generalisations rather than reporting of statements memorised as static facts.

Fidelity

It is also incumbent on curriculum developers and on teachers to have a clear sense of what the idea of "fidelity of implementation" will mean in the context of any particular set of curricular materials in any particular school context. Within the literature, many scholars place strong emphasis on implementing curriculum with fidelity; in particular, researchers examining the effectiveness of any particular curriculum or method must examine and report carefully on the fidelity with which the treatment under study is implemented, or any results are called into serious question (O'Donnell, 2008). However, some scholars have argued that the very concept of fidelity of implementation is an elusive one; teachers bring a value-laden and individualised interpretation to any curriculum, resulting in considerable variation in implementation, yet not all these interpretations are valid reflections of the developers' intentions (Remillard, 2005). Consequently, curriculum developers have a responsibility for "identifying ranges of acceptable variation and clarifying the essential components of a curriculum" (Remillard, 2005, p. 240)—defining what kinds of adaptations maintain the integrity of the curriculum and helping teachers to explore and internalise these ranges as they consider how to implement in their own context.

Curricular documents and classroom practice are fundamentally linked yet distinct; Ben-Peretz (1990) argued that curriculum provides "more than any teacher could possibly use, and yet less that any teacher really requires" (p. vii). From a practical perspective, it is important for school leaders, curriculum developers, and teachers to have an open and ongoing discussion about the application of concept-based curriculum in the classroom and what it looks like to be implementing curriculum as it is intended (Drake & Sherin, 2006). It is critical that teachers have a strong voice in this context; the conversation cannot be only one way, from curriculum developers to teachers, because of the interpretation that teachers will bring to curriculum in the way that they read it and the way that they share what it contains with their students.

This discussion of fidelity of implementation also opens up the conversation about how curriculum developers, school leaders, and classroom teachers conceptualise the curriculum overall, along with the recognition of the inevitable adaptations and modifications teachers will make to enact the curriculum in the real context of the classroom. Shulman (1990) emphasised that "[t]he essential value of curriculum is how it permits teachers to adapt, invent, and transform as they confront the realities of classroom life" (p. vii).

Professional Development

The role of the implementing classroom teacher is central to the effectiveness of the curriculum in practice with students. Professional development that explores the curriculum and its conceptual basis in detail is paramount, but that professional development cannot be limited to an initial workshop that introduces the curriculum and then leaves teachers on their own. Rather, professional development needs to include extended opportunities for teachers to read and digest the curricular materials, to discuss and interpret them with colleagues, to anticipate and plan for student responses and potential misconceptions, and to reflect upon and debrief their implementation (Borko, 2004; Little & Paul, 2011, Remillard, 2005). Indeed, professional development around concept-based curriculum needs to be viewed as a process of learning, with both internal and external components for the teacher, and not as an event.

As previously described, teachers' own perceptions, attitudes, and experiences related to the content area under study, their pedagogical knowledge and preferences, and the students with whom they work all influence how they will implement curriculum, and therefore professional development should include attention to having teachers examine their own perceptions to the degree possible. Such reflection requires time and dialogue with colleagues (Remillard, 2005). Other literature has emphasised the influences on teacher change, highlighting the significance of results with students among other salient outcomes as influential on changes in teacher's attitudes and behaviours (Clarke & Hollingsworth, 2002; Guskey, 1986; Richardson, 2003). These perspectives support the importance of sustained, ongoing opportunities for teachers to reflect upon their implementation of new methods, how those methods align with their established practices and perspectives and how the results they see with students affect their attitudes and understanding (Little & Paul, 2011).

Professional development activities that introduce the curriculum to teachers should not only direct attention to the framework, organisation, and instructional and assessment approaches incorporated within the curriculum but also highlight the substance of the material in terms of both the key conceptual understandings and the content topics and how these two areas of emphasis are linked. Teachers may need multiple structured and unstructured opportunities for exploring the specific content addressed by the curriculum, particularly if it is focused on content that is unfamiliar, differently presented, or more advanced than material they have previously taught. When the content is particularly challenging or less familiar, it becomes even more critical that teachers have opportunities to examine the content with the conceptual lens with colleagues and under the facilitation of content experts and/or curriculum developers, to clarify possible misconceptions the teachers themselves may develop, as well as to anticipate misconceptions among students and how to recognise them (Borko, 2004).

Such exploration of the curriculum must not only emphasise the content of the curriculum itself being presented but must also explore the coherence of the new material under study with what teachers already know and do. Teacher perception of *meaningfulness* in the curriculum has been demonstrated to be a major factor in influencing their levels of participation in the professional development context, along with perceptions of feasibility of the practice for implementation in their own contexts (Kwakman, 2003). Several studies have demonstrated the importance of supporting teachers in integrating new knowledge with their existing ideas (Higgins & Spitulnik, 2008)—indeed, the importance of helping teachers explore their conceptual understandings *about curriculum and instruction* within particular content areas. Milligan and Wood (2010) discussed the value of helping teachers focus on the thinking and conceptualisation involved in preparing for instruction rather than viewing planning for curriculum implementation as an effort of compliance. Once again, this brings the focus to conceptual understandings as *tools*—for the teacher as well as the students—rather than as discrete statements of fact to be memorised and reported. This overall professional development process should include individual and collaborative time, to promote individual understanding and also socially supported construction of concepts. Clearly, such intensive and long-term professional development also requires the allocation of time and resources, as well as administrative commitment to supporting teachers' processes of struggle and growth with new material.

Conclusion

Our minds have the capacity for constantly reforming and reshaping our conceptual understandings of the world around us. It is important that when we think about classroom curriculum, we are actively examining our own understandings and providing contexts in which students may be developing and refining their own. The process of making meaning is a constant effort of creation, building, reshaping, and reorganising what we know, how we know it, and how all the ideas and understandings fit together. Concept-based curriculum can provide an organised context whereby as educators we guide students in that process of building and creation, providing some guidance and expertise from our position of greater knowledge and experience, but with recognition that the concepts themselves and the understandings are tools and scaffolds. Successful development of concept-based curriculum requires dedication of time, expertise, and resources at each stage, along with a commitment to deep thinking, questioning, and exploration of the concepts at the root of human thinking and learning.

References

Adler, M. J. (1952). *The great ideas- A syntopicon of great books of the western world*. (Vol. 1 and 2). Chicago, IL: Encyclopaedia Britannica Inc

American Association for the Advancement of Science. (1990). *Science for all Americans*. New York: Oxford University Press.

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2000). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Boston: Allyn & Bacon.

Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is—or might be—the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher, 25*(9), 6–14.

Barton, K. C., & Levstik, L. S. (2004). *Teaching history for the common good*. Mahwah, NJ: Lawrence Erlbaum.

Ben-Peretz, M. (1990). *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts*. Albany, NY: State University of New York Press.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3–15. doi:10.3102/0013189X033008003.

Bracken, B. A., VanTassel-Baska, J., Brown, E. F., & Feng, A. (2007). Project Athena: A tale of two studies. In J. VanTassel-Baska & T. Stambaugh (Eds.), *Overlooked gems: A national perspective on promising students of poverty* (pp. 63–67). Washington, DC: National Association for Gifted Children.

Brophy, J., & Alleman, J. (2006). A reconceptualised rationale for elementary social studies. *Theory and Research in Social Education, 34*, 428–454. doi:10.1080/00933104.2006.10473317.

Chappell, K. K., & Killpatrick, K. (2003). Effects of concept-based instruction on students' conceptual understanding and procedural knowledge of calculus. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies, 13*(1), 17–37. doi:10.1080/10511970308984043.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*, 947–967.

Coll, R. K., France, B., & Taylor, I. (2005). The role of models and analogies in science education. *International Journal of Science Education, 27*, 183–198.

Drake, C., & Sherin, M. G. (2006). Practicing change: Curriculum adaptation and teacher narrative in the context of mathematics education reform. *Curriculum Inquiry, 36*, 153–187. doi:10.1111/j.1467-873X.2006.00351.x.

Erickson, H. L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Erickson, H. L. (2007). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.

Feldhusen, J. F. (1994). Developing units of instruction. In J. VanTassel-Baska (Ed.), *Comprehensive curriculum for gifted learners* (2nd ed., pp. 91–128). Boston: Allyn & Bacon.

Frykholm, J. A. (2004). Teachers' tolerance for discomfort: Implications for curricular reform in mathematics. *Journal of Curriculum and Supervision, 19*, 125–149.

Gallagher, S. (2012). *Concept development: A Hilda Taba teaching strategy*. Unionville, NY: Royal Fireworks Press.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher, 15*(5), 5–12.

Heffron, S. G., Gallagher, S. M., & Downs, R. M. (2012). *Geography for life* (2nd ed.). Washington, DC: National Council for Geographic Education.

Higgins, T. E., & Spitulnik, M. W. (2008). Supporting teachers' use of technology in science instruction through professional development: A literature review. *Journal of Science Education and Technology, 17*, 511–521.

Jacobs, H. H. (1989). *Interdisciplinary curriculum: Design and implementation*. Alexandria, VA: Association for Supervision and Curriculum Development.
Jonassen, D. H. (2006). On the role of concepts in learning and instructional design. *Educational Technology Research and Development, 54*, 177–196. doi:10.1007/s11423-006-8253-9.
Kaplan, S. N. (2009). The grid: A model to construct differentiated curriculum for the gifted. In J. S. Renzulli, E. J. Gubbins, K. S. McMillen, R. D. Eckert, & C. A. Little (Eds.), *Systems and models for developing programs for the gifted and talented* (2nd ed., pp. 235–252). Waco, TX: Prufrock Press.
Kwakman, K. (2003). Factors affecting teachers' participation in professional learning activities. *Teaching and Teacher Education, 19*(2), 149–170.
Little, C. A., Feng, A. X., VanTassel-Baska, J., Rogers, K. B., & Avery, L. D. (2007). A study of curriculum effectiveness in social studies. *Gifted Child Quarterly, 51*, 272–284.
Little, C. A., & Paul, K. A. (2011). Professional development to support successful curriculum implementation. In J. VanTassel-Baska & C. A. Little (Eds.), *Content-based curriculum for high-ability learners* (2nd ed., pp. 413–435). Waco, TX: Prufrock Press.
Lloyd, G. M., & Wilson, M. (1998). Supporting innovation: The impact of a teacher's conceptions of functions on his implementation of a reform curriculum. *Journal for Research in Mathematics Education, 29*, 248–274.
Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives* (2nd ed.). Thousand Oaks, CA: Corwin Press.
McCoy, J. D., & Ketterlin-Geller, L. R. (2004). Rethinking instructional delivery for diverse student populations: Serving all learners with concept-based instruction. *Intervention in School and Clinic, 40*, 88–95. doi:10.1177/10534512040400020401.
Milligan, A., & Wood, B. (2010). Conceptual understandings as transition points: Making sense of a complex social world. *Journal of Curriculum Studies, 42*, 487–501. doi:10.1080/00220270903494287.
National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards: Mathematics*. Washington, DC: Authors.
National Research Council. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.
O'Donnell, C. L. (2008). Defining, conceptualising, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research. *Review of Educational Research, 78*, 33–84. doi:10.3102/0034654307313793.
Partington, A., & Buckingham, D. (2012). Challenging theories: Conceptual learning in the media studies classroom. *International Journal of Learning and Media, 3*(4), 7–22. doi:10.1162/IJLM_a_00079.
Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research, 75*, 211–246. doi:10.3102/00346543075002211.
Richardson, V. (2003). The dilemmas of professional development. *Phi Delta Kappan, 84*, 401–406.
Seiger-Ehrenberg, S. (2001). Concept development. In A. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (3rd ed., pp. 437–441). Alexandria, VA: Association for Supervision and Curriculum Development.
Shulman, L. (1990). Preface. In M. Ben-Peretz (Ed.), *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts*. Albany, NY: State University of New York Press.
Spillane, J. P. (2000). A fifth-grade teacher's reconstruction of mathematics and literacy teaching: Exploring interactions among identity, learning, and subject matter. *The Elementary School Journal, 100*, 307–330.
Taba, H. (1962). *Curriculum development, theory, and practice*. New York: Harcourt, Brace, and World.
Taba, H., Durkin, M. C., Fraenkel, J. R., & McNaughton, A. H. (1971). *A teacher's handbook to elementary social studies: An inductive approach* (2nd ed.). Reading, MA: Addison-Wesley.
Twyman, T., Ketterlin-Geller, L. R., McCoy, J. D., & Tindal, G. (2003). Effects of concept-based instruction on an English language learner in a rural school: A descriptive case study. *Bilingual*

Research Journal: The Journal of the National Association for Bilingual Education, 27, 259–274. doi:10.1080/15235882.2003.10162806.
VanTassel-Baska, J. (Ed.). (1994). *Comprehensive curriculum for gifted learners* (2nd ed.). Boston: Allyn & Bacon.
VanTassel-Baska, J. (2011). An introduction to the integrated curriculum model. In J. VanTassel-Baska & C. A. Little (Eds.), *Content-based curriculum for high-ability learners* (2nd ed., pp. 9–32). Waco, TX: Prufrock Press.
VanTassel-Baska, J., Bracken, B. A., Stambaugh, T., & Feng, A. (2007, September). *Findings from project clarion.* Presentation to the United States Department of Education Expert Panel, Windsor, CT.
VanTassel-Baska, J., & Stambaugh, T. (2008). *What works: 20 years of curriculum development and research*. Waco, TX: Prufrock Press.
Vygotsky, L. (1962). *Thought and language*. Cambridge, MA: MIT Press.
Ward, V. (1981). *Differential education for the gifted*. Ventura County, CA: Office of the Superintendent of Schools.
Wiggins, G., & McTighe, J. (1998). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Concept-Based Curriculum Design and Practice in the United States

Tamra Stambaugh and Emily Mofield

An Introduction: Why Does Concept-Based Curriculum Matter?

The US educational landscape is changing as societal demands and new definitions of what it means to be an educated citizen require students to be prepared to live in a world they have yet to envision. For many US schools, there is a focus on twenty-first century skills and a documented need to better prepare students for college and career readiness and for work in a global society. Outcomes such as the Common Core State Standards (CCSS) have been created in an effort to emphasise international competitiveness. Fast-paced technological advances and access to immense amounts of information open the world to students in ways that were not previously possible. Our new generation of students is computer literate before formal schooling begins and many have already amassed more information than others of their same age from previous generations.

The P21 Partnership for 21st Century Learning (P21) (2015) recognises these issues and recommends that in order to be competitive in the world market place students need to master discipline-specific content and connect that content to conceptual understanding. Emphases are on investigations of real-world issues (especially those that focus on global awareness), economics (personal and global), responsible citizenship, health and environmental education (including how humans interact with the world around them). P21 further recognises that twenty-first century citizens must be able to think creatively, apply critical thinking strategies, communicate effectively, collaborate with others, understand how to access and analyse large amounts of information, use technology appropriately and adapt to an ever-changing world (Partnership for 21st Century Learning [P21], 2015). These are not

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separate skills but ones that must be understood within the complexity of our current and future society.

With so much information to be acquired or accessed, concept-based curricula provides a way to help students link multiple disciplines together and make sense of significant amounts of information (Erickson, 1998). Common ideas within or across disciplines allow students to synthesise information into concepts and generalisations with the inclusion of relevant facts and details as justification of conceptual understandings. There are strong theoretical underpinnings for teaching a concept-based curriculum, and these approaches have been advocated in the United States for quite some time (Erickson; Taba, 1962; VanTassel-Baska, 1986).

This chapter explains the rationale for using a concept-based curriculum, as well as considerations for developing such curriculum. Models and intervention studies found successful with a variety of student populations will also be cited, and examples of concept-based curriculum will be provided, including key features of the curriculum design process, ideas for introducing concepts to students in creative ways and suggestions for leaders who are implementing, designing or adopting a concept-based approach to curriculum and instruction.

Concept-Based Curriculum Models and Efficacy

Why a Concept-Based Curriculum in US Classrooms?

How does a concept-based curriculum development model differ from more traditional approaches in curriculum, instruction and assessment? Unlike other models of curriculum, a concept-based curriculum model is structured around themes and ideas rather than isolated subjects or process skills, providing opportunities for students to make interdisciplinary connections (Erickson, 2012; VanTassel-Baska, 1986). The overarching concepts provide a basis for organising knowledge and comparing facts and ideas, which would otherwise be unrelated. The organisation around concepts allows students to study the relationships between ideas and facts from multiple disciplines and in the same disciplines. If topics and issues associated with a content area are chosen skillfully, the learning is also integrated to life applications for the learner (Taba, 1962). For example, within a concept-based curriculum framework, students can make connections to the concept generalisation "power as the ability to influence" by examining rhetorical arguments in political speeches, catalyst variables within science experiments, factors that influence trends in mathematical data sets and character motives and decisions within fictional stories. Students can personally integrate this knowledge by reflecting upon how their choices in life have the power to influence their future. This contrasts sharply with isolated lessons about rhetoric, chemistry, statistical analysis and characterisation with little or no self-reflection applied in learning. The concept-based curriculum approach permits an integrated thread to connect factual content to abstract ideas that result in enduring understanding rather than rote learning (see Wiggins & McTighe, 2005).

Models for Concept Development and the Efficacy of Use

Curriculum models that include concepts, an emphasis on discipline-specific facts and related process skills such as reasoning, thinking or problem-solving will better equip students for the world in which they will be working and leading (P21, 2015; VanTassel-Baska, 1986). The development of expertise is also dependent upon the level of the individual's understanding of the key ideas and generalisations within a discipline. When comparing experts and novices, Bransford, Brown and Cocking (1999) found that experts are more likely than novices to organise their knowledge into larger conceptual understandings so that they can retrieve major ideas and facts within their field by chunking information into patterns. They are also more readily able to learn new ideas when they have amassed larger amounts of information previously and can link new information to past content. Moreover, experts notice patterns within a field and connect those patterns to key ideas and principles (Bransford et al., 1999). Therefore, teachers who incorporate curriculum development models that link foundations, structures and skills to key concepts and principles are more likely to nurture the development of expertise than when they focus on fact-building and skill-based activities alone. So, when subject matter is taught at the level of concepts (e.g. organising ideas into one or two word ideas) and generalisations/principles (e.g. the connection of two or more concepts into statements), knowledge is more readily transferable such that students grasp and apply complex ideas associated with seemingly isolated facts (Erickson, 1998, 2012).

Few models and formalised materials exist that focus explicitly on concept-based approaches as a major component of curriculum design. Erickson's Structure of Knowledge Framework (see Erickson, 1998) is one such model for designing concept-based curriculum and has been previously discussed in this book. Many teachers and school districts have endorsed the model and created lessons and units based on key conceptual understandings with anecdotal success. Other organised approaches and curriculum design models such as the International Baccalaureate (IB) programme and the Integrated Curriculum Model (VanTassel-Baska, 1986) include concepts as a critical part of a curriculum framework. Use of these models positively impacts students' achievement as well as non-academic factors essential for learning.

International Baccalaureate (IB) programmes are popular in school districts across the United States and around the world. Part of the IB model is to emphasise concepts that span multiple disciplines. By using this method, students focus on the key ideas instead of simply memorising facts (Erickson, 2012). As such, students are better equipped to determine intercultural understandings instead of isolated skills. Specific effects of this concept-based approach used in IB programmes have been studied in the United States and are found to impact students' interest in global awareness positively (IB, 2015) and overall achievement in multiple subject areas including science (IB, 2015), reading (particularly for those students who are economically disadvantaged) (IB, 2015), civic-mindedness and model citizenship (Saavedra, 2014). Students who participate in IB programmes were also more likely than their non-IB peers to more easily adjust to college life and coursework, and low-income IB participants were more likely than their non-IB counterparts to enrol and remain in college (IB, 2015).

The Integrated Curriculum Model (ICM, VanTassel-Baska, 1986) also focuses on concept-based instruction as an essential component of the curriculum design process. Units have been developed using a concept-based approach in the areas of language arts, science and social studies. Several short-term, descriptive, longitudinal and quasi-experimental studies conducted by the developer of the model show that students who are exposed to the curriculum posit significant achievement gains in their content area (MacFarlane & Stambaugh, 2009; VanTassel-Baska & Brown, 2007; VanTassel-Baska & Stambaugh, 2009). The ICM includes a three-pronged approach for curriculum development: advanced content of the discipline, content-specific and advanced processes and models (i.e. scientific inquiry, problem-solving, reasoning, literary analysis, creative thinking) and concepts and themes that include principles and generalisations applicable within and across disciplines (i.e. systems, change, cause and effect). The ICM design has also been replicated in external settings with positive effects on student achievement, especially in reading/language arts (Mofield & Stambaugh, 2016a, 2016b, 2016c) and science (Cruz & Stambaugh, 2014).

Designing a Concept-Based Curriculum

How do educators design a concept-based curriculum? How does a concept-based curriculum development model differ from more traditional approaches in curriculum, instruction and assessment? What can leaders do to support the institution of a concept-based approach to student learning? These questions and practical applications will be addressed.

How Do Educators Design a Concept-Based Curriculum?

Teachers with an in-depth knowledge of content, the inquiry process and the ability to make interdisciplinary connections can design concept-based curriculum (VanTassel-Baska, 1986). Thoughtful consideration must be given to how content topics are organised as part of an overarching theme, otherwise forced associations will not translate to enduring learning (Taba, 1962). We introduce some broad considerations for designing instruction and assessment for concept-based units, followed by specific practical approaches for designing engaging learning experiences.

Key Considerations

Select a Fidelity Model That Has a Strong Theoretical Basis and/or Evidence of Effectiveness A concept-based approach requires more than just discussing a concept or adding a concept to a set of facts. Curriculum design approaches require careful selection and adherence to a framework that has a theoretical and evidential basis. Careful selection of appropriate generalisations like those agreed upon by experts in a discipline as opposed to teacher-created ones also ensure that misconceptions are less likely to be generated. Likewise, when curriculum developers adhere to a framework, they are more likely to achieve the goals as replicated by previous studies and theories. Curriculum units that focus on concepts such as those from the College of William and Mary Center for Gifted Education and Vanderbilt University Programmes for Talented Youth are carefully designed using the Integrated Curriculum Model (VanTassel-Baska, 1986), which has a concept focus.

Determine the Content Students Need to Know and Connect That Content to Conceptual Understandings and Processes of the Discipline Content knowledge is important and serves as the basis for curriculum design. When teaching, concepts and generalisations are introduced first and then content and processes of the discipline are continually linked back to the concept, as illustrated in Fig. 1. The concept serves as an umbrella that links together the content and thinking skills inherent to the subject area. An overarching, real-world question helps students determine the purpose for learning the content. Concepts connect the processes and content together.

Make Sure Objectives Are Included for Concepts as well as Content and Processes (VanTassel-Baska, 1986; VanTassel-Baska & Stambaugh, 2006). Each is equally important in unit designs and lessons. The inclusion of objectives in each area helps students and teachers understand the importance of thinking skills, concepts and content in ways that transfer knowledge and help students acquire a deeper understanding of a content area. Figure 2 shows an example of how concepts, processes of higher-level thinking and content-based skills link together with an overarching concept and objectives in each area as part of planning for a science unit.

Regularly Help Students Link Processes and Content to Concepts and Generalisations for Consistent Application of Newly Learned Information to Larger Ideas There are many ways to apply this to the classroom.

- Students may create their own concept maps and add to their maps each day or week as part of a journal or working document. This supports student reflection, allows the teacher to see how students are organising their ideas around concepts and keeps concepts at the forefront of the conversation.
- Teachers may also create an interactive bulletin board or working wall that lists the key generalisations and concepts in a way that students can add facts and ideas related to a specific statement as they learn new content. More specifically, let's assume a teacher is focusing the concept of exploration. He has placed spe-

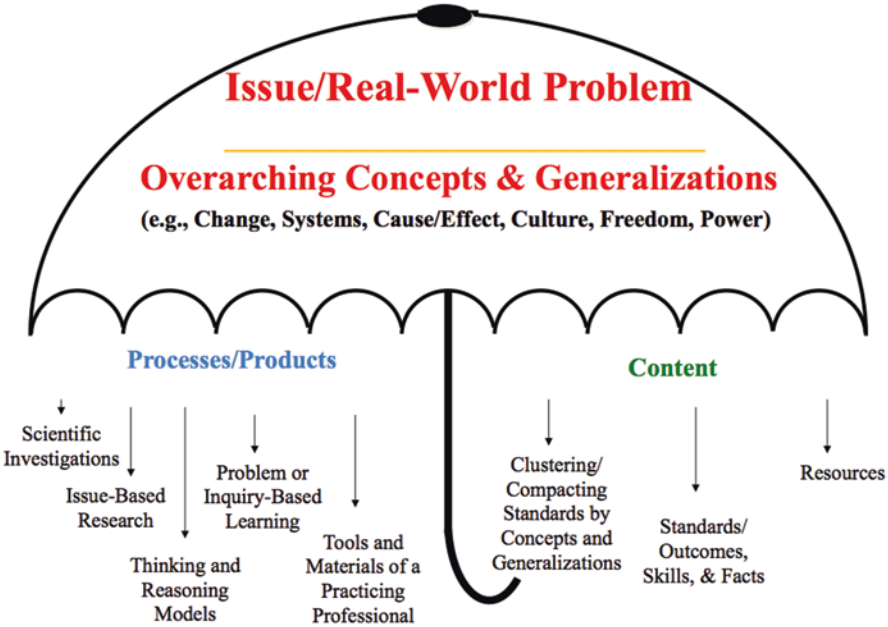

Fig. 1 A model for concept development with processes and content

cific generalisations about exploration (e.g. exploration involves risk; exploration results in new findings or confirmation of previous findings; exploration confronts the unknown) on a bulletin board. After a lesson or series of lessons, students add specific facts and examples under each principle as related to the outcomes he is required to teach in science (planetary systems), reading (character development in a fictitious story) and math (mathematical problem-solving strategies). More specific discipline-focused concepts are discussed in the next section of this chapter.

- Students may individually or in small groups analyse primary source documents, art or artefacts and connect their findings to generalisations of power (or another concept) by completing an organiser based on their understanding, as shown in Fig. 3. Of course any concept could be substituted using the organiser as a guide. Students complete this organiser several times throughout a course of study to be reminded constantly of the larger ideas associated with their learning.

Ensure that Students Are Assessed on Their Knowledge of Concepts in Addition to Content and Processes Concept-based models are more difficult to measure and are usually not measured or emphasised to the same degree as lower-level, skill-based knowledge. However, if it is worth teaching, it is worth measuring. Thus, assessing students' understanding of concepts requires an approach that is more task-based, open-ended and is generally assessed by a rubric.

Should we stop natural erosion?

Accelerated Content (Concept Map)	Processes and Goals (Short Answer Question/Diagram)	Concept Goals (Short Answer Question/ Diagram)	Products/Guiding Questions
Understand the factors that contribute to erosion. Explain how the different types of erosion impact landscapes in different geographic areas. Determine the differences between man-made and natural erosion. Explain how erosion over time has led to the earth's current landscape.	Debate the positive and negative and short term and long term implications of erosion on the earth. Explain how different points of view and geographic locations affect decisions made regarding erosion. Explain assumptions and evidence regarding erosion and the ebb and flow of the earth's landscape.	Explain how the elements of a system change when the inputs and outputs of that system change. Outline how systems interact with each other through the lens of erosion.	Persuasive Essay: Should we stop natural erosion? Design a playground on the beach that does not contribute to erosion, preserves natural resources, and allows safe recreation. Draw a systems diagram to outline the playground design and the different inputs, outputs, elements, boundaries, and interactions.

Fig. 2 A unit design example of outcomes for generalisations, processes and content (Adapted from the College of William and Mary, Center for Gifted Education (2007)

Strategies to Help Link Concepts Across Multiple Disciplines

Here are a few examples of how assessments may be constructed so that students can show their understanding of a concept in multiple content areas:

Examples of Products for a Unit Focused on the Concept of Freedom Conduct a rhetorical analysis about a speech or text from two different perspectives. Be sure to examine how the text promotes or limits freedom for a selected group (Mofield & Stambaugh, 2016a). (Note how students must justify a specific generalisation based on the concept of freedom, their understanding of a speech and their process of rhetorical analysis.)

- Draw an editorial cartoon or abstract illustration showing the principles delivered in an historical document. Include a written description to accompany your illustration that describes how it relates to a generalisation about freedom (Mofield & Stambaugh, 2016a).

Design a Formative Assessment Prompt and Include Rubric Guidelines One example of a prompt for analysing text might be: *What does the following document*

Literature, Art, or Media:	Literature, Art, or Media:	Literature, Art, or Media:
Power is the ability to influence.		
Power is connected to a source.		
Power may be used or abused.		
Examine the relationship between power and another concept.		

Fig. 3 Concept organiser for power (Used with permission from Mofield and Stambaugh (2016b)

reveal about freedom? (Mofield & Stambaugh, 2016a). Figure 4 shows the rubric guidelines for the assessment of concept curricular goals.

Assess Student Learning as a Culminating End-of-Unit Product For example, students may be asked to respond to the following prompt: Which should be more valued, the individual or society? Choose four individuals from the unit (characters

0	1	2	3	4
Provides no response.	Response is limited, vague, and/or inaccurate.	Response lacks adequate explanation. Response does not relate or create a generalisation about freedom. Little or no evidence from text.	Response is accurate and makes sense. Response relates to or creates an idea about freedom with some relation to the text.	Response is accurate, insightful, and well-written. Response relates to or creates an accurate generalisation about freedom with evidence from the text.

Fig. 4 Rubric for assessing concept curricular goals (Used with permission from Mofield and Stambaugh (2016a)

or real people) and respond to the question from their point of view. Then, create a visual collage or multimedia movie to reflect their viewpoints. Incorporate abstract symbols, words, pictures and quotes about individuality, identity, conformity, society, belongingness, etc. Also turn in a written description of symbols used (from Mofield & Stambaugh, 2016c).

Similar ideas in other content areas can easily be constructed. A related example from a concept and problem-based science unit (see Cruz & Stambaugh, 2014) requires students to respond to the following question as a formative assessment after introducing the concept of systems: *In the first lesson, we determined the effects of exposure of various elements (light, water, carbon dioxide) on plants. What happens if one of the elements of the plant system was removed (i.e. light, water, carbon dioxide)? What are the implications of removing that part of the system on plant life? Now consider content in another class you have taken (i.e. language arts, social studies, math). Select a system you have learned about and then link the parts of a system to it (e.g. inputs, outputs, boundaries, elements). How does the system in your other subject area content compare to the photosynthesis-respiration cycle?*

As students progress through the unit, they link their own data gathered from scientific investigations to conceptual understandings about plants and systems.

In mathematics, similar ideas can be applied using generalisations about systems (or another concept). For example, students may examine the boundaries of number systems as related to equations, the impact of negative or fractional numbers on number systems or how different bases interact.

When curricula are designed in this way, significant achievement gains in students' understanding of content, processes specific to a discipline and concepts are noted based on pre- and post-assessment data (Mofield & Stambaugh, 2016a, 2016b, 2016c; VanTassel-Baska & Stambaugh, 2009).

Introducing Concepts in Practical Ways

As many US teachers are not used to teaching concept-based curriculum, they may need assistance, ongoing modelling and professional development to support their attempts. In addition, in order to ensure that concepts are taught in a variety of ways, teachers can vary the ways concepts are introduced and taught. The teacher should thoughtfully plan how to introduce the concept to students so that it is relevant, meaningful and interesting to their students. The following are suggested activities for introducing a concept for a unit of study:

- Draw or sculpt the concept or related concept. This open-ended task allows students to draw either abstract or literal representations of the concept. For example, for the concept of power, students may draw a light bulb representing the literal idea of electrical power, or a pen, representing the more abstract idea of the power of an idea in writing.
- Apply Taba's (1967) concept formation strategy:

    1. Create a list of 20–25 examples of the concept.
    2. Develop several non-examples of the concept.
    3. Examine patterns of the examples and sort them into three or four categories and label the categories.
    4. Develop broad generalisation statements about the concept based on the examples and categories created.

- Provide a list of several quotes related to the concept. Students paraphrase a quote into their own words, create a drawing or symbol to go with the quote and share their idea with the class relating it back to the conceptual theme.
- Ask students to brainstorm a list of several movies, stories or events that relate to the concept studied. Then, ask students to examine the list for patterns and similarities across their ideas.
- Ask students to define the concept in their own words and then explore various dictionary definitions of the word and related words. Examine the positive and negative connotations of these words and the nuances in meaning. This may lead to insightful discussion as students explore issues such as "Is truth the same as reality?" or "Is freedom the same as autonomy?"
- Show a series of short movie clips related to the concept. Several websites have searchable video clips sorted by theme (e.g. www.wingclips.com). After viewing the clips, students develop broad generalisation statements about the concept.
- Students create similes and metaphors to make comparisons between abstract ideas and concrete details. This task was presented within a unit on truth. Student responses included:

  - "Truth is like the binary computer coding system — it can either be a 0 or 1; truth either is true reality or it is not."
  - "Truth is like sweet and sour candy — it can be hurtful (sour) and beneficial (sweet) at the same time."

- Ask students to complete a forced association (synectics) to demonstrate their understanding of the concept (Gordon, 1961). For example, ask, "How is truth like a tree?"

Strategies for Building Greater Sophistication of Conceptual Understanding

The following are suggested class activities for guiding students to a more sophisticated understanding of a concept.

- Post the concept generalisations in your classroom and ask students to make connections to them throughout the lesson. Through a unit of study, add to the list as students develop additional connections. Additional examples of this were explained in the previous section of this chapter including working word walls, organisers and individual concept maps.
- Develop quick debates around problems, issues or controversies related to the concept. For example, while studying a text about the pros and cons of technology, the teacher may pose an evaluative question to relate the content to the concept of "change": "Does technology bring about positive or negative change for the human experience?" Students may stand on opposite sides of the room to support their point of view through a quick debate on the issue. Debates can also be centred around two contrasting concepts. For example, when studying Van Gogh's "Starry Night", students may debate whether the art displays the concept of hope or despair, supporting their ideas with evidence from their art. The concepts of "hope" and "despair" can then be connected to the unit concept such as "power" by asking students to make connections to generalisation statements.
- Guide students to examine concrete details of a text, art or an experiment; ask them to consider how they might represent a big idea or concept. It is often beneficial to do this first with a familiar visual and then with lesson content so they have time to focus on the concept development process with something easier before delving into new information and conceptual development. For example, a student may view a car advertisement and note specific details about the background scenery. The larger idea represented by the scenery is the concept of "freedom" or "escape". Children's books are also a good way to introduce how concepts are represented by characters and plot events. For example, the concepts of "deception" and "judgement" are evidenced in *Little Red Riding Hood*. As more sophisticated texts are introduced, students should be able to associate concepts with specific characters or symbols. For example, in Emily Dickinson's

poem, "I like to see it lap the miles", the train is symbolic of the concept of "human progress" or "change". As students continue to examine the patterns of the train in the poem, they can make generalisation statements about change from this evidence.

- When students are engaged in a close reading of a text, develop text-dependent questions that relate to the concept. For example "How does the author define truth?" or "What textual evidence supports the generalisation 'perception of truth varies'?"
- If students need support in developing concept generalisations, scaffolding can be provided by giving students a word bank. For example, the teacher may state, "Based on today's lesson, write a generalisation that includes 'power' and one of the following words: change, risk, vulnerability, conflict." A sample response might be "Conflict results from an imbalance of power".
- Ask students to evaluate generalisations as part of problem-solving within a discipline. The generalisation "structure promotes function" can be explored by evaluating the *best* structure that promotes function after considering multiple solution options. The following are examples:
  - Math: formulate the best ratio(s) for a bridge design to carry a specific load.
  - Science: justify why their choice is the best bioengineering design for solving a specific problem.
  - Social studies: what criteria you might establish to determine the best way to structure a law to solve a problem?
  - English/Language Arts: evaluate the best way to structure an essay for building an effective argument in order to persuade your solution.
- Concept generalisations and definitions can be debated or explored through multiple points of view. Specific examples for application:
  - Students explain contrasting ideas about truth from the perspectives of M.C. Escher and Plato.
  - Venn diagrams can be used to compare and contrast perspectives on concept generalisations and definitions.
  - Students compare their individual findings from a scientific experiment as related to photosynthesis and the concept of systems.
- Students make real-world connections to reflect on the implications of the concept on their own life or other aspects of society. This is critical to help students understand the relevance of the content to other aspects of their life and the world around them. One way to organise these ideas is through a big idea reflection guide. An example is noted in Fig. 5. Although the guide in Fig. 5 is targeted towards reading and analysing a variety of media, teachers can connect any concept and subject area together to determine the relevance and significance of the content.
- Students identify problems associated with the concept in relation to the content area. The following are problems that relate to "power is connected to a source":

	Questions for Reflection	Student Responses
What?	**Concepts:** What concepts/ideas are in the text?	
	Generalisations: What broad statement can you make about one or more of these concepts? Make it generalisable beyond the text.	
	Issue: What is the main issue, problem, or conflict?	
So What?	**Insight:** What insight on life is provided from this text?	
	World/Community/Individual: How does this text relate to you, your community, or your world? What question does the author want you to ask yourself?	
Now What?	**Implications:** How should you respond to the ideas in the text? What action should you take? What are the implications of the text? What can you do with this information?	

Fig. 5 Big idea reflection of concepts to the real world (Used with permission from Mofield and Stambaugh (2016b)

- Social Studies: Power is connected to the source of wealth — the distribution of wealth influences problems associated with social class structure.
- Science: Power is connected to human interference. Human interaction with plants and animals within ecological systems can pose problems within those systems.
- English/Language Arts: Power is connected to a character's decision. A character's decision influences additional conflicts within the plot.
- Math: Power is connected to sample size. An outlier within a small sample size will not accurately reflect the sample representation of a population.

- Students examine the concept as a factor of causality. For example, the teacher can pose questions such as "How does *structure* promote function? How does *order* affect outcome? How does *freedom* for a specific group cause changes in social structure, economics, politics and culture?"
- Students reflect on lesson content by relating newly learned content to concept generalisations on exit slips as they leave the classroom.

It is important to note in each of these examples show how students are consistently linking concepts and principles to content and processes such as the scientific process, mathematical problem-solving and literary analysis. Conceptual development is not accidental but is a deliberate and ongoing approach to connect facts and skills to larger ideas so that the transfer of learning occurs within and across disciplines (Erickson, 2012).

Concept-Based Teacher Barriers in the United States

In the past decade, schools in the United States have faced several issues when attempting to implement a concept-based curriculum or emphasise concept-based teaching. As such, concept-based teaching has not been a common approach in many classrooms. In the United States, some versions of content-based curriculum standards have been adopted and vary by state. These standards drive the creation of assessment measures for students. In fact, student achievement scores are a commonly used indicator of school district success and may be used as part of a teacher accountability and even evaluation system. Therefore, if concepts are not explicitly included as part of the content standards or assessed as part of an assessment, it is unlikely that teachers will focus on teaching concepts, especially if concepts are not included in the standards or as part of a high-stakes assessment. Many teachers express difficulty teaching conceptually when the assessments and standards in their state are geared towards skill-based questions and tasks (Education Research Center, 2011). Government officials at the national level have realised this expressed difficulty as well. For example, in many states, when comparing student scores on state assessments versus the National Assessment of Education Progress (NEAP), findings suggest that state requirements and measures are significantly lower and many students who score at moderate to high levels of proficiency on state assessments are performing poorly on the NAEP assessment which is said to be better aligned to international tests (National Council for Educational Statistics, 2015).

Thus, most recently, the Common Core State Standards (CCSS) were introduced as a way to better prepare students for college and careers. Many states have adapted the CCSS to meet their own needs, and this has resulted in a recent revamping of curriculum and subsequent assessment measures and teaching methods in many states. According to the CCSS authors, "the new standards focus on core concepts and procedures starting in the early grades, which gives teachers the time needed to teach them and gives students the time needed to master them" (paragraph 3). As the standards have just recently been introduced and the first round of assessments are just now being published and administered, it is unknown whether or not a shift in teaching and assessment will lead to a more explicit focus on concept-based teaching. If the high-stakes assessments continue, it is likely that this will drive what teachers teach and to what extent concept-based approaches are included as part of an integral component of student learning.

What Can Leaders Do to Support the Institution of a Concept-Based Approach to Student Learning?

Instructional leaders who focus on student learning can support teachers in their development of concept-based teaching by providing evidence-supported curriculum as models for replication, giving tangible and intangible resources, and holding teachers accountable for teaching in a conceptual way that embeds facts and skills with overarching concepts and principles. In low-income schools in particular, where teacher and student attrition are more likely, placing high-powered curriculum in the hands of good teachers with targeted training may enhance ongoing use and fidelity over time when using new methods (Stambaugh & Chandler, 2011).

It must be noted that accountability is not intended to be punitive but rather supportive of specific approaches. Accountability for teacher change includes providing built-in structures (i.e. planning/collaboration time, coaching, modelling, appropriate resources) and student learning targets (i.e. data analysis, data-based decision-making, goal setting for student growth) to support fidelity of implementation. Instructional coaches and teacher leaders in the school can teach model lessons, support curriculum implementation and provide consistent feedback to improve instruction using conceptual understandings and key principles/generalisations. When teachers see modelled lessons with their own students, try a lesson on their own and note positive reactions to a new approach, they are more likely to adopt the strategy (Guskey, 2000).

When planning for instruction, leaders can require that teachers bring all of the facts and skills they need to teach and organise them around concepts and themes such that multiple skills and facts can be taught as part of a larger conceptual approach. Thus, when teachers realise and view first hand that many of their required standards can be incorporated and this buys them more time to adequately "cover" multiple skills within one or two related concepts, it is plausible that they will be more likely to.

Most importantly, administrators must remember that changes take time, consistent monitoring and focus. With guided and intensive professional development and ongoing support as previously discussed, positive results in student achievement are likely to be seen within 3–5 years (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997). However, with a concept-based approach, leaders may find that teachers are a bit more resistant to change if high-stakes testing does not measure conceptual thinking, and embedded institutional systems discourage the acquisition of higher-level thinking skills. In these situations, it is imperative that the administrator help teachers understand how the development of expertise and transfer of knowledge occurs and that students retain more information for the high-stakes assessment if they have a way to "contain" the new information learned through conceptual understandings that connect multiple ideas/facts. And isn't it really about learning and the transfer of knowledge, anyway?

References

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Borko, H., Mayfield, V., Marion, S., Flexer, R., & Cumbo, K. (1997). Teachers' developing ideas and practices about mathematics performance assessment: Successes, stumbling blocks, and implications for professional development. *Teaching and Teacher Education, 13*(3), 259–278.

College of William and Mary, Center for Gifted Education. (2007). *Where's the beach?* Dubuque, IA: Kendall-Hunt.

Cruz, N., & Stambaugh, T. (2014). *The case of the dead tomato plants: Exploring photosynthesis and respiration cycles*. Nashville, TN: Vanderbilt Programs for Talented Youth.

Education Research Center. (2011). Issues A-Z: Standards. *Education Week.* Retrieved from http://www.edweek.org/ew/issues/standards/

Erickson, L. (1998). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.

Erickson, L. (2012). *Concept-based teaching and learning*. Retrieved from http://www.ibmidatlantic.org/Concept_Based_Teaching_Learning.pdf

Gordon, W. J. J. (1961). *Synectics: The development of creative capacity*. New York: Harper.

Guskey, T. R. (2000). *Evaluating professional development*. Thousand Oaks, CA: Corwin Press.

International Baccalaureate. (2015). *Key findings from research on the impact of IB programmes in the Americas*. Retrieved from http://www.ibo.org/globalassets/publications/ib-research/Research-IBA-en.pdf

MacFarlane, B., & Stambaugh, T. (Eds.). (2009). *Leading change in gifted education: The festschrift of Dr. Joyce VanTassel-Baska*. Waco, TX: Prufrock Press.

Mofield, E., & Stambaugh, T. (2016a). *Finding freedom: ELA lessons for gifted and advanced learners in grades 6–8*. Waco, TX: Prufrock Press.

Mofield, E., & Stambaugh, T. (2016b). *Perspectives of power: ELA lessons for gifted and advanced learners in grades 6–8*. Waco, TX: Prufrock Press.

Mofield, E., & Stambaugh, T. (2016c). *I, me, you, we: ELA lessons for gifted and advanced learners in grades 6–8*. Waco, TX: Prufrock Press.

National Council for Educational Statistics. (2015). *Mapping state proficiency standards onto NAEP scales*. Retrieved from https://nces.ed.gov/nationsreportcard/subject/publications/studies/pdf/2015046.pdf

Partnership for 21st Century Learning, P21. (2015). *Framework for 21st century learning.* Retrieved from http://www.p21.org/our-work/p21-framework

Saavedra, A. R. (2014). The academic impact of enrollment in international Baccalaureate diploma programs: A case study of Chicago public schools. *Teachers College Record, 116*(5), 1–40.

Stambaugh, T., & Chandler, K. (2011). *Effective curriculum for underrepresented gifted students: A CEC-TAG joint resource*. Waco, TX: Prufrock Press.

Taba, H. (1962). *Curriculum development; theory and practice*. New York: Harcourt Brace & World.

Taba, H. (1967). *Teacher's handbook for elementary social studies*. Palo Alto, CA: Addison-Wesley.

VanTassel-Baska, J. (1986). Effective curriculum and instructional models for talented students. *Gifted Child Quarterly, 30*(4), 164–169.

VanTassel-Baska, J., & Brown, E. (2007). Toward best practice: An analysis of the efficacy of curriculum models in gifted education. *Gifted Child Quarterly, 51*(4), 342–358.

VanTassel-Baska, J., & Stambaugh, T. (2006). *Comprehensive curriculum for gifted learners*. New York: Alyn & Bacon.

VanTassel-Baska, J., & Stambaugh, T. (2009). *What works: 20 years of research and development in gifted education*. Waco, TX: Prufrock Press.

Wiggins, G., & McTighe, J. (2005). *Understanding by design* (Expanded 2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Concept-Based Curriculum: An Australian Experience

Sally Godinho

Introduction

In Australia, approaches to concept-based curriculum have been embraced by progressive teachers who recognise that a conceptual framework allows learners to summarise, synthesise and organise key ideas. They support learners in the transition from the acquisition of myriad atomised facts to the development of broader conceptual knowledge and understanding. Ideally, a concept-based curriculum identifies the driving concepts; articulates the targeted knowledge, skills or capabilities; frames the assessment tasks for providing evidence of learning; and includes an appropriate sequence of learning experiences (Erickson, 2002; Wiggins & McTighe, 2005). Teachers who engage in this approach to curriculum planning understand the interconnectedness of curriculum, pedagogy and assessment and identify the importance of the conceptual lens in helping students to make meaning and deepen their thinking around the curriculum content.

Concept-based curriculum in Australian schools often presents as curriculum integration—an intended outcome of concept-based curriculum (Drake & Burns, 2004; Erickson, 2002). Curriculum integration is an investigative, inquiry-based approach to learning around a generative theme or topic (Kincheloe, Slattery, & Steinberg, 2000) that aspires to make students' learning experiences more relevant and transferable. Through the identification of a focus conceptual lens, curriculum integration enhances opportunities for authentic cross-disciplinary connections.

This chapter begins by providing further discussion of what concept-based curriculum means in the Australian context. A brief historical snapshot of the way the states and territories' curricula and the recently developed Australian curriculum have engaged with integrative approaches to learning is then presented. This detail

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foregrounds the presentation of some concept-based curriculum integration units undertaken in primary and secondary schools, prior to addressing challenges and issues that have arisen at the school programme level and making some recommendations for advancing concept-based integrative curriculum in the Australian context.

Defining Concept-Based Curriculum in the Australian Context

Curriculum integration resonates with the theorising of progressive educational luminaries John Dewey and Jerome Bruner who aspired to achieve a more coherent curriculum. However, there is 'a bewildering range of terms' associated with different approaches to curriculum integration (Dowden, 2007, p. 5), for example, *integrated*, *interdisciplinary*, *multidisciplinary*, *transdisciplinary*, *pluri-disciplinary* and *cross-disciplinary curricula*, to name a few. These terms are often used interchangeably, albeit inappropriately, given they signify different approaches for different rationales (Brady & Kennedy, 2007) and do not necessarily align with concept-based curriculum. Table 1 provides some generic descriptions of integrative approaches that are referred to in this chapter.

A commonality of these approaches is the attempt to make students' learning more connected as the Latin word *integrare* suggests. Gardner and Boix-Mansilla (1994) posit that multidisciplinary and transdisciplinary curricula are pre-disciplinary versions of integration. They argue that interdisciplinary work can only be truly implemented once students are somewhat conversant in the disciplinary perspectives—their distinct epistemological and methodological contributions. This usually does not occur until the secondary years of schooling, which resonates with the examples presented later in the chapter. But what ultimately distinguishes a concept-based curriculum from other attempts to integrate students' learning experiences is the explicit identification of a conceptual lens. As Lynn Erickson (2002) has noted, it is:

Table 1 Integrative approaches

Multidisciplinary	Linking subjects/disciplines by a theme or issue. No attempt is made to synthesise subject/discipline knowledge
Transdisciplinary	Planning commences with an issue, problem or topic, and a framework is established around concepts and a central idea or question. The fluidity of subject curriculum frameworks is emphasised
Interdisciplinary	Achieving a synergy by examining a theme topic, issue or problem through disciplinary-based perspectives (essential knowledge base, methods of inquiry and forms of communication)

Adapted from Godinho and Abbott (2011)

> [the] conceptual lens on a topic that forces thinking to an integration level … Without the focus concept, we are merely coordinating facts and activities to a topic, and fail to reach higher-level curricular and cognitive integration. (p. 63)

Kath Murdoch and David Hornsby (1997) argue that without a framework that defines the driving concepts and associated big ideas for a curriculum topic, students struggle to make connections across subjects and with their life experiences. They suggest it is akin to give students a jigsaw puzzle without the picture on the lid (Murdoch & Hornsby, 1997). Nayler (2014) asserts that with an integrated curriculum, concepts can be common to learning areas or overlap; alternatively, they may be derived from two or more learning areas or subjects but are complementary in meeting the needs of the specific learning context. Concepts are the connective thread for making sense of subject-specific content—knowledge fact coverage—and to synthesise personal experiences and learning from different disciplinary/subject perspectives, a process necessitating critical and reflective thinking that deepen learners' conceptual understanding. Essentially, it is the driving concepts and big ideas that 'join the dots' to provide a more holistic learning experience for students.

Concept-based curriculum integration involves planning that commences with establishing a topic or unit focus and proceeds outwards to the learning experiences through explicit identification of concepts and/or big ideas. Concepts may be drawn from the states and territories or the Australian curriculum frameworks. In some instances these are explicitly identified, as described in the next section. Or they may be identified by teaching teams as the lens for framing the big ideas associated with social or global issues that determine integrated curriculum topics when engaging with school-based curriculum development, as the case study examples reveal later in the chapter.

Topics generally relate to significant self and/or social issues—what Tina Blythe (1998) and the team from Project Zero refer to as 'generative topics'. This approach to curriculum design, illustrated in Fig. 1, acknowledges the dynamic relationships between curriculum, pedagogy, assessment and the learning environment/context.

Subject content relates to what is mandated in curriculum frameworks—the intended content. Decision-making around this content requires adaptation to be relevant to student's needs and consideration of their prior knowledge and experiences, the learning context and appropriate pedagogies. Students, as Garth Boomer (1982) insisted, need some agency in curriculum decision-making—opportunities to negotiate aspects of curriculum content, albeit teachers ultimately have the responsibility of delivering the curriculum and engaging the students with the intended content, undertaking assessments and mediating teacher-student interactions. The learning environment or context is also critical to curriculum making. Available resources, students' social and cultural backgrounds, curriculum frameworks and mandated assessments all influence what is taught and how it is taught.

Fig. 1 Curriculum planning dynamic

The implementation of a concept-based curriculum integration is dependent on what is termed *authentic pedagogy* or what Shirley Grundy (1998) refers to as the need for a *pedagogical view of the curriculum*. Authentic pedagogy emphasises active learning and constructivist perspectives that establish standards of intellectual quality rather than focussing on techniques or processes as the central target of teaching practices (Newmann, Marks, & Gamoran, 1996). The Queensland *New Basics* programme (Queensland Government Department of Education, Training and Employment, 2004) describes six characteristics with intellectual quality: *deep knowledge*, *higher order thinking*, *substantive conversation*, *metalanguage* and *problematic language*. As Ladwig asserts, 'putting curriculum to a pedagogical test requires understanding pedagogy as enacted curriculum' (2009, p. 276).

Yet integrative approaches to curriculum design in Australia continue to be perceived by many educators as alternative forms of curriculum organisation (Brady & Kennedy, 2007*)* that pose a risk of diluting or subsuming disciplinary knowledge. Catherine Harris and Colin Marsh (2007)—authorities on state and national curriculum frameworks—claim that attempts to integrate curriculum have failed consistently to get a lasting foothold. To gain insights into the issues and trends in designing and implementing concept-based curriculum in Australian schools, some snapshots of curriculum frameworks and their evolvement are now considered.

Situating Concept-Based Curriculum Within Australian Curriculum Frameworks

State and territory curriculum frameworks all endorse integrative curriculum. Yet it has been conceived very differently by the individual states. Tasmania, South Australia and Queensland's frameworks transcended traditional subject boundaries by defining 'essential learnings' and integrating subjects into this framework (Yates, 2011, p. 36). Although praised for their social equity focus and innovation in curriculum design, this transition of boundaries was contested by those who favoured didactic, subject/disciplinary teaching. The conflation of disciplines led to an outcry that the intellectual depth of the disciplines would be lost, but essentially assessment issues led to the demise of the Tasmanian *Essential Learnings* (ELs) innovation (Connor, 2011) and a very limited take-up of the Queensland *New Basics* (Queensland Government Department of Education, Training and Employment, 2004) curriculum framework.

Since the 1990s an increasing number of independent and government schools have taken up the International Baccalaureate's Primary Years Program (PYP) for children aged 3–12 years and the Middle Years Program (MYP), as alternative curriculum framework. Applying a spiral curriculum approach, key macroconcepts—form, function, causation, change, connection, perspective, responsibility and reflection—are revisited throughout students' schooling to deepen their level of understanding and provide the focus for all units of work.

From the mid-1990s onwards, however, reporting to outcomes has impacted on school-based curriculum innovations (Yates, Collins, & O'Connor, 2011). National testing, recording and reporting of students' attainment of standards, which commenced in 2008 with the National Assessment Programme—Literacy and Numeracy (NAPLAN) and the online publication of data on the *My School* website (ACARA, 2015), have undoubtedly further impacted the content and delivery of content in some schools. As the deputy principal of an Australian primary and secondary school commented:

> The emphasis on reporting student performance against standards and the fact that NAPLAN English and maths results really matter, means that teachers are feeling more pressure to foreground these areas at the expense of other curriculum areas such as our integrated units of work, which have traditionally had such a strong emphasis in our school. (Godinho, 2016, p. 247)

In a review of literature relating to the impact of high-stakes testing on students and their families by Polesel, Dulfer and Turnball (2012), evidence has emerged in the Australian context of a narrowing of the curriculum offered by schools. Wyn, Turnball and Grimshaw's study (2014) affirmed this finding, noting:

> there is a disconnect between the formal and inflexible style of NAPLAN and learning and teaching approaches that emphasise deep learning supported by student and teacher teamwork in a process that tailors learning to the student's needs. (p. 6)

As the Cambridge Review of Primary Education (Alexander, 2010) reported, curriculum breadth is incompatible with the relentless pursuit of standards in 'the basics'—numeracy and literacy. Likewise, international, meta forms of bench marking, for example, the Organisation for Economic Cooperation and Development (OECD), have influenced Australian educational policy and at the classroom level impacted curriculum and pedagogy.

Recently, the Australian curriculum, Assessment and Reporting Authority (ACARA) has sought to unify a somewhat fragmented state and territory approach to curriculum development by establishing a national curriculum. Essentially, this is a discipline-based curriculum, but ACARA (2013) does advocate cross-disciplinary learning and the use of integrative approaches and pedagogies, where appropriate, acknowledging that the twenty-first-century learning does not fit neatly into a curriculum solely organised by learning areas or subjects that reflect the disciplines. ACARA's scoping statement for the Australian curriculum gives teachers some autonomy with regard to engaging with integrated concept-based approaches.

> Schools are able to decide how best to deliver the curriculum, drawing on integrated approaches where appropriate and using pedagogical approaches that account for students' needs, interests and the school and community context. School authorities will be able to offer curriculum beyond that specified in the Australian Curriculum. (2013, p. 10)

While concept-based curriculum is not a term used within the Australian curriculum framework, references are made to concepts in all learning areas. Notably, very explicit references to macroconcepts are made in science and the humanities and social sciences learning areas. For example, in the Year 7 history subject (humanities and social sciences learning area), the framework states that the content provides opportunities to develop historical understanding through the key concepts—evidence, continuity and change, cause and effect, perspectives, empathy, significance and contestability—and connect to the broader enduring ideas that underpin humanities and social sciences. Similarly, in the science learning area, reference is made to opportunities for students to develop an understanding of important science concepts and processes from the first school year to Year 10, identifying six key ideas relating to the macroconcepts—patterns, order and organisation, form and function, stability and change, scale and measurement, matter and energy and systems.

Both in the science and the humanities and social sciences learning areas, the development of the concepts is confined to the learning area strands. This is a concept-based curriculum that has a discrete learning area focus and supports Alan Reid's (2011) argument that integrated curriculum will continue to be contested by the subject hierarchies. Ultimately, it is the reporting of assessment that is likely to drive teachers' planning, not the cross-curricular potential embedded in curriculum frameworks. As Yates et al. (2011) argue so poignantly, the intersection of curriculum initiatives and politics cannot be overlooked, impacting how curriculum is produced for Australian schools and how schools and teachers respond. This will be a key factor in determining how the states, who have their own curriculum authorities and frameworks, take up the newly developed Australian curriculum.

What Does the Research Indicate?

Writing in the *International Handbook of Curriculum Research*, Bill Green (2003) calls attention to the lack of Australian research on curriculum matters. In part, he attributes this to curriculum inquiry being a complex undertaking. Additionally, he argues that an enduring feature of Australian curriculum history is its bureaucratic and administrative character, subordinated by policies rather than a deep tradition of curriculum scholarship and empirical research. However, a very relevant Australian study of curriculum integration in the middle years of schooling that spanned a decade looked at reality over the rhetoric of curriculum integration (Wallace, Sheffield, Rennie, & Venville, 2007). Revisiting the nine schools that participated in the 1996 study in 2006, only five were still actively engaging with some form of curriculum integration. Four fundamental enabling conditions that sustained an integrated curriculum design were identified as:

- Shared purpose: administrative and community support
- Collegial relations: mutual sharing, assistance and joint effort among teachers
- Norms of improvement: commitment by teachers to improve practice
- Structure: flexible timetable, dedicated planning time, teaching space and resources

Conversely, the inhibiting conditions included community wariness of integrated approaches, teachers' allegiance to disciplinary traditions and structures, new staff coming on board with different perspectives on curriculum design, heavy workloads working and lack of planning time, timetabling restrictions and a lack of resourcing. But of particular note regarding enabling conditions was the existence of a small, stable learning environment—in effect the presence of a learning community.

These examples resonate with my own case studies (Godinho & Abbott, 2011; Godinho & Imms, 2011) that are discussed in the next section. In these studies, the complexity of designing curriculum frameworks and assessment for cross-disciplinary work (see also Boix-Mansilla & Gardner, 2008) are identified as key inhibiting factors to effective implementation of curriculum integration. Studies also identify the need for sustained ongoing professional development to support teachers with the planning processes (Godinho & Abbott, 2011; Shulman & Sherin, 2004; Wallace et al., 2007). In particular, Shulman and Sherin assert there is considerable intellectual challenge in developing conceptual understandings that cross their subject boundaries to create a connected, cohesive curriculum. This resonates with my own experience with the endeavours of both practising teachers and preservice teachers to articulate their big ideas/enduring understandings when designing integrated units of work.

Research has focussed on identifying different approaches to integration design (e.g. Wallace et al., 2007), but there is a noticeable lack of any recent substantive research that explicitly identifies the impact of cross-disciplinary approaches on teachers' knowledge and students' learning outcomes and how these might differ from discipline-based curriculum approaches.

Freebody and Muspratt (2007) note that the research deficit that exists around curriculum inquiry extends even more so for pedagogy. However, an ongoing study of the NSW/quality teaching model (Ladwig, 2009), which looks at pedagogies, including the intellectual quality of classroom practice, found that typical practice requires:

> fairly weak levels of intellectual demand for students, with very little higher order thinking, few students engaged in substantive communication on a regular basis and a central focus on key concepts or ideas typically clouded by peripheral or disconnected content. (p. 275)

Further, Ludwig noted the rarity of observing links being made to other contexts, or larger social purposes being made, leading to the conclusion that school curriculum is not consistent with *authentic pedagogy.*

In the USA, Stevens, Wineberg, Herrenkol and Bell (2005, p. 127) found that 'research is almost entirely descriptive (of programme, of theoretical approaches, of teacher lesson plans)'. Likewise, Venville (2010), referring to the Australian context, acknowledges that measuring learning outcomes other than content knowledge, which is likely to be more meaningful to an integrated curriculum, is frequently ignored by both teachers and researchers. He argues that integrative knowledge is often deemed 'soft'—subjective and open to debate. Yet in his own case study, he concluded that it was the integration of science with English, mathematics, art, technology and society and environment that provided the students with both powerful scientific knowledge and powerful values in social and civic responsibility. Such outcomes, however, are contingent upon a clearly identified conceptual lens to support connections across the disciplinary content of learning areas or subjects.

So within the context of curriculum frameworks and research, *how have educators interpreted and assessed learner outcomes of concept-based curriculum?* Drawing on snapshots of studies of implementation and personal experiences of professional learning and teaching, a tentative response to this question is now drawn.

Teachers' Beliefs and Perceptions of Concept-Based Curriculum Design

Given the multiple approaches to curriculum integration, the snapshot examples of concept-based integrative curriculum are taken from Australian primary and secondary schools where there has been continuity of their programmes over time and where teachers have a deep understanding of the associated pedagogies and guiding principles.

Primary Schools

Primary teachers, usually being generalists, rather than subject-specific teachers, are less inclined to be trapped within the subject/disciplinary boundaries. However, Kath Murdoch (2007), who has published educational resources and provided professional development for teachers around concept-based integrative curriculum for the past two decades, notes that the intention is more often to ‘cover’ curriculum rather than ‘uncover’ deep learning. Perhaps, this can be attributed to primary teachers not having a sufficiently deep understanding of the breadth of disciplinary concepts or time constraints when there are so many learning areas or subjects to address.

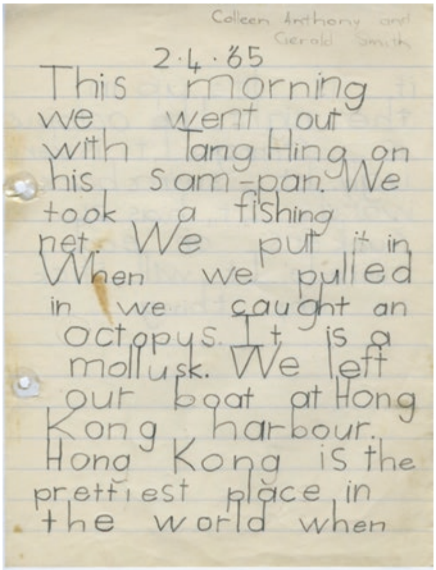
For some schools, electronic unit planners and/or templates have assisted teaching teams to engage with a concept-based curriculum. Inter@ct Schools, an online planning resource (Dressing & Green, 2012), provides teachers with a template that supports the development and implementation of a spiral curriculum around eight macroconcepts (identity, sustainability, social justice, creativity, community, change, necessity and curiosity) and produces prepared units of work that teachers can modify and refine for their own needs. Similarly, IB schools use a template to guide teachers in planning around the key concept/s that will focus the students’ learning experiences.

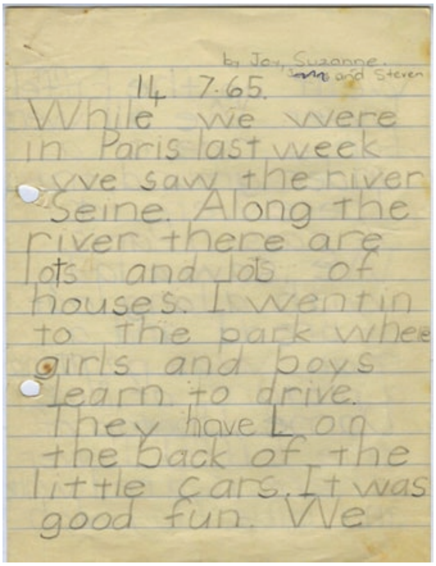
While teachers may claim online tools and IB templates assist their planning, curriculum content only becomes realised through teachers’ deep understanding of what students are required to learn and how productively students are engaged through the pedagogies they enact. This also applies to the use of published integrated units (e.g. Wilson & Wing Jan, 2003) or unit samples provided on websites (e.g. ACARA, 2013; Australian Academy of Science, 2016).

The importance of a *pedagogic curriculum* perspective (Grundy, 1998) is cogently illustrated in a retrospective study of a teacher’s approach to curriculum integration (Godinho & Imms, 2011). Drawing on this *multidisciplinary* example enacted over 45 years ago reveals that attempts to make learning connected and cohesive are not a recent phenomenon but have sustained their currency with progressive teachers.

In 1965, Margaret Richmond converted her classroom, situated in a government school and located at the coastal town of Devonport, Tasmania, into a ship sailing around the world. Each child was given a daily shipboard task, and the SS Discovery ‘visited’ countries in Asia, Europe, Africa and South America, with the children building models, creating artworks, reading stories and role-playing historical events relevant to each port visited.

Although concepts and big ideas were not documented explicitly, indicative of a *multidisciplinary* curriculum, and therefore this could be perceived as a weakness of Margaret’s approach, a genuine attempt was made to make learning more connected and relevant to these children’s lives through crossing subject/disciplinary divides by using the conceptual lens of place and space, change, customs and rituals.


Colleen Anthony and Gerald Smith
2.4.65
This morning we went out with Tang Hing on his sam-pan. We took a fishing net. We put it in. When we pulled in we caught an octopus. It is a mollusk. We left our boat at Hong Kong harbour. Hong Kong is the prettiest place in the world when


by Joy, Suzanne, and Steven
14.7.65.
While we were in Paris last week we saw the river Seine. Along the river there are lots and lots of houses. I went in to the park where girls and boys learn to drive. They have L on the back of the little cars. It was good fun. We

The rare opportunity to interview five former students revealed that the rigour of the learning and the engagement level in this class provided strong foundations for their primary years. Analysis of work samples according to current ACARA Achievement Standards for English in Year 3 showed that English literacy practices were enriched, not diluted by her rich pedagogies. Writing samples showed that while studying geography, humanities and the arts, the Year 2 students were acquiring knowledge about the English language, developing an appreciation of literature and building a repertoire of English usage which inspired them to write fluently, creatively and confidently. This experience differs from recent observations of integrated studies in primary classes, where curriculum integration is generally relegated to the afternoon classes with no attempt to explore concepts as part of the numeracy and literacy blocks when relevant to do so; thus, learning remains fragmented rather than holistic.

When pressed to theorise her approach to teaching, Margaret Richmond insisted 'What is most important is the relationship you have with each child. I was always devising ways to interact with each individual child'. This primary connection with the children accords with Fig. 1 that places the students at the centre of the curriculum planning dynamic Margaret expressed gratitude that in this period, there were not the curriculum constraints and mandatory high-stakes testing, giving her the freedom to develop school-based curriculum that was relevant and meaningful and met the children's learning needs. These comments resonate with those of Dr Pasi Sahlberg, Director General, Ministry of Education, Finland, who attributes his country's sustained success in the OECD's PISA ranking, in part, to empowering teachers to engage in school-based curriculum making and having, what he terms *trust-based responsibility* before *test-based accountability* (Sahlberg, 2012).

Importantly, the case study reveals a focus on what students are actively and cognitively doing when using conceptual learning: productively gathering and analysing information, reviewing new information against existing knowledge, seeking connections and relations between ideas, noticing patterns and throughout this process refining, deepening or modifying existing concepts and building new ones.

The rationale and approach taken by Ringwood Heights Primary School in Victoria affirm the effectiveness of a school-based curriculum that is integrated and concept based. With a reputation as a lighthouse school for its curriculum integration programmes, the deputy principal and special education teacher introduced an integrated unit with several groups of low-achieving literacy students, using a web resource, *The Venom Patrol* (The University of Melbourne, 2011). The resource, developed around venomous animals and the prevention and treatment of their bites and stings, resonated with the students who were able to draw on their personal experiences with venomous animals to deepen their understanding of the concepts' cause and effect. This generated engagement not only with the science content knowledge but with the development of multiliteracy skills required for processing information and transforming their new knowledge into presentation format to show their peers (Molyneux & Godinho, 2012). The range of multimodal literacy activities included:

- Screen-based text reading of the venom rating chart to identify a dangerous or deadly animal.
- Identifying the main idea and then adding details to create a descriptive profile of the animal.
- Participating in the quiz 'Amazing Facts about Venomous Animals' that required students to read the venom rating data chart, use the resource's glossary and hyperlink between screen sites to locate information.
- Producing PowerPoint presentations about *The Venom Patrol* for others to access. In some instances, students incorporated filmed interviews and comments about their own experiences with venomous animals (Fig. 2).

What was evidenced was 'the holistic nature of multimodal literacy' (Walsh, 2011, p. 29) afforded by a powerful digital media resource. This enabled students to investigate, research, record and create emphasising the integral relationship between science and literacy. Like Margaret Richmond, the staff at Ringwood Heights Primary School also saw the potential of rich content and concepts that were relevant and connected with their students' lives as the impetus for developing essential literacy skills. It was the conceptual lens of cause and effect that facilitated the curriculum connections and assisted in deepening the students' understanding of venomous animals. Moreover, these concepts fostered interdisciplinary skills such as curiosity, collaboration, communication and the justification of new information, time management, responsibility, sense of purpose, persistence and reflection, ownership and self- and peer assessment all of which are transferable when researching other topics. Such interdisciplinary skills build more effective and efficient learners

Fig. 2 *The Venom Patrol* home page

in crowded curricula at the primary level or subject teaching at secondary level which is atomised.

Secondary Experiences

Despite curriculum integration being considered firmly on the middle school reform agenda to address disengagement (Beane, 2006; Wallace et al., 2007), in Australian secondary schools, it is often a one-off special event, for example, introduced for one school term in Year 9 or a study of life in the city for one week of the school year. Unlike the primary years, where models of integration have been developed and guidance around the planning of integrated unit and the use of rich pedagogies provided (Murdoch & Hornsby, 1997; Pigdon & Woolley, 1992; Wilson & Wing Jan, 2003), this level of support is notably absent at the secondary level (Dowden, 2007).

Toni Dowden's (2007) investigation of challenging, integrative exploratory curriculum design for middle-level schooling in Australia noted that in the 1990s, Pigdon and Woolley (1992) and Murdoch and Hornsby (1997) developed an integrative curriculum model that provided an explicit focus on concept-based teaching and learning. In this inquiry-focussed model, content knowledge is drawn from a host subject. The key concepts and big ideas that connect with the host subject's content are then identified, enabling authentic connections to be made with other subjects (learning areas) and grounding the planning of learning experiences. Their influential work included advice on planning units of work and developing rich pedagogies but was oriented to primary schooling.

Further, resistance to curriculum integration can be more intense in secondary schools where subject teachers view discipline knowledge as sacrosanct to their subjects. Such attitudes can lead to a gatekeeper's role, with teachers safeguarding their subject's disciplinary knowledge, wanting to ensure it is not devalued, diluted or subsumed. Not surprisingly, little is known about the learning that occurs when the theorising of integrating disciplines meets with practice or with student responses to this way of learning.

With this context in mind, the planning of a cross-disciplinary unit, *Reality Bites*, undertaken by a Year 8 teaching team in a large independent school in the state of Victoria is discussed. Teachers from four disciplines—English, science, religious studies and multimedia—were allocated 9 h of planning time to map how the concept of reality would play out in their subject-based lessons. What this example reveals is how the focus on an overlapping concept can safeguard disciplinary content knowledge from being subsumed or diluted and in effect disrupt disciplinary teachers' territoriality. The teachers described their unit as *transdisciplinary*, but the focus on the disciplinary lens of the subjects is commensurate with an *interdisciplinary* design.

The planning was mediated and facilitated by an educational consultant, Dr Julie Landvogt, termed by the teachers as 'an outsider with an insider relationship', who also provided ongoing support during implementation. As one teacher noted, the planning meetings enabled us 'to wrestle with what reality was' and frame questions to focus the planning of the learning experiences for each subject (Table 2).

Some outcomes of this cross-disciplinary approach to planning are evidenced in the students' comments about shifts in their conceptualisation of reality:

> Science doesn't interest me personally but when they bring in stuff like that it forces you to think … it pushes you to your limit and you think hang on there could be something I am not thinking about. And in a way it forces you to learn even if you don't want to.
>
> There was this one idea in the science lesson that blew me away … The idea that we have become so conditioned to only believing what we already know and what we are used to seeing that our brain has become insensitive to things we haven't seen before.
>
> Thinking back to what Henry said, we discard things that don't fit the pattern that we are used to … I think that's why people like Kristov started to get so worried when Truman didn't fit the patterns of reality they had set.

It was the *pedagogical view of the curriculum* taken by English teachers and their focus on a dialogic pedagogy or what Robin Alexander (2008) refers to as *learning talk* that enabled students to start considering reality from a disciplinary perspective in their English classes. These teachers dedicated class time to exploring ideas, providing examples and seeking clarification of each other's ideas to enable *cognitive advancements* (Miller & Boix-Mansilla, 2004) to occur. Thoughtful questioning and probing of students' thinking scaffolded a discussion orientation to learning and focussing on characteristics associated with intellectual quality: *deep knowledge*, *higher order thinking*, *substantive conversation*, *metalanguage* and *problematic language*.

Table 2 Subject framework for planning the learning experiences

Subject	Key question	Supplementary questions	Making connections
English	What is it to be human?	How real was Truman? What did we learn from this about the reality of human lives?	How might these ideas be connected to the idea of reality?
Science	What is real and how do we know? How do we know about things in the world that we cannot see?	How can you prove something beyond doubt? What methods do scientists use to establish reality?	How did Truman use scientific method to real the truth/reality of his world existence at Seahaven?
Religious education	What is reality and how can we be sure?	What is meant by freedom? What is the meaning of lie? What is meant by morality and ethics?	What links can be made between your understanding of these terms and what you know of Truman's life?
Multimedia	Is there more to media than meet the eyes?	What roles do the media play in shaping our reality and what we perceive to be real? Do the media always tell the truth? How can we be sure?	To what extent are we all 'Trumanised' by the media?

The high levels of student engagement a curriculum integration approach can stimulate have influenced the design of the emergent approach known as *Learning through Country* programmes (Fogarty, 2010) for secondary students in remote indigenous communities. These programmes recognise indigenous land and sea management as localised learning opportunities and as an employment pathway. Curriculum is framed around the concept of biodiversity with students working on projects with local indigenous rangers and elders that connect learning and employment with caring for country. Projects include spider diversity and abundance, crocodile egg collecting, patrolling of foreign fishing vessels, buffalo disease monitoring, longneck turtle protection and harvesting of turtle eggs.

William Fogarty and Robert Schwab (2012) note that *Learning through Country* programmes support the development of science concepts in the areas of biology and environmental sciences while also emphasising the explicit teaching of English literacy and numeracy skills. They argue that 'direct instruction' models which target the basics of literacy and numeracy disregard the research evidence (e.g. Catts & Gelade, 2002; Gelade & Stehlik, 2004; Miller, 2005) that indigenous students learn best when learning has immediate or localised utility and is connected to their life experiences.

Building on the *Learning through Country* project work undertaken at the Maningrida School—a remote Northern Territory community school 550 km east of Darwin—an interdisciplinary team from the University of Melbourne has worked with teachers and students to use and transform their 'on-country' knowledge to

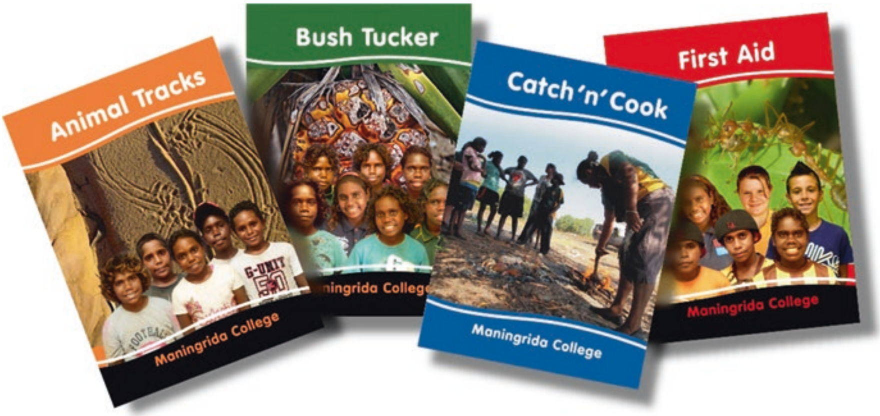


Fig. 3 Pocket books authored by Maningrida College students

develop their visual and written literacy skills. A series of some small pocket books, shown in Fig. 3, adaptable for ecotourism purposes, were produced: *Bush Tucker*, *Cath 'n' Cook*, *Animal First Aid* and *Animal Tracks*, revealing the positive outcomes that can be achieved with a concept-based, curriculum integration approach. Adopting a continued improvement model, further curriculum documentation is being undertaken to encourage students to reflect on and make explicit links between the key concepts of food gathering and consumption, human health and safety and environmental management and sustainable biodiversity in order to provide assessable evidence of deep learning.

Notwithstanding the positive outcomes identified in these snapshots, the implementation of concept-based, curriculum integration is not without its challenges and issues, which accounts for this approach to design and pedagogy not gaining a strong foothold in Australian curriculum (Harris & Marsh, 2007). Some of the challenges and issues that have emerged from the case study examples, recent research and my practical experience are now discussed.

Challenges and Issues

So what have I learned from the research findings and practical experiences when working with practitioners in schools?

Assessment

In the UK, the Cambridge Review of Primary Education (Alexander, 2010) reported that curriculum breadth is incompatible with the pursuit of standards in 'the basics'—numeracy and literacy. Government policies for the past decade have stressed more time be spent on literacy and numeracy, which has led to an increasing emphasis on standardised assessment and teacher accountability for student outcomes rather than focussing on curriculum design. This narrowing of the curriculum works against school-based curriculum making and concept-based curriculum integration attempts.

A major challenge for integrative concept-based curriculum is teachers' comfort level with the efficacy of assessment practices. Veronica Boix-Mansilla and Gardner (2008) from the Harvard Graduate School of Education refer to assessment as the 'Achilles heel' of interdisciplinary education, resonating with the teachers' experiences with the *Reality Bites* unit. Questions asked by the teaching team included 'How does one actually assess across the subject areas?' and 'How does the performance of learning across disciplines transfer to a report grade?' In the primary school, assessment is generally less of an issue as teachers are more conversant with working across the disciplines and designing tasks that assess several learning areas, viewing this as strategic practice. But without an endpoint assessment destination in mind, 'any old road will get you there' as Wiggins and McTighe argue (2005, p. 14). Defining the assessment first means that learning experiences can then be planned accordingly.

A *backward design* (Wiggins & McTighe, 2005) approach required by the IB's PYP and MYP planners, where planning of the assessment is undertaken prior to planning the learning experiences, is a sound starting point. But there is no silver bullet—a one-size-fits-all approach to assessment for curriculum integration. It is indeed challenging to create a summative assessment task that is respectful of the disciplines and embraces the concept of interdisciplinary learning (Godinho & Abbott, 2011) which will reveal whether or not learning outcomes/goals were achieved, in addition to undertaking formative, ongoing student assessments. Regardless of good planning, the endpoint assessment can be short-changed given time issues both at primary and secondary levels, such as activities taking longer than anticipated and unforeseen circumstances.

The challenge for teachers is to ensure that appropriate assessment is thoughtfully planned and implemented. But more importantly, the reporting of assessment should not be at the expense of achieving cross-curricular potential, a risk that Yates et al. (2011) have identified. The experience of Queensland's *New Basics* project is a reminder that assessment must not become too complex. Here the *Rich Tasks* that formed the assessment of students' learning dominated and de-emphasised the focus on highly innovative curriculum and pedagogical approaches (Weir, 2005) that supported a concept-based integrated curriculum.

Whole-School Approach

Another major challenge is developing a school culture that embraces concept-based, curriculum integration. For primary schools such as Ringwood Heights Primary School, curriculum integration is a whole-school approach that has been sustained over many years. There is a scope and sequence of units audited against state curriculum frameworks to ensure a balanced spread of topics and development of key concepts. Likewise, the IB approach to curriculum planning rigorously monitors and records the *transdisciplinary* units at each year level. Subsequently, teachers are familiar with the theorising of curriculum integration and planning around concepts, big ideas and the associated pedagogies.

The continuity of approach across year levels means that students and staff become enculturated into the expectations around this way of working. While the teachers of the *Reality Bites* unit were very vocal about safeguarding this way of planning, at present, it is but 'an island within the organisation'. Unless concept-based curriculum integration is embedded as a school-wide approach, it is unlikely to be sustained over time—the reified positioning of subject-based curriculum (Harris & Marsh, 2007) winning out. A major weakness of the *Learning through Country* programme in Maningrida is the dependence upon the commitment and drive of a particular teacher with an interest in science and strong cultural community connections (Fogarty & Schwab, 2012).

Additionally, a potential issue for schools is the intellectual challenge of developing a conceptual framework and defining the big ideas (Shulman & Sherin, 2004). There must be ongoing school commitment to dedicate the time needed for developing and augmenting the conceptual framing of units. With subject-based teachers in the secondary level, opportunities for sustained dialogue to share knowledge and experiences and to grapple with tensions around disciplinary/subject ways of communicating, inquiring and pedagogies are essential.

Disciplinary Knowledge and Pragmatics

Harvard studies of interdisciplinary learning (Boix-Mansilla & Gardner, 2008; Boix-Mansilla, Miller & Gardner, 2000; Nikitina, 2002) advocate it is best implemented when teachers have expertise across the subjects. This is unusual in Australian secondary schools where teachers specialise in one or two disciplines. Planning is at team level but lessons are generally taught at subject level, which means teachable moments are not always optimised when disciplinary knowledge is required. The reality of teachers having majors in science and arts is unlikely, but the deepening of disciplinary connections can be but imagined if this was the case for these students participating in the *Reality Bites* unit.

For example, despite students making a cognitive advancement in their conceptualisation of reality in the *Reality Bites* unit following viewing a film clip in their science lesson, there was fuzziness in the students' expression of scientific concepts. Their English teachers understandably did not feel confident to scaffold the development and advancement of their students' scientific thinking (Godinho & Abbott, 2011) as they struggled to grasp the underpinning quantum physics that explained the phenomenon of reality. Studies of integrating science in the middle years (Years 5–9) have found that integration can lead to students retaining naïve understandings because misconceptions are not addressed or mediated (Venville, 2010; Wallace et al., 2007). This signals a need for beginning a unit with specific content subjects such as science and its technical concepts and language, as the primary models have emphasised (e.g. IB, 2007; Murdoch & Hornsby, 1997; Wilson & Wing Jan, 2003). This is an essential consideration given the anxiety around curriculum coverage of content and student achievement of standards.

While teachers may actively engage with the planning, it is well documented that planning is not always consistent with the reality of what is lived in the classroom (Elmore, 2006; Fullan, 2003; Rennie & Wallace, 2009). There is, as Yates, Collins and O'Connor state, 'a considerable gap between curriculum ambitions and curriculum practice' (2011, p. 5). Despite the planning team's intellectualisation of 'reality', seldom were disciplinary connections made explicit. Pragmatics also impacted the disciplinary connections with the timing of exams that meant the number of dedicated science lessons in the *Reality Bites* unit was reduced considerably. Time is of course an ongoing challenge from the planning phase to implementation, and this is exacerbated when working across unrelated disciplines.

A Dialogic Pedagogy

For discussion of concepts and big ideas, a dialogic pedagogy is imperative to support, extend, elaborate and deepen students' conceptual thinking. While questioning is often used effectively as a pedagogical tool, the explicit actions and practices associated with dialogue, such as active listening, building on ideas, clarifying statements and asking for elaboration, are less frequently enacted. The processing of ideas necessitates supportive teacher input so that when coupled with the cumulative way students build on each other's ideas coherent lines of thinking can then develop.

Discussion around big ideas is core business in the Humanities and Arts-based subjects according to Alexander, (2008). Yet not all teachers are skilful in mediating student interactions. This may be due to a teacher's individual pedagogical practices but also to a discipline's way of communicating knowledge and the history of its pedagogy (Godinho & Abbott, 2011). It is well documented that transforming practices, such as classroom talk that is always directed through the teacher, take considerable time (Alexander, 2008).

An issue for some students with a dialogic teaching approach is they grapple with recognising the value of dialogue as opposed to written tasks. Students participating in the *Reality Bites* unit commented on the dilemma of transferring complex thinking that emerged from discussions on to paper: ‘it was too hard to write what you have experienced in your head [and to] condense it into two sentences’. A dialogic approach takes time to become part of an embedded classroom cultural practice where the students and teachers apply the talk patterns associated with dialogic teaching and recognise its value.

Moving Forward: Recommendations

With an expanding curriculum focus, particularly evidenced in the Australian curriculum, a conceptual lens means it is strategic for teachers to see how authentic conceptual connections can be made across learning areas or subjects. Nayler (2014) has identified that in Years 3–4 and Years 5–6, there are 15 and 16 curriculum areas to address, respectively. However, identification of the challenges and issues that the case study schools experienced has particular relevance in light of the autonomy ACARA gives teachers for implementing integrated approaches. As discussed, not all integrated approaches have equal merit. This suggests some guidelines are needed to support educators when determining the capacity of an approach and identifying what constitutes an integrative concept-based curriculum. Characteristics would include:

- A conceptual lens (the big/key ideas, issues, problem) and inquiry focus that connect the curriculum learning areas and gives meaning to facts and skills
- Overarching questions to assist students to engage with the key conceptual lens
- Targeted curriculum standards for the learning areas or foci to be targeted
- Planning for the collection of evidence of student learning both during and at the endpoint of a unit
- Clearly defined performance tasks that make the assessment criteria explicit
- A planned sequence of experiences that takes into consideration the students’ learning context—their specific needs and interests

Importantly, generic guidelines would support teachers in making judgements about the wide range of integrated units make available to schools and educators by ACARA, state curriculum authorities, teaching associations, commercial publishers and online web-based electronic versions.

Further, given the complexity of the integrative design, it is recommended that novices seek some ongoing professional support, as was accessed in several of the cases studies. Teachers need support and guidance when planning and implementing a unit and determining the pedagogical approaches that will best facilitate conceptual learning. This includes engaging with learning talk—dialogic pedagogy (Alexander, 2008)—so critical for building deep conceptual understandings.

Essentially, there is a pressing need for classroom-based research of concept-based integrative curriculum in Australian schools to describe and clarify effective planning practice and pedagogies, including the IB’s PYP and MYP approaches that are gaining popularity as an alternative curriculum. While ACARA acknowledges that the twenty-first-century learning does not fit neatly into a curriculum solely organised by learning areas or subjects that reflect the disciplines, data is needed on how teachers are moving beyond the single subject learning area boundaries to deepen students' thinking and understanding through common or complementary concepts.

Conclusion

There are many different approaches and rationales for concept-based integrated curriculum in Australian schools. Yet the highly innovative state curriculum frameworks such as Queensland's *New Basics* and Tasmania's *Essential Learnings* which seek to move beyond the disciplinary subject-based structure are testimonies that integrative approaches to curriculum design continue to be contested and undermined by the *subject hierarchies* (Reid, 2011).

Concept-based, integrative curriculum has had more leverage in Australian primary schools. In part, this positioning can be attributed to quality teacher resources being developed to guide teachers in whole-school approaches (Dowden, 2007). Despite the championing of curriculum integration as a middle school strategy to re-engage students with learning, its adoption in secondary school has been piecemeal—one-off programmes. While these individual school programmes demonstrate perceived benefits for secondary students, rarely is integration adopted as a whole-school approach. This is courtesy of the reified positioning of subject-based curriculum and the challenges and pragmatics of implementation frequently overriding their sustainability.

With a highly prescriptive learning sequence for the disciplines at each year level in the recently developed Australian curriculum, there is a risk of even further reducing the opportunities for students to engage in more contextual, issue-based and applied learning that does not fit within the boundaries of the traditional disciplines (Wallace et al., 2007) both at primary and secondary level. Indeed, with a focus on concepts and key ideas in the learning areas of humanities and social sciences and science, what may emerge is more emphasis on disciplinary concept-based curriculum, rather than the integrative approaches, that the Australian curriculum indicates teachers may choose to use when appropriate.

Yet as the Australian experience has demonstrated, within a range of school settings, there are concept-based, integrative programmes that are inspirational. They continue to serve as reminders of the quality learning outcomes that can be achieved by concept-based curriculum approaches. Given the current emphasis placed on Australia's OECD's PISA rankings, perhaps Sahlberg's (2012) assertion that a factor in Finland's sustained high rating is the empowering of their teachers to engage in school-based curriculum making will resonate with Australia's curriculum authorities and policymakers. Curriculum design will always be open to innovation, and ultimately it is people who are the major determinant of a programme's success or failure (Fullan, 2003; Venville et al., 2002): teachers, students and school leadership teams. Importantly, regardless of what is prescribed as curriculum content and its incumbent processes and strategies, it remains 'intended'. Concept-based curriculum only becomes 'realised' through teachers' deep understanding of what students are required to learn and how productively students are engaged through the pedagogies teachers enact.

References

Alexander, R. (2008). *Essays on pedagogy*. London: Routledge.

Alexander, R. (Ed.). (2010). *Children, their world, their education. Final report and recommendations of the Cambridge primary review*. Abingdon, UK: Routledge.

Andersen, P., & Oerlemans, K. (2011). Curriculum change: The context for the development of the Tasmanian essential learnings curriculum. In L. Yates, C. Collins, & K. O'Connor (Eds.), *Australia's curriculum dilemmas: State cultures and the big issues* (pp. 66–85). Melbourne, Australia: Melbourne University Press.

Australian Academy of Science. (2016). *Primary connections*. Retrieved from https://primaryconnections.org.au/

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2011). Retrieved from http://www.acara.edu.au/curriculum.html

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2012). *Alternative curriculum recognition*. Retrieved from http://www.acara.edu.au/curriculum/alternative_curriculum_recognition.html

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2013). *The shape of the Australian curriculum version 4*. Retrieved from http://www.acara.edu.au/verve/_resources/the_shape_of_the_australian_curriculum_v4.pdf

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2015). *My school*. Retrieved from https://www.myschool.edu.au/

Beane, J. (2006). *Middle years curriculum: From rhetoric to reality* (3rd ed.). Melbourne, Australia: Hawker Brownlow.

Blythe, T. & Associates. (1998). *The teaching for understanding guide*. San Francisco, CA: Jossey Bass Publishers.

Boix-Mansilla, V. (2004). *Assessing student work at disciplinary crossroads*. Harvard University Goodworks® Project Report Series, Number 33.

Boix-Mansilla, V., & Gardner, H. (2008). Disciplining the mind. *Educational Leadership, 65*(5), 14–19.

Boix-Mansilla, V., Miller, W., & Gardner, H. (2000). On disciplinary lenses and interdisciplinary work. In S. Wineberg & P. Grossman (Eds.), *Interdisciplinary curriculum: Challenges to implementation* (pp. 17–38). New York, NY: Teachers College Press.

Boomer, G. (1982). *Negotiating the curriculum: A teacher-student partnership*. Sydney, Australia: Ashton Scholastic.

Brady, L., & Kennedy, L. (2007). *Curriculum construction* (3rd ed.). Sydney, Australia: Pearson Australia Group Pty. Ltd.

Catts, R., & Gelade, S. (2002, April). *Rhetorics and realities: Equating the delivery of Indigenous VET to the demands of its context: Commonalities from two research projects*. Australian Vocational Education and Training Research Association Conference, Melbourne.

Connor, J. (2011). Why curriculums fall over. In L. Yates, C. Collins, & K. O'Connor (Eds.), *Australia's curriculum dilemmas: State cultures and the big issues* (pp. 261–265). Melbourne, Australia: Melbourne University Press.

Dowden, T. (2007). Relevant, challenging, integrative and exploratory curriculum design: Perspectives from theory and practice for middle level schooling in Australia. *Australian Educational Researcher, 34*(2), 51–71.

Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum*. ASCD: Alexandria, Egypt.
Dressing, A., & Green, K. (2012). *Inter@ct schools: Transforming the potential*. Retrieved from http://www.interactschools.com/
Elmore, R. (2006). *Improvement of teaching at scale*. Math Science partnership learning network conference. Retrieved from http://media.mspnet.org/conferences/06lnc/06relmore/transcript/index.htm
Erickson, L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press Inc.
Erickson, L. (2007). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press Inc.
Fogarty, W. (2010). *Learning through country: Competing knowledge systems and place based pedagogy*. PhD thesis, CAEPR, ANU, Canberra.
Fogarty, W., & Schwab, R. (2012). *Indigenous education: Experiential learning and learning through country* (CAEPR working paper No. 80/2012). Centre for Aboriginal Economic Policy Research, ANU College of Arts and Social Sciences. Retrieved from http://caepr.anu.edu.au/Publications/WP/2012WP80.php
Freebody, P., & Muspratt, S. (2007). Beyond generic knowledge in pedagogy and disciplinarity: The case of science textbooks. *Pedagogies: An international journal, 2*(1), 35–48.
Fullan, M. (2003). *Change forces with a vengeance*. London: RoutledgeFalmer.
Gardner, H., & Boix-Mansilla, V. (1994). Teaching for understanding in the disciplines: And beyond. *Teachers College Record, 96*(2), 198–218.
Gelade, S., & Stehlik, T. (2004). *Exploring locality: The impact of context on indigenous vocational education and training aspirations and outcomes*. Adelaide, Australia: National Centre for Vocational Education Research.
Godinho, S. (2016). Planning for practice: Connecting pedagogy, assessment and curriculum. In R. Churchill, S. Godinho, N. Johnson, A. Keddie, W. Letts, K. Lowe … M. Vick (Eds.), *Teaching making a difference* (3rd edn, pp. 254–295). Milton, Australia: Wiley.
Godinho, S., & Abbott, C. (2011). The challenges of interdisciplinary learning: Reality Bites. *Learning and Teaching, 4*(2), 5–22.
Godinho, S., & Imms, W. (2011). Voyage of SS discovery and the Truman show: Case studies of integrative approaches to bridging the disciplinary divide. *Curriculum and Teaching, 26*(1), 87–107.
Green, B. (2003). In W. Pinar (Ed.), *International handbook of curriculum research* (pp. 123–141). Mahwah, NJ: Lawrence Erlbaum Associates.
Grundy, S. (1998). The curriculum and teaching. In E. Hatton (Ed.), *Understanding teaching* (2nd ed.). Sydney, Australia: Harcourt Brace.
Harris, C., & Marsh, C. (2007, July 6–10). *SOCE curriculum structure: Where to now?* Paper presented at the biennial conference of the Australian Curriculum Studies Association, Melbourne.
International Baccalaureate Organization. (2007). *Making the PYP happen*. Geneva, Switzerland: IBO.
Kincheloe, J., Slattery, P., & Steinberg, R. (2000). *Contetualizing teaching: Introduction to education and educational foundations*. New York: Longman.
Ladwig, J. (2009). Working backwards towards curriculum: On the curricular implications of *Quality Teaching. Curriculum Journal, 20*(3), 271–286.
Miller, C. (2005). *Aspects of training that meet Indigenous Australians' aspirations: A systemic review of research*. Adelaide, Australia: National Council for Vocational Education Research.
Miller, M., & Boix-Mansilla, V. (2004). *Thinking across perspectives and disciplines*. Retrieved from http://pzweb.harvard.edu/interdisciplinary/pdf/Miller-VBM_ThinkingAcross_2004.pdf
Molyneux, P., & Godinho, S. (2012). "This is my thing!": Middle years students' engagement and learning using digital resources. *Australasian Journal of Educational Technology, 28*(8), 1466–1486.

Murdoch, K. (2007). Journeying towards an integrative curriculum. *Curriculum Perspectives, 27*(1), 67–70.
Murdoch, K., & Hornsby, K. (1997). *Planning curriculum connections: Whole school planning for integrated curriculum*. Melbourne, Australia: Eleanor Curtain.
Nayler, J. (2014). *Enacting Australian curriculum: Making connections for quality learning*. Issues paper prepared for the Queensland Studies Authority. Retrieved from https://www.qcaa.qld.edu.au/downloads/p_10/ac_enact_ac_paper.pdf
Newmann, F., Marks, H., & Gamoran, A. (1996). Authentic pedagogy and student performance. *American Journal of Education, 104*(4), 280–312.
Nikitina, S. (2002). *From a community of people to a community of disciplines: The art of integrative humanities at St Paul's School* (Goodwork® Project, Project Zero). Cambridge, MA: Harvard Graduate School of Education.
Pigdon, K., & Woolley, M. (Eds.). (1992). *The big picture: Integrating children's learning*. Perth, Australia: Eleanor Curtain Publishing.
Polesel, J., Dulfer, N., & Turnball, M. (2012). *The experience of education: The impacts of high stakes testing on school students and their families: An educator's perspective*. Literature review. Whitlam Institute, The University of Western Sydney. Retrieved from http://www.whitlam.org/__data/assets/pdf_file/0010/409735/High_Stakes_Testing_An_Educators_Perspective.pdf
Queensland Government Department of Education Training and Employment. (2004). Retrieved from http://education.qld.gov.au/corporate/newbasics/
Reid, A. (2011). The influence of curriculum pasts on curriculum futures: A South Australian case study. In L. Yates, C. Collins, & K. O' Conor (Eds.), *Australia's curriculum dilemmas: State and cultures and the big issues* (pp. 45–65). Melbourne, Australia: Melbourne University Press.
Rennie, L., & Wallace, J. (2009). Disciplinary versus integrated curriculum. Issue 10, *The New Critic*, The University of Melbourne.
Sahlberg, P. (2012). A model system: School education in Finland. *The University of Melbourne Voice, 8*(10), 5.
Shulman, L., & Sherin, M. (2004). Fostering communities of teachers as learners: Disciplinary perspectives. *Journal of Curriculum Studies, 1*(2), 135–140.
Stevens, R., Wineberg, S., Herrenkol, L., & Bell, P. (2005). Comparative understanding of school subjects: Past, present and future. *Review of Educational Research, 75*(2), 125–157.
The University of Melbourne, (2011). *The Venom Patrol.* Retrieved from http://venompatrol.info/
Venville, J. (2010). Disciplinary versus integrated knowledge: The challenge for school science. *The New Critic*, p. 10. Retrieved from http://www.ias.uwa.edu.au/new-critic/ten/venville
Venville, G. J., Wallace, J., Rennie, L. J., & Malone, J. A. (2002). Curriculum integration: Eroding the high ground of science as a school subject. *Studies in Science Education, 37*, 43–84.
Victorian Curriculum and Assessment Authority. (2009). *Victorian essential learning standards*. Retrieved from http://vels.vcaa.vic.edu.au/support/crosscurricular/index.html
Victorian Essential Learning Standards. (2010). *List of sample units*. Retrieved from http://vels.vcaa.vic.edu.au/support/units/units.html
Wallace, J., Sheffield, R., Rennie, L., & Venville, G. (2007). Looking back, looking forward: Re-searching the conditions for curriculum integration in the middle years of schooling. *The Australian Educational Researcher, 34*(2), 29–49.
Walsh, M. (2011). *Multimodal literacy: Researching classroom practice*. Newtown, Australia: Primary English Teaching Association (e:lit).
Weir, K. (2005). *The discourse of reform: A critical analysis of the New Basics curriculum*. Refered paper presented at ACSA the Biennial Conference 21–23 September, University of Sunshine Coast, Queensland.
Wiggins, G., & McTighe, J. (2005). *Understanding by design* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.
Wilson, J., & Wing Jan, L. (2003). *Focus on inquiry*. Melbourne, Australia: Curriculum Corporation.

Wyn, J., Turnbull, M., & Grimshaw, L. (2014) *The impact of high stakes testing on schools, students and their families: A qualitative study*. Whitlam Institute, The University of Western Sydney. Retrieved from https://www.whitlam.org/__data/assets/pdf_file/0011/694199/The_experience_of_education_-_Qualitative_Study.pdf

Yates, L. (2011). Re-thinking knowledge, rethinking work. In L. Yates, C. Collins, & K. O'Connor (Eds.), *Australia's curriculum dilemmas: State cultures and the big issues* (pp. 25–44). Melbourne, Australia: Melbourne University Press.

Yates, L., Collins, C., & O'Connor, K. (2011). Curriculum in Australia: The challenges, the past and the future. In L. Yates, C. Collins, & K. O'Connor (Eds.), *Australia's curriculum dilemmas: State cultures and the big issues* (pp. 309–326). Melbourne, Australia: Melbourne University Press.

Developing Science Curriculum for Gifted Learners in South Korea

Hae-Ae Seo

Background of Curriculum Development in Gifted Education in Korea

Curriculum for the gifted learners in Korea is supposed to be differently designed and implemented depending on different gifted educational institutions under the guidance of individual provincial offices of education.[1] General guidelines and directions for curriculum development of gifted education have been prepared at national level and recommended for gifted educational institutions to implement at regional level. The guidelines were mainly developed by NRCGTE, KEDI[2] and distributed amongst 16 provincial offices of education. Korea established a Law of Gifted Education in 2000 and the first national plan for promotion of gifted education began in 2003 and continued for 5 years until 2007 and the second plan followed between 2008 and 2012. Currently, Korea has implemented its third plan, which is from 2013 to 2017. During the first national plan, a general guideline for developing curriculum for gifted education was developed by KEDI (Seo, Park, & Park, 2004) and distributed nationwide. Although the general guidelines for curriculum development were not mandatory, individual provincial offices of

[1] There are 16 provincial offices of education in Korea and each office has an autonomous governing system, while the Ministry of Education provides education policy directions and promotes policy implementations through administrative and financial support and evaluation systems.

[2] NRCGTE is a National Research Center for Gifted and Talented Education and is a sub- research unit of Korean Education Development Institute (KEDI). KEDI was founded in 1972 as a government commissioned NGO institution and serves as a leading institution in educational policy research and planning, guiding the national agenda in formulating a unique education system contributing to Korea's dynamic growth. www.kedi.re.kr

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education adopted them to a certain extent for evaluation of gifted educational institutions.

The national guidelines for developing gifted education curriculum in 2004 mainly emphasised organisation and implementation of curriculum. First, curriculum of gifted education should be integrated and enriched. The guidelines presented advised that gifted education teachers should organise content as core concepts and/or themes integrated and enriched across subject matters. Second, curriculum should be individualised and differentiated. Various learning materials were provided for satisfying students' interests. Each student was encouraged to perform tasks at his/her own pace. Third, content should be selected to enhance creativity and higher order thinking ability. Content should be differentiated and challenging students' abilities. Students explore similar themes but are allowed to use diverse approaches. Fourth, content should include the values of leadership and integrity. Above all, the guidelines presented effective ways of choosing what teachers teach and how teachers teach gifted learners.

Each provincial office of education prefers to implement national level policy directions with their guideline publications. Most gifted education policies at individual provincial offices of education adopt the national guidelines for curriculum development and apply them as criteria for the evaluation of gifted educational institutions. For example, the Busan Metropolitan City Office of Education evaluates the gifted educational institutions every 2 years, and their evaluation criteria include three sections: (1) input (four subsections of programme planning, human resources, facilities and administrative and financial support system), (2) process (student screening process, curriculum, instruction and community participation) and (3) output (student products, student attitudes and behaviours, students and parents' satisfaction, student record and development report management). Under the section of curriculum, there are several criteria to evaluate how curriculum is organised and implemented (see Table 1).

For gifted education curricula to meet the criteria outlined in Table 1, especially in terms of ensuring that curriculum is integrated and content is selected based on its capacity to foster deeper thinking and creativity, gifted programme educators would have to utilise a concept-focused approach to teaching and learning. The literature on concept-based learning point out that using concepts to drive instruction requires an emphasis on dialogic teaching, meaning making and interpretation and helping learners find relevance by making connections between the concepts espoused by the discipline and experiences in the real world. However, in practice, teachers and gifted programme coordinators may feel that they need to show that their students have achieved these criteria through their lesson products and assessments. Much of the time in the lessons therefore may go into ensuring that students focus on their products. In this sense, they may lose sight of the processes that help children focus on their conceptual understanding during the lessons.

Table 1 Evaluation criteria of curriculum implementation at gifted educational institutions

Category	Criteria
Organisation of curriculum	
Integrated	Curriculum is organised with core concepts and principles, and the concepts can be applied across different subject matters and implemented in each subject matter
	Curriculum is organised with various topics and themes across different subject matters in consideration with students' interests and concerns
	Curriculum is organised with integrated themes, and the themes can be applied across subject matters so that classes can be unified, if needed
Enriched	Various diagnostic assessment methods are systematically conducted in order to collect students' learning styles, prior knowledge levels, interests, etc., at the beginning of the semester
	Within a gifted group, any student who displays higher levels of knowledge and skills than others is provided with additional learning materials and activities as differentiated and individualised curriculum
	During classroom teaching, any student who finishes tasks earlier than others is provided with further enriched tasks as differentiated and individualised curriculum
	Any student who displays better understanding of content and advanced knowledge is allowed to begin individual projects
	During classroom teaching, any small group which displays better understanding of content and advanced knowledge is provided with further enriched tasks as differentiated and individualised curriculum
Content of curriculum	
Creativity and higher order thinking ability	Activities with differentiated content are provided according to students' thinking ability
	Advanced level tasks are provided to challenge students' creativity
	Advanced learners are provided with differentiated learning materials
	Various approaches which allow students to produce different products under the same theme
Character and leadership	In the lesson content, it is clearly stated that there are high expectations of nurturing students' integrity and leadership
	In overall curriculum, students are able to fully nurture their integrity and leadership
	During individual/small group projects, teachers instruct students about how researchers conduct research with integrity and responsibility and serve as role models
	During small group projects, teachers instruct students to take turns to play different roles as well as being the group leader
	During presentation and discussion, teachers instruct students how presenters, presiders and discussants keep manners and attitudes

Note. The 2012 Self-evaluation Manual of Gifted Educational Institutions under the Busan Metropolitan City Office of Education (BMCOE)

Concept-Based Curriculum in Science Education and Thoughts for Science Gifted Education

If a concept-based curriculum is implemented in regular classrooms, the lesson would have to go through several phases, such as the three-phase learning cycle adopted in the science curriculum improvement study trialled in the USA (Karplus, 1964; Lawson, Abraham, & Renner, 1989). At the beginning phase of such a lesson, science teachers would provide an introduction in which students would learn through their own actions and reactions about a specific scientific phenomenon. They would explore new objects, events and/or natural phenomena with minimal guidance by teachers. Students with the new experience should raise questions, even as some may encounter complexities that they cannot resolve with their accustomed ways of thinking. Students would find out regularities, patterns, cause-effect relationships and so on. It is expected that students might encounter discrepancies with the way the phenomenon occurs and figure out that this differs from what they had previously known or assumed. This may give rise to cognitive conflicts in their understanding, and this is where students' misconceptions are revealed, with some even trying to develop new explanations. This is named as the 'exploration' phase of the lesson. Following this phase, students go through a 'concept introduction' phase where, while students are allowed to present their explanations based on their earlier explorations, teachers would explain ideas as concepts and help students to make sense of these new concepts. The last phase of the lesson is 'concept application', where students are expected to apply new concepts to another situation and acquire deeper understanding of concepts.

In Korea, the learning cycle models are widely known as appropriate teaching strategies for teaching concepts in science classrooms. Required science teaching method courses at preservice science teacher education programmes at teachers' colleges emphasise the use of several expanded models such as 5E (engage →explore → explain → elaborate → evaluate), 7E (elicit → 5E → extend), POE (predict → observe → explain) and PEOE (predict → explain → observe → explain) (Cho & Choi, 2002). Hence, science teachers of gifted education in Korea are assumed to understand concept-based curriculum as teaching and learning through learning cycle models in settings of science classrooms (Kwon, Nam, Lee, Lee, & Choi, 2013).

Considering a concept-based curriculum, how appropriate content is for curriculum organisation significantly matters, while the other aspect is curriculum implementation adopting learning cycles, inquiry processes and others. In the USA, the American Association for the Advancement of Science (AAAS, 1990) identified concepts such as systems, patterns of change, scale, models, evolution, nature of scientific process and reductionism as important broad themes of concepts in science curriculum which have mainly been adopted as appropriate concepts in

Table 2 Contents of the 2009 National Science Curriculum for 7th–9th graders in Korea

	Contents of science curriculum				
Category		7th grade	8th grade	9th grade	
Matters and energy	What is science?	Force and energy	Composition of matter	Electricity and magnetism	Science and mankind culture
		Work and daily life	Light and wave	Regularity in chemical reaction	
		Molecular movement and phase change	Characteristics of matter	Various chemical reactions	
			Work and energy transformation		
Life and earth		Earth system and changes of geosphere	Atmosphere and daily life	Solar system	
		Photosynthesis	Digestion, circulation, respiration and excretion	Reproduction and development	
		Water composition and circulation of hydrosphere	Stimulus and responses	Inheritance and evolution	
				Exosphere and space development	

Source: MEST. (2011). Science curriculum. Proclamation of the Ministry of Education, Science and Technology (MEST): #2011-36 [Separate Volume 9]. p. 4

concept-based curriculum for high ability learners in the USA. From there, Korea needs to find out which science concepts are considered as appropriate for science gifted education in her country.

The national science curriculum in Korea is organised around basic contents of science. The most recent revision, the 2009 National Science Curriculum for 7th–9th graders, presents two parts, materials and energy and life and earth (MEST, 2011; see Table 2).

A science course at the beginning of 7th grade starts with the unit 'What is science?' This helps enhance students' awareness and influence of science in daily life and of science-related careers. At the end of 9th grade, the science course accomplishes greater integration of the ideas taught with a unit entitled 'Science and Mankind Culture' to enhance students' understanding of historical cases influenced by science and forecasting future situations influenced by advancing science and technology. The contents in the national science curriculum are selected to arouse student's curiosity through inquiry about natural phenomena and objects and in the process help them understand basic concepts of science and develop scientific thinking skills and creative problem-solving abilities. The core concepts in science are therefore taught in connection with students' experience and through opportunities to apply science knowledge and inquiry skills for problem solving in society and daily life.[3]

Contents in science curriculum should be selected according to the five principles that contents should (1) be interrelated between elementary, middle and high school levels, (2) be organised for self-directed learning, (3) be chosen as familiar with students' experience, (4) enhance problem-solving ability and creativity in science and (5) allow student-centred inquiry learning (KOFAC, 2011). Using the content of 'stimulus and responses' at middle school level as an example, the main concepts deal with human body capacity to maintain optimum state with responses to environmental changes. Students would understand the structure and function of sensory organs, nervous and hormone systems, pathways of responses to stimuli and regulations of hormones and nerves to changes of inner and outer body conditions. During teaching, students conduct inquiry activities of experiments related to visual senses, responses to stimuli and simulation of regulating levels of blood sugar (KOFAC, 2011).

As shown above, the national science curriculum is designed around basic concepts. In contrast to the concept-focused goals of the national science curriculum, the reality in the science classrooms is the predominance of memory-oriented teaching and learning of science concepts, with authentic inquiry-based learning rarely being observed. A qualitative research based on in-depth interviews with students in secondary schools found that the few who understood science concepts tended to enjoy science learning and inquiry-oriented experimental activities and wanted more time to do more real-world inquiry-oriented experimental activities (Park & Song, 2009). It is clear that students would acquire deeper understanding of science concepts when there is more time devoted to revisiting science-related experiences that they are familiar with and giving them more opportunities to connect the extant science concepts to their experiences. Science gifted education programmes in Korean classrooms are premised on arranging such science learning conditions as after-school programmes and to provide sufficient time for implementing concept-based curriculum.

[3] By learning about science, students are able to recognise the relationships between science, technology and society as well as the value of science. The objectives of the science curriculum are to educate students who are able to (1) understand the basic concepts of science through inquiring natural phenomena, (2) develop the ability to scientifically investigate natural phenomena, (3) enhance curiosity and interest in natural phenomena and develop an attitude to scientifically solve problems in daily life and (4) recognise the relationship between science, technology and society (MEST, 2011, pp. 2–3).

Practices of Concept-Based Curriculum in Science Gifted Education

Even though concept-based curriculum is not well recognised amongst the gifted science education community, the practice of ensuring that teaching and learning are concept focused is widely accepted. From this standpoint, current gifted science education curriculum is discussed in this section. Curriculum of gifted science education in Korea tends to be enriched and integrated. In classroom practices, science teachers in gifted education try to ensure that concepts are an important part of their teaching. During the second national plan for promotion of gifted education between 2008 and 2012, the guidelines for curriculum of gifted science education by KEDI included (1) enrichment of regular curriculum, (2) transdisciplinary contents and activities, (3) advanced contents, (4) higher order thinking process, (5) students' products in quality and (6) career education (Yoo, Lee, & Seo, 2012).

Using these general guidelines, individual provincial offices of education develop their own guidelines and often utilise them as evaluation criteria (see Table 2). The main focus of organising curriculum is enrichment and integration, and various gifted educational institutions choose topics and themes in relation to the content found in the regular science curriculum to develop their gifted science education programmes. However, that the gifted science curriculum should be concept based and focused on teaching conceptually is not a common view of teachers. Rather, concept-based curriculum seems to be perceived as concept enriched and the integration of concepts as themes or topics into science gifted science education programmes. This has consequences for the teaching and learning of science amongst gifted learners.

Research has pointed to gifted science teachers' perceptions of concept-based curriculum as enriched and integrated themes, with science curriculum for gifted learners being developed with the assumption that the curriculum should be organised around abstract concepts and/or themes as content to meet the gifted learners' characteristics, interests and abilities. In 2003, a national study of gifted education investigated 263[4] gifted science education teachers' perceptions about their content of curriculum through questionnaires as multiple choice items[5] (Seo & Son, 2003). The results found that only 24 % of science teachers (62 out of 263) perceived that their curriculum content was accelerated and enriched to suit the needs of learners (see Table 2). The rest of the study participants responded that their science content was accelerated (14 %; 38 teachers) and enriched (61 %, 159 teachers) without consideration of differentiation to each learner's ability level. This seems to point to

[4] The 263 science teachers were nation widely sampled from 181 (45.9 %) out of 394 gifted educational institutions in total in 2003, where the gifted learners' grade level includes 5th, 6th, 7th and 8th from elementary and middle schools.

[5] How do you think about your gifted educational institution's curriculum in science? (a) accelerated by teaching contents from upper grades' curriculum, (b) enriched by teaching contents in depth from regular curriculum of same grade, (c) differentiated as enriched and accelerated in consideration with each student's ability and (d) others

Table 3 Science teachers' perceptions to their contents of teaching in gifted education from the national studies in 2003 and 2012

	2003 survey (*n* = 263)		2012 survey (*n* = 207)	
Curriculum	Differentiated	23.6 % (62)	Project based	19.8 % (41)
	Accelerated	14.4 % (38)	Accelerated	28.0 % (58)
	Enriched	60.5 % (159)	Enriched	52.2 % (108)
	Others	1.5 % (4)	Others	0 % (0)
	Total	100.0 % (263)	Total	100.0 % (207)
Abstractness of content	Almost always	6.9 % (18)	Strongly agree	0.0 (0)
	Often	23.3 % (61)	Agree	7.3 (15)
	Sometimes	39.7 % (104)	Do not know	29.6 % (61)
	A few	24.4 % (64)	Disagree	50.7 % (105)
	Almost never	5.7 % (15)	Strongly disagree	12.6 % (26)
Variety of content	Almost always	6.9 % (18)	Strongly agree	16.9 % (35)
	Often	26.7 % (70)	Agree	64.7 % (134)
	Sometimes	38.5 % (101)	Do not know	15.9 % (33)
	A few	22.9 % (60)	Disagree	2.4 % (5)
	Almost never	5.3 % (14)	Strongly disagree	0 % (0)

teachers believing that gifted education curriculum needs to be accelerated as the students are seen as above average. Therefore the tendency is for the science curriculum to draw on content from the upper grades. These results imply that most science teachers working with the gifted in 2003 did not implement individualised and differentiated curriculum. More importantly, this means that concepts were chosen as content and that the teaching concepts were not student centred and inquiry oriented following a learning cycle model.

Additional questionnaire items in the 2003 study (Seo & Son, 2003) revealed that over 25–30 % of science teachers of gifted education rarely implement content that focuses on abstract contents and various ideas (see Table 3). Respondents were asked how often they used abstract concepts, themes and theories that have a wide range of applicability for transfer within and across subject matters in their science lessons. The science teachers' response to this item, using a five-point Likert scale (1 = never, 5 = almost always), was 3.01 (±.99; $n = 262$). Another item asked how often teachers provided content from a range of areas of interests to gifted students including ones not found in regular curriculum, and their response was 3.07 (±.99; $n = 263$). These results revealed that the percentage of science teachers who provided abstract concepts and a variety of ideas did not go beyond 35 %. From the viewpoint of concept-based curriculum, it could be inferred that there was not enough emphasis on students' understanding of concepts and concept-based learning in the gifted science lessons.

Ten years later, in 2012, another national study of gifted science education surveyed 207[6] science teachers regarding their perceptions of the level of acceleration,

[6] The 207 science teachers were sampled from 1486 science teachers at gifted educational institutions in total in 2012, where the gifted learners' grade level includes 5th, 6th, 7th and 8th from elementary and middle schools.

enrichment and individual project-based teaching and learning that took place in their classrooms[7] (Yoo, Lee, & Seo, 2012). Teachers who perceived their teaching contents as individual project-based teaching were 20 % (41 teachers), accelerated 28 % (58 teachers) and enriched 52 % (108 teachers). Science teachers of gifted education were also asked how strongly they agreed that their teaching contents were abstract. Their response on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) was 2.31 (±.78; n = 207). Another item asked how strongly they agreed that their teaching contents were varied according to students' interests and abilities and their response was 3.96 (±.65; n = 207).

When comparing the results of the 2003 and 2012 studies, as shown in Table 3, the number of science teachers in 2012 who perceived their curriculum as accelerated doubled those in 2003. In addition, the percentage of science teachers who perceived their curriculum as enriched decreased by around 8 % in 2012. Furthermore, the percentage of teachers' negative perceptions to abstractness of the science content taught doubled, registering 63 % in 2012 compared to 30 % in 2003. Based on this comparison, science teachers in gifted education programmes in 2012 tended to teach more accelerated content and less abstract concepts while bringing variety of contents. It is possible that increases in variety of contents in 2012 are due to greater access to accumulated programmes of science gifted education for the last 10 years. In conclusion, it can be interpreted that real and authentic concept-based curriculum in gifted science education in Korea is implemented by around 20–30 % of teachers.

Examples of Concept-Based Lessons in Science Gifted Education Programmes

A sample lesson of gifted science education programmes, which was observed during the 2003 study, illustrates how gifted science programmes were implemented in comparison with science teaching in regular schools (see Table 4). It is certain that more student-centred learning activities were provided with students in gifted science classrooms than in regular classroom. Students in gifted science classrooms were given opportunities for planning and conducting experiments and presenting experimental results. However, some weak points were evident such as lesson themes not being initiated by students' ideas and instead being made by teachers. Consequently, students were somewhat passive learners at the beginning of the lessons. Furthermore, although students were allowed to plan experiments, teachers to some extent limited students' creative thinking ability by providing learners with starting materials. Additionally, students were not actively involved in discussions during the group presentation of experimental results. Hence, in 2003, teachers tried to teach a concept-based science curriculum, but in reality it turned out that

[7] What curriculum is possible when you teach in science gifted educational institutions? (a) accelerated, (b) enriched and (c) project based differentiated

Table 4 Comparison between 7th graders of gifted and regular classrooms in science teaching

	Gifted education classroom	Regular education classroom
Science teachers' perceptions to science teaching		
Teaching goals	Nurture thinking ability in breadth and potential to be top-level manpower in life sciences in order to contribute to national development	Character education
Lesson objectives	Develop ability to use scientific methods and conduct project-based research independently	Develop habits of the scientific mind and nurture attitude to enjoy science
Teacher's role	Introduce problems to solve	Assist students' learning
	Promote higher order thinking abilities	Transfer contents to students
Science teachers' viewpoints of students		
Good students	Students who are challenging and raising many questions	Students who are aware of rationale of learning
		Students who show positive attitude
Characteristics	Students have above-average cognitive abilities and are affective	Students have below-average cognitive abilities and show difficulty in learning the national science curriculum
Science teachers' ways of organising curriculum		
Contents	Reorganise contents of regular science curriculum from upper grades at middle and high school levels	Choose contents of regular curriculum at a given grade level
Emphasis	Adjusting the level of difficulty to average students of gifted class	Opportunity for experiencing scientists' ways of conducting experiments
	Various instructional strategies of lectures, discussion, lab activities, etc.	Teacher demonstration and lecture
Characteristics of lessons (based on results from researchers' classroom observation)		
Lesson objectives	Understand organelles of plant where photosynthesis occurs and able to explain process of photosynthesis	Understand principles of telescope and explain them
Lesson activities	Concepts introduced by teacher	Principles introduced by teacher (reasons for studying solar system, evolution process of the sun, telescopes)
	Instructions of experiments presented	
	Group of four students conducted experiments	
	Each group presented experiment results to class	Teacher demonstration of how to operate telescopes
	Write experiment report	

(continued)

Table 4 (continued)

	Gifted education classroom	Regular education classroom
Researchers' opinions	Students were allowed to plan and carry out experiments and appreciate scientists' ways of conducting experiments	Students were not given explanation about connections between telescopes and solar system
	Students were not given problem-finding tasks based on their interests at the beginning of lesson	Students were not given opportunities for operating telescopes

Source: Seo and Son (2003, pp. 295, 297). Results from classroom teaching observation in 2003

Table 5 Time allotment of each theme in gifted science education programmes in 2012

Time allotment	Number of science gifted education programmes	(%)
2–3 themes in one block time (90–180 min)	28	33.3
1 theme in one block time	40	47.6
1 theme in one semester (17 weeks)	6	7.1
1 theme in 1 year (34 weeks)	5	6.0
Unable to categorise	5	6.0
Total	84	100

Source: Yoo et al. (2012)

concepts were not properly introduced by teachers and students were not fully allowed to explore concepts.

Gifted science education in Korea is offered as after-school programmes and takes place on Saturdays. They can also include lessons during the summer and winter vacations. Students attend gifted education programmes every two Saturdays during the semester and, in some cases, every day for 1 or 2 weeks during vacations throughout the academic year beginning in March and ending in February of the following year. Table 5 shows the time allotment by themes in the gifted science education programmes. Out of 84 programmes, 11 programmes (13 %) reported that they taught a substantial theme/topic including abstract concepts over an extended period of time. Forty-eight percent of the respondents reported that they covered one theme in one block time programme, which would have provided students with marginal time to explore the new concepts presented in the theme. Twenty-eight programmes (33 %, out of 84) reported covering more than one theme in one block time, and there is a great deal of possibility that this would have involved a large amount of teacher-centred focusing to ensure that there was transmission of core content with little time for self-directed learning activities or concept exploration and explanation by the learner. Implementing concept-based curriculum demands a series of classroom periods and block time arranged, so that it is evident that this was not achieved in about half of the programmes teaching science to gifted learners.

An example of a gifted science programme for elementary 4th graders included four themes in one academic year, and they were (1) a dinosaur project, (2) rising

Table 6 An example of themes of gifted science education programmes in 2012 characterising enrichment triad model

Triad E model	Subthemes	Key learning	Time (min)	Date
Type I: general exploratory activities	Activity 1: what are the different kinds of dinosaurs?	Investigate, analyse, classify	135	3/30
Type II: group training activities	Activity 2: investigate dinosaur fossils and produce your own fossils	Explore, data collect, analyse	135	4/6
	Activity 3: rebuild dinosaur as real creature	Discuss, experiment, analyse	135	4/20
	Activity 4: explore environmental conditions and extinction of dinosaurs	Experiment, classify, discuss	135	4/27
Type III: individual and small group investigation of real problems	Activity 5: produce 'Love Dinosaur' Project	Discuss, present	135	5/4

Source: Yoo et al. (2012)

and falling, (3) build a weather observation station and (4) Dream of Icarus.[8] However, there was also no evidence of interrelated concepts that connected the four subthemes through the 1-year programme. The learning activities for the first theme of dinosaurs are shown in Table 6. While this theme can explore the possible concepts of the characteristics of dinosaurs as living organisms and its extinction in relation to environmental conditions, it appears that there was no extant concept that was focused on, from an exploration of the lesson documents.

Teaching the concept-based curriculum is assisted by the adoption of specific instructional models, such as the triad enrichment model (Renzulli, 1976) and problem-based and project-based learning models. Of the 84 gifted science education programmes surveyed for the 2012 study, only 47 programmes were perceived to have adopted any specific instructional model. Of the 47, 18 programmes showed characteristics of the triad enrichment model (Renzulli, 1976) with time allotment ranging from one block time to one academic year. The second frequently appeared model of teaching and learning of gifted science education programmes was the inquiry-oriented model. Fifteen programmes out of 47 were characterised with providing inquiry-oriented learning activities. However, none of the 15 programmes allowed students to initiate inquiry themes and to explore their own inquiry questions at the beginning of the programme, so that they were not adequately differentiated to cater to self-exploration or building on students' interests. On the other hand, it was noticed that these 15 programmes allowed students to choose different vari-

[8] Icarus is the son of the master craftsman, Daedalus in Greek mythology. Icarus attempted to escape from Crete by means of wings that his father constructed from feather and wax. He ignored instructions not to fly too close to the sun, and the melting wax caused him to fall into the sea where he drowned. www.wikipedia.org

ables when they were designing experiments and to present experiment results in various ways. A few programmes appeared to utilise problem-based learning (eight programmes) and the project-based model (six programmes). Hence, we can conclude that some level of concept-focused learning is taking place through the application of teaching models, although it may not result in full-fledged concept-based curriculum-related learning.

Some Reflections and Issues with Concept-Based Curriculum in the Korean Context

In conclusion, it can be said that concept-based curriculum in Korea is indirectly perceived as enriched and integrated around themes and topics in gifted science education. Curriculum is organised around the regular science curriculum, and concepts are often related as themes and/or topics (integrated with other science areas or other discipline areas and/or related to daily life of students). Concept-focused teaching is implemented to varying degrees in terms of differentiating learning with regard to students' interests, connecting concepts to prior experiences in daily life, and the practice of student-directed inquiry activities. Learning cycle models such as Renzulli's triad enrichment and problem-based learning are employed in some cases. On the other hand, themes are more distinguished from that in regular science curriculum with some overarching themes lasting 1 year.

Regarding the organisation and implementation of concept-based curriculum, an issue related to different developmental stages of students can be raised. A study (Kang, 2007) in Korea suggested that curriculum of gifted education programmes for students at elementary school level would be effective if curriculum was less accelerated, the themes adopted were more interdisciplinary, and topics were more related to the learners' daily life. It argues that a wider curriculum that caters to the broadening of intellectual abilities and skills would be more appropriate for such learners, given the developmental differences between elementary and secondary school children. Once elementary students have a broader understanding of science and its relation to the real world, their interests will become distinct, and this will allow educators to better meet the needs of gifted students at middle and high school levels. Schools then cater to their needs with more accelerated and enriched themes and topics in specific science areas to help them maximise their potential.

Another issue related to designing concept-based curriculum for gifted learners in science is related to the perspective that the intellectual abilities of the gifted often result in them seeking interrelatedness amongst various ideas from different subject matters. This can later result in learners proposing new integrated ideas and reaching an understanding of the overarching framework of knowledge. To meet these needs, concept-based curriculum should be organised and implemented with content embedding big concepts across science disciplines and include other disciplines such as mathematics, technology, engineering and even the arts and the humanities. The interdisciplinary concept model proposed by Jacobs and Borland (1986) provides one approach of integrating ideas across disciplines and can help to address this issue. In fact, this recent trend of integrating science, technology, engineering, arts and math (STEAM) is now underway in current reviews of the national science curriculum in Korea.

One final concern with implementing concept-based curriculum is the concern about the extent of teacher's science curriculum knowledge and expertise in gifted education. A study (Seo, Park, & Park, 2007) surveyed[9] 531 science teachers in gifted education in order to measure their professionalism in terms of science curriculum knowledge in gifted education and found that levels of science teachers' professional knowledge in science curriculum of gifted education significantly differed, depending on types of in-service training programmes attended, highest degree earned and types of elementary or secondary school. The importance of developing teachers' professional expertise and knowledge in gifted science curriculum needs to be emphasised in order to see the effective design and implementation of a concept-based curriculum.

References

American Association for the Advancement of Science. (1990). *Science for all Americans*. New York: Oxford University Press.

Busan Metropolitan City Office of Education. (2011). *The 2012 self-evaluation manual of gifted educational institutions*. Busan, South Korea: Busan Metropolitan City Office of Education.

Cho, H.-h., & Choi, K. (2002). Science education: Constructive perspectives. *Journal of the Korean Association for Research in Science Education, 22*(4), 820–836.

Jacobs, H., & Borland, J. (1986). The interdisciplinary concept model: Theory and practice. In J. VanTassel-Baska & S. Reis (Eds.), *Curriculum for gifted and talented students* (pp. 93–102). Thousand Oaks, CA: Corwin Press.

Kang, C. Y. (2007). An exploration of the development of school-based curriculum model for the gifted in elementary school. *Journal of Gifted/Talented Education, 17*(2), 223–250.

Karplus, R. (1964). The science curriculum improvement study. *Journal of Research in Science Teaching, 2*(4), 293–303.

KOFAC. (2011). *Research of the 2009 revision of science curriculum*. PR 2011-10. Seoul, South Korea: Korea Foundation for the Advancement of Science & Creativity (KOFAC).

Kwon, Y. J., Nam, J. H., Lee, K. Y., Lee, H. N., & Choi, K. H. (2013). *Science education: From thinking to learning*. Seoul, South Korea: Bookshill.

[9] Items of survey questionnaire to measure science curriculum knowledge in gifted education in five-point Likert scale included (1) understand how themes are related to each other in overall frame of science curriculum in gifted education, (2) understand how themes are related to other science disciplinary areas of science curriculum in gifted education, (3) understand how gifted students develop understanding of scientific knowledge, (4) understand how science curriculum in gifted education is related to other disciplinary areas and (5) organise themes of content of science curriculum in gifted education in relation to students' interests and concerns. Respondents of 531 teachers were sampled as 28 % of the total population (total 1883 science teachers of gifted education; elementary 803 and secondary 1080 teachers) of teachers in science gifted education in the year of 2005.

Lawson, A., Abraham, M., & Renner, J. (1989). *A theory of instruction: Using the learning cycle to teach science concepts and thinking skills*. Manhattan, KS: National Association for Research in Science Training (NARST) monograph, Number One.
MEST. (2011). Science curriculum. *Proclamation of the Ministry of Education, Science and Technology (MEST)*, #2011-36 [Separate Volume 9], 4.
Park, D. C., & Song, J. W. (2009). When do science lessons appeal to students?: Secondary school students' views on the value of school science and the appealing aspects of science lessons to students. *Journal for the Korea Association of Science Education, 29*(6), 593–610.
Renzulli, J. (1976). The enrichment triad model: A guide for developing defensible programs for the gifted and talented. *Gifted Child Quarterly, 20*, 303–326.
Seo, H. A., Park, K. H., & Park, J. E. (2007). Status of science teachers' professional knowledge for teaching the gifted. *Journal of Research in Curriculum & Instruction, 11*(1), 1–14.
Seo, H. A., Park, K. H., & Park, J. E. (2004). *Implementation manual for gifted education*. RM 2004-63. Seoul, South Korea: Korean Educational Development Institute.
Seo, H. A., & Son, Y. A. (2003). *Current status of teaching and learning at education institutions for the gifted*. CR2003-26. Seoul, South Korea: Korean Educational Development Institute.
Yoo, K. J., Lee, K. S., & Seo, H. A. (2012). *A study of operation guideline development for science curriculum for the gifted*. CR 2012-52. Seoul, South Korea: Korean Educational Development Institute.

Leading a Radical Shift in the Education of High Ability Learners

Virginia Cheng

Introduction

Education must prepare our young for the future. To do so all school leaders have to take into account new developments in education and pedagogy and strengthen their knowledge and understanding of what is possible for the schools they lead. The way schools are organised also makes a significant difference to student outcomes. The challenge for school leaders then is to create distinctive learning experiences and opportunities for each and every child who comes to school.

In Singapore, when the Ministry of Education announced its review of the upper secondary-junior college system to widen the scope and breadth of learning for high ability students in 2002, four schools applied with their proposals and received approval for the introduction of their programmes. This 'through-train programme', later known as the Integrated Programme (IP), allows secondary school students to proceed to junior college without taking the 'O' levels. The hallmark of this programme is innovation and the provision of a holistic education; schools that initiate this programme have the autonomy to design and organise learning to add breadth and depth to the learning experiences of their students. This chapter aims to share the experience of a school leader in leading educational innovation and change.

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The Innovation Begins in National Junior College: A Case Study

The Genesis

Every school sets its vision, values, philosophy, aims and intended outcomes which, in turn, inform its strategic plans and policy. Prior to 2002, National Junior College (NJC) was a school which ran a 2-year pre-university 'A' level programme for high ability students. When it received approval for its proposal in 2002, NJC had the opportunity to create and implement a programme which enabled them to fulfil their vision, values and philosophy of holistic schooling. By 2004, NJC was ready to initiate a 4-year integrated programme (IP) and enrolled high ability students who were 15 years of age. In 2009, the benefits of the 4-year IP were enhanced when the Ministry of Education approved the NJC's programme to be extended to 6 years. The radically redesigned new 6-year IP would benefit students from age 13 as it provided the crucial time and platform for a sustained programme that will develop students into persons who would possess excellent character, sound leadership and a strong sense of service to the school and nation.

Phases of Programme Development

The IP seeks to fulfil the ideals expressed in the desired outcomes of education for a Junior College (JC) and tertiary institution (see Table 1) as well as the NJC's philosophy.

The structure of the programme is customised for ability-driven, broad-based and interdisciplinary application learning with a strong emphasis on independence, character development and national education. By integrating common areas in the

Table 1 MOE desired outcomes of education and NJC's vision

	MOE desired outcomes of education (JC)	NJC's vision
Student outcomes	Resilient and resolute	Academic excellence
	Sound sense of social responsibility	Critical and creative thought
	Entrepreneurial and creative	Enterprising spirit
	Able to think independently and creatively	Passion for knowledge
	Strive for excellence	Sound moral values
	Have a zest for life	Deep sense of responsibility to the college and country
	Understand what it takes to inspire and motivate others	Lead with sensitivity
	Understand what it takes to lead Singapore	Serve with honour

Table 2 NJC's integrated programme outcomes

Academically excellent, reads widely, communicates clearly and effectively
Critical, creative and a mature problem-solver
Deep sense of responsibility to society
Understand what it takes to lead and is able to provide strong and committed leadership
Passionate about his interests and appreciates and explores other intellectual, social, cultural and aesthetic domains
Risk-taker and embodies the entrepreneurial spirit

upper secondary-JC curriculum as well as within and across subject areas, the IP will provide a seamless learning experience eliminating redundancy and overlap. The cognitive and affective development of a student in the school's IP will go beyond the traditional academic pursuit of paper qualifications as the school seeks to nurture every student's capacity through a broader spectrum of learning experiences so that he gains a wider perspective on life and a deeper and more genuine understanding and appreciation of his environment and all things around him. The school's desired outcomes for all its graduates include their being persons with a deep sense of responsibility to society and who understand what it takes to lead, as well as in being able to provide strong and committed leadership (see Table 2).

To arrive at these outcomes, the school formed teams of key personnel and teachers who shared the same interest and were enthusiastic to be on the project. The steering team included the principal, vice-principals and heads of department. They were supported by four working committees which were led by heads of department.

The team researched models and frameworks which emphasised practices that engage students and encourage the transfer of ideas within and across the disciplines and facilitated students' quest for the identification of repeated ways in which something happens and the connection of concepts and ideas when new knowledge is created (Erickson, 2002). They recognised the value of organising content around concepts and that this would result in clarity about what students should know, understand and be able to do. For example, teachers would need to state the conceptual objectives for their students as they design their modules. The construct of a qualitatively differentiated curriculum would provide opportunities to learn core knowledge, relationships and connections; apply knowledge; and develop affinities within and across discipline.

Their focus was to customise an ability-driven, broad-based and interdisciplinary curriculum that would be concept-based and facilitate the application of learning. Concept-based learning would provide depth of learning and enable students to organise their ideas and connect patterns. The teams and teachers involved in teaching IP students attended customised workshops conducted by the Gifted Education Branch of the Ministry of Education and were further guided by an education consultant who is a specialist in the field of gifted education. The team members were guided by the four fundamental adaptations of curriculum (VanTassel-Baska, 1998) and were advised that (a) the level of the curriculum must be sufficiently advanced to interest and challenge the learner, (b) the pace at which the curriculum is offered must be adjusted to suit the learner, (c) the complexity of the curriculum should reflect the capacity of the learner to engage and enable simultaneous rather than linear processing of ideas and (d) the depth of the curriculum should allow the learners to continue exploring an idea of special interest at the level of an expert.

The first phase of this development process, from the conceptualisation of the initiative to the construction of the framework and the preparation of the curriculum for first year implementation, took a period of 23 months. The steering committee, led by the school leaders and four other working committees, facilitated the extensive process which included (a) brainstorming sessions with the staff and stakeholders, (b) development of the programme structure as well as the temporal distribution of the components of the programme over eight semesters (see Table 3), (c) setting major thrusts and focus of the curriculum, (d) design and development of components in curriculum and (e) setting the assessment system to emphasise both process and product.

In curriculum planning and design, the teams were aware of the theoretical perspectives and possible curricular models. They selected a mix of appropriate and compatible models to produce the desired outcomes. At the subject level, the heads of department and their teams organised the content, taking into account the scope and sequence, essential concepts and skills, selection of instructional materials and assessment models. NJC faculty members also had to ensure vertical alignment in scope and sequence across the 6 years of their students' education in the school.

The result of this process was the IP curriculum framework which determined the curriculum and instruction and set the path for the achievement of the intended outcomes. The team from NJC decided that the programme would run on a modular curriculum from junior to middle years. Apart from the foundational modules, students had the option to choose from a range of elective modules that they were interested to study. Block scheduling also enabled students to engage in a choice of collaborative and research projects with varied opportunities to work with their seniors.

Programme Structure

The IP curriculum focused on a semester-based modular framework with the two main areas being the integrated curriculum and special programmes.

Integrated Curriculum The curriculum offered a wide range of 'integrated' core and elective modules to the students. In its 'integrated' approach, the IP presents a radical departure from the mainstream subject-based curriculum into delivering 'integrated' cross-disciplinary modules throughout the years. Examples of such modules were biochemistry, earth science, environmental science, space science, development studies and trade and aid, just to name a few. In the design of these 'integrated' modules, the following main principles were adhered to:

Table 3 NJC's programme structure

General component				Language component		Integrated application component				Subjects component		
Various bases of knowledge	*Community service*	Physical education	Arts appreciation	All 'AO' and 'O' level subjects		Interdisciplinary in nature				Advanced specialised content		
Philosophy behind ideas	*Adventure and entrepreneurship*	Co-curricular activities	Visual and performing arts			Application of theories and subject-based content				All 'A' and 'S' level subjects		
Application of theories	Achievement					*Authentic approaches to problem-solving*				Broad-based curriculum		
Integrated learning	Leadership (governance and society)					Independent learning				All 'O' and 'AO' level subjects		
Man and ideas	CAAL	PE	Arts	EL	MT	ABL	IC	AS	IRP	SCI	HUM	MATHS

CAAL Community, adventure and achievement leadership, *GS* governance and society, *PE* physical education, *EL* English language, *MT* mother tongue, *ABL* application based learning, *IC* integrated curriculum, *AS* attachment scheme, *IRP* individual research project, *SCI* science, *HUM* humanities

(a) Learning outcomes of the various subjects that lend themselves to a meaningful integration would be integrated in a manner such that each 'integrated' module did not compromise the depth of its constituent subjects. This meant that at the very least, the learning outcomes of an 'integrated' module would be more than the sum of its parts.
(b) Learning outcomes of the various subjects that did not lend themselves to a meaningful integration would be taught within the subject. This again ensured that the depth of the curriculum of any subject was not compromised.

Special Programmes In addition, NJC's IP offers six special academic and non-academic programmes, that all students would experience as they were aimed at nurturing and developing the complete individual. For instance, 'Man and Ideas' goes beyond subject matter and seeks to develop student's creative and critical thinking skills. Students will question the bases of knowledge through the study of ideas, ideologies and theories of various political, economic and religious thinkers. They also seek to examine different cultures, values, customs and practices to identify cultural and ideological biases. The Special Programme in Inquiry and Research (SPIRE) gives the students opportunity to undergo specialised study, training and research and apply their skills and knowledge as they will work with a member of the teaching staff and a tutor from the research institutes or industry. This will culminate in students showcasing their work at international conferences, seminars, fairs or competitions. The Community, Adventure, Achievement and Leadership (CAAL) programme focuses on (a) encouraging commitment to long-term community projects and service by doing, (b) venturing and experiencing both local and overseas expeditions, (c) attaining achievements that would groom students to develop their special talents and (d) providing leadership opportunities to gain first-hand experience of what it means to be a leader.

All six special programmes were designed and aligned to meet the intended outcomes of the school. They would be delivered together with the 'integrated' curriculum. However, not all of them would run concurrently. Frameworks of these six special programmes and integrated modules—core and elective—can be found in Table 3.

The 6-year IP saw the infusion of a more holistic, gradual and developmental approach towards identity and character education into the curriculum. It attended to providing uninterrupted, sustained identity formation and character education during a time when our students go through 'the most substantial shift' (Sprinthall & Sprinthall, 1990) of their lives.

The IP programme would ensure the development of student leadership from a young age by offering different levels of incremental leadership development experiences. It would provide the main environmental catalysts (Gagne, 2003) that contribute to the quality of students' leadership experience by putting them in contact with leadership theory, strategic thinking and philosophy, with inspiring role models, and offering them a chance to conceptualise, organise, execute and participate in special activities that would help them and their peers develop as leaders.

A non-examinable component called ‘Exploration and Discovery’ was also offered to students to encourage them to explore and discover their interests in an intellectually challenging field at their own time. It could be an interest in a field related to archaeology, astronomy, political science, genetics, ethics, etc.

In addition, substantial periods of enrichment where students could participate in overseas summer/winter programmes/immersions or engage in science/humanities research and collaborative projects at various levels were offered. Such opportunities would broaden their perspective, promote an appreciation of diverse cultures and thinking and provide them with a platform to develop at a global level.

A 6-year IP is congruent with research that suggests the benefits of extending or ensuring more continuity in child-teacher contact across the years or grades. Six years would thus provide sufficient time to develop a strong relationship with and sense of belonging to the school which would indirectly develop a stronger sense of rootedness with the nation, given the great emphasis on national education in the school.

Assessment of Learning Outcomes and Curriculum Evaluation

Two critical elements of curriculum design are the assessment of outcomes and the evaluation of curriculum and its revision. To ensure that the curriculum leaders were clear about the process, workshops were conducted by the Gifted Education Branch and guidance provided by the consultant. The teams and teachers involved learnt the purpose and mode of assessment, authentic assessment, evaluation of creative products, portfolio assessment and rubric design. They also studied the assessments used by the Centre for Gifted Education at the College of William and Mary. From this they learnt about a wider range of assessments: performance-based, portfolio, content versus concept assessments; self, peer and teacher assessments; project and presentation assessments; overall unit assessments; and informal assessments. They then applied what they had learnt to actual practice in their assessment framework for all the modules designed.

The teams recognised the fundamental role of evaluation to provide information that could be used for improvement. Through regular term evaluations, they were able to assess the appropriateness of the programme and modules and planned their action for improvement. The teams would decide on the multiple data sources to be used. One key evaluation used is the assessment of classroom practice and regular lesson observations and feedback. Such regular evaluation enabled the school to make improvements in instructional delivery, curriculum alignment and programme implementation, student impact data and staff development.

Leading the Change

According to Kotter (2006), major change efforts in organisations fail because they do not take a holistic approach to see the change through. He suggests the use of his eight-step process for leading change successfully in organisations.

Guided by Kotter's theory, the team leaders at NJC realised that no initiative can succeed without the enthusiastic participation of every teacher and the support from all its stakeholders. It was therefore necessary to explain the need for change, where to make the change and how to make the change. The rationale for the change was hence clearly communicated to all stakeholders.

Time was set aside to meet with all the stakeholders to clarify the purpose for the introduction of this change. Plans, goals and strategies were shared and discussed. The school and team leaders listened to the diverse views and feedback and responded with empathy while advocating the need for change.

Teams of key personnel and teachers who shared the same interest in concept-based curriculum researched further and made study trips and learning journeys to schools which had implemented similar curriculum. These teams were given opportunities to share their learning with the rest of the staff so as to enthuse them as well.

The school leader and working teams also needed to develop a proposal for their initiative to the sponsoring authorities to request for funding and resources required for implementation of the programme. Once the proposal was approved, the school leader and team publicised the school's new and innovative curriculum to the public especially to the parents of eligible students who would like to be part of this programme. A comprehensive publicity campaign was undertaken to market the programme to students and parents, convincing them of its benefits. Such a campaign would at the very least involve school visits and public seminars. Other strategies included capitalising on the uniqueness of the programme and leveraging on the strengths of the organisation.[1]

For teachers to change their classroom practice in any radical way, a great deal of unlearning will first have to happen because their practice was being modified and they would experience a sense of disorientation. To overcome this, the school leaders had to persuade and develop a 'buy-in' from the teachers and at the same time, help them prepare for this change. The team leaders (a) facilitated brainstorming sessions with teachers for them to reflect on current practice and suggested the things that must be in put in place in the classroom in order for differentiated and concept-based instruction to work; b) shared the importance of and provided clarity about the intent of the curriculum; (c) increased the professional capacity of the teachers by bringing in the consultants and experts to increase pedagogical knowledge and pedagogical content knowledge; (d) involved teachers in the design of the curriculum framework, instructional design and strategies; (e) formed support groups and created time to share and reflect on practice; (f) shared success stories of teachers who have applied their new learning in the classrooms; (g) encouraged peer

[1] Annex 1: Details the proposed marketing strategies and tactics

mentoring and sharing; and (h) carried out learning journeys to visit other schools practising concept-based curriculum.

For instance, to increase the professional capacity of the teachers in NJC, training in designing an integrated curriculum was conducted with the help of a consultant. The teachers worked on the overall framework that spanned all six-years, syllabi for the first year, scheme of work, assessment rubrics, sample lesson plans for the first year, and a tutor's package and other supporting instructional materials. The consultant was present to guide and advise on curriculum design and development. Sample syllabi and schemes of work were also used as a basis for discussion and critique.

Issues and Challenges

Selection of Teachers

Given the high expectations and heavy demands of the programme, the identification of forward-looking, enthusiastic and innovative teachers who are flexible and adaptable to the new curriculum and the teaching approaches was challenging. Identification of such teachers is important as the school needed a mix of experienced and beginning teachers.

Curriculum Design and Development

For the 'integrated' curriculum as well as the special programmes, there were no precedents to follow. While the overall framework has been completed, there was only enough time in the first year to detail, field-test and review the syllabi and scheme of work for the first year of the IP, i.e. IP1/JH1. Detailed syllabi and scheme of works for the second year (or IP2/JH2) and thereafter were developed, field-tested and reviewed as they progressed. A major challenge for and an expectation of teachers in the IP were to function as teachers and curriculum and programme designers concomitantly. When these requirements were placed in the context of implementing an entirely new programme with its fair share of operational issues, there was no doubt that heavy demands, amidst high expectations, would have been placed on them.

Teaching Load

In order to design and deliver innovative and effective lesson plans and activities based on concept-based and differentiated curriculum, the IP teachers needed the space and time to do so. Again, there was the need to consider the teaching load for all IP teachers.

Staffing

An important factor that had to be addressed for staffing was the need for more staff as the IP teachers had to take charge of curriculum and programme design and development for the subsequent years over and above functioning in the capacity of teachers at the same time. Also, to ensure continuity and adequacy in the design and development of the IP curriculum for the subsequent years, the deployment of teachers was critical. Fortunately, this was provided for by the MOE as a start-up resource for IP schools for the first 3 years. This helped them drive the curriculum design and development for the subsequent years.

Selection of Students

Given the rigour of the school's selection process, the identification and selection of students was an increasingly demanding undertaking every year. Teachers and support staff needed to manage the administration of the admission applications, tests and the interviews, which was a 6-month process.

Funding

Additional funds for materials and resources for the curriculum as well as the special programmes were needed both for the start-up as well as recurrent costs.

Some Useful Tips: 3P + 3S Formula

To promote and initiate concept-based curriculum successfully, the following are useful tips:

Purpose Be clear in purpose. Create a vision that is aligned with school's mission, vision and values. Develop strategies to translate the vision into action.

People Form committees where members have both ability and skills to lead the change effectively. Empower committees to take risks and come up with ideas and activities and to put up action plans for implementation.

Process Advocate, communicate and cascade the intended change to all stakeholders. Explain the rationale and involve as many stakeholders as necessary. Equip the teachers who are implementing the programme with knowledge, understanding and the skills to help them succeed in the classroom. 'Walk the talk' as action speaks louder than words and has to be consistent with what is advocated.

System Conduct reviews of current systems and introduce improvements and changes to systems, structures and policies. Changes to systems, structures and policy are necessary so as to facilitate the progress and success of the change and to give credibility to the new initiative.

Support Share successes on a regular basis to all stakeholders in the community. Recognise and acknowledge those who have contributed to these achievements. Source for additional resources in terms of funding, staffing, facilities, experts, etc. Form networks and connections to build up continuity of support.

Sustainability Institutionalise the new systems, processes, structures and policies while putting in place the practice of regular reviews for improvement. Ensure there is continuity in terms of leaders and key personnel who have knowledge of the change and are able to sustain the change as well as make continuous improvement.

Conclusion

NJC began its initiative in 2002. They have shown clarity of purpose and have aligned this with what they believed in, that is, mission,[2] vision[3] and values.[4] All stakeholders, including teachers, support staff, school advisory committee, alumni association and parents, understood what was intended and gave their wholehearted support. Communication was clear to external stakeholders and various means were used to persuade and advocate the need for this initiative. Despite challenges, the school was well supported through our development. The team members were able

[2] College of the Nation: home of scholars and leaders who serve with honour

[3] Students have sound moral values and a deep sense of responsibility to the college and country. Their passion for knowledge is nurtured in a vibrant learning environment which fosters academic excellence, critical and creative thought and an enterprising spirit. They are prepared to lead with sensitivity and serve with honour.

[4] Loyalty with integrity, scholarship with creativity, leadership with sensitivity and service with honour

to design the IP programme in phases and made constant improvements in response to the needs of our students. Their success was evidenced by the confidence the Ministry of Education had placed in them through the approvals and support for the 4-year IP school to a 6-year IP school with boarding. The school had successfully sustained the creative implementation of the IP curriculum effectively while regularly reviewing their systems, structures and processes so as to stay ahead in their delivery of quality education to all the cohorts of students. They have done this well and have done their part to 'mould the future of the nation'.

Annex 1

Marketing Strategies and Tactics

Strategies

The following five main strategies will be used:

1. Capitalise on the appeal of the curriculum.
2. Leverage on the pioneer status for maximum publicity.
3. Leverage on staff credentials.
4. Rely on school's position as a 'top 5 JC' as an assurance of quality.
5. Raise school's public profile through a concerted approach.

Tactics

The table below lists the marketing tactics and tools that the school will employ to achieve its objectives

Tool	Qty	Remarks
Public forums and tours	5	Public forums will form a major part of the marketing effort especially in raising awareness amongst parents. A target of 500 per session has been set
Media features and interviews	3	The profile of the programme may be further raised through carefully timed press releases and sneak previews for the print media. In addition, features in current affairs programmes like *Talking Point* will also be sought
Website	1	To make information about the programme available anytime and anywhere, an interactive website will be developed
CD-ROMs	3000	Interactive CD-ROMs highlighting key features of the programme will also be developed as promotional material
Brochures	6000	Traditional promotional materials such as brochures will also be designed and distributed
Open house	1	In addition to the annual open house for the mainstream, an exclusive open house for this programme will be organised

(continued)

Tool	Qty	Remarks
School visits	12	School visits, especially to target schools, will also be undertaken
Professional bodies	5	The school will leverage on professional networks of the SAC/ alumni as pervasive vehicles of publicity for the programme

References

Erickson, H. L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.

Gagné, F. (2003). Transforming gifts into talents: The DMGT as a developmental theory. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3rd ed.). Boston: Allyn and Bacon.

Kotter, J. P. (2006). Leading change: Why transformation efforts fail. In *Harvard business review on leading through change.* Boston: Harvard Business School Publishing Corporation.

Sprinthall, N. A., & Sprinthall, R. C. (1990). *Educational psychology: A developmental approach* (5th ed.). New York: McGraw-Hill.

VanTassel-Baska, J. (1998). Key issues and problems in secondary programming. In J. VanTassel-Baska (Ed.), *Excellence in educating gifted and talented learners* (3rd ed.). Denver, CO: Love Publishing.

Designing a Concept-Based Curriculum: The Raffles Girls' School (RGS) Experience

Mary George Cheriyan and Lucille Puay Lan Yap-Chua

Change begins with a complete understanding of where schools have been, where schools are now and where schools are going.

(Glasgow, 1997, p. 8)

Introduction

Schools aspire to create learning experiences that cater to the individual needs of their students. They seek to provide educational pathways and adopt pedagogical approaches that are appropriate to their students' intellectual abilities and talents. Raffles Girls' School (Secondary) is no exception. As a school that caters to the top 3–5 % of the national cohort, it constantly reviews its programmes to optimise the potential of the students. In one such review, the school decided to embark on a concept-based curriculum framed by the principles of the Understanding by Design (UbD) model (Wiggins & McTighe, 1998). This chapter describes the school's journey in designing a concept-based curriculum. It examines the events and players who contributed to the focus on *teaching for understanding* so that students do not merely regurgitate facts but are critical, conceptual thinkers.

What Is a Concept-Based Curriculum?

A concept is a mental construct, represented by one or two words and examples that share common attributes like timelessness, universality, abstraction and breadth (Erickson, 2002). The concept acts as a lens for students to analyse the content and facts in a particular topic. By doing so, they go beyond mere content acquisition to deeper understanding of the big ideas. These big ideas are often termed as 'enduring

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understandings' (Wiggins & McTighe, 2005) or 'Generalisations' (Erickson, 2002). For instance, in the study of the Chinese Communist Revolution of 1949, students study facts like *reasons for the revolution* and the *events that led to the Communist victory.* To facilitate students' conceptual engagement with these facts, the teacher deploys instructional strategies that uncover the enduring understanding or Generalisation that 'Revolutions may transform established norms and ways of thinking'. When students further analyse sources and materials to evaluate the impact of the revolution on society, they also deepen their skills in information processing

In a nutshell, the heart of a concept-based curriculum is the *synergy* (Erickson, 2002) between the two critical elements: conceptual knowledge and content knowledge. By thinking conceptually, students make connections and derive patterns that go beyond mere factual recall. Erickson argues that conceptual thinking should be a conscious design goal in the curriculum (2006). This chapter describes how RGS consciously plans for conceptual learning through a curriculum design and review process that involves teacher development, inquiry and sound leadership.

Changing Contexts, Changing Curriculum

In curriculum reform and innovation, context matters. As Fullan asserts, 'organisations transform when they can establish mechanisms for learning in the dailiness of organisational life' (Fullan, 2007). So, what is the RGS context? How has it influenced the implementation of a concept-based curriculum? What are the events and decisions that contribute to its development? What is the role played by the leadership in this journey?

RGS: Background

Raffles Girls' School (RGS) had its origins as a one-room department in Raffles Institution in 1844. RGS was officially established in 1879 with the appointment of its first Headmistress. As a school for high-ability females, it declares sterling achievements in both the academic and non-academic domains; namely, sports and performing arts. The RGS students, who constitute the top 3–5 % of the national cohort, gain admission based on their Primary School Leaving Examination which they sit for at the end of Primary 6 or through Direct School Admission (DSA).[1] Students admitted via DSA possess exceptional talent in either specific academic domains, sports or the aesthetics. About 30 % of the students are from the Ministry

[1] The DSA-Secondary Exercise allows secondary schools to select Primary 6 students for admission to secondary one, based on their achievements and talents. They, therefore, gain admission even before the Primary School Leaving Examination results are released.

of Education's Gifted Education Programme (GEP), which is offered to the top 1 % of the cohort based on their verbal-linguistic and mathematical aptitude.

In 1993, RGS joined a group of schools selected by the Ministry of Education to be on the Independent School scheme. These schools are given autonomy in areas like curriculum, staff recruitment and student admission. In 2004, RGS embarked on the Raffles Programme (RP), a 6-year programme that leads to the 'A' level examinations at Raffles Institution.

In these developments, the enduring focus is on creating a learning environment that optimises the potential of the highly able students through a robust curriculum that stretches thinking and plugs the students into the real world. This focus is encapsulated in the school's mission: nurturing the high-ability girl to be a leader who will realise her talents in service to nation and community.

It is within this context that curriculum decisions and planning operate.

Why Did RGS Embark on a Concept-Based Curriculum?

The school's focus on a concept-based curriculum emerged as a result of its curriculum review process. In 2001, led by the Principal and the Head of the Staff Development Committee (SDC), the school reviewed its instructional practices, by asking this fundamental question: 'To what extent does the Instructional Programme achieve its objectives?'

We found ourselves stumped! In fact, we began asking more questions:

- What constitutes our Instructional Programme?
- What are its objectives? Is our pedagogy aligned to these objectives in the first place?
- Do our assessments reflect the objectives?

These questions, we realised, revealed a fundamental gap in our curriculum practices: the lack of clear, explicit alignment between instructional objectives, assessment and instruction. To address this gap, we decided to explore the use of the Understanding by Design (UbD) (Wiggins & McTighe, 1998) framework for curriculum planning.

At the heart of the UbD framework is the notion of beginning with the end in mind or backward design. Its three-stage planning process consists of the following stages:

Stage 1:intended understandings, including knowledge and skills
Stage 2: evidence of learning
Stage 3: strategies and activities for learning

We decided to adapt the UbD framework for our own curriculum planning as it provided the structure for the curriculum-assessment-instruction alignment that we lacked.

A key thrust in Stage 1 of the UbD framework is the uncovering of enduring understandings. Enduring understandings refer to the big ideas which are abstract and transferable (Wiggins & McTighe, 2005, p. 40) and consist of key concepts and principles which lie at the heart of the discipline. Consequently, as the RGS teachers delved into the heart of the discipline for various subjects, we learned to identify and make explicit the key concepts that students have to understand, for example, concepts of revolution and ideology in history and equilibrium in biology. We also examined Lynn Erickson's work which similarly alluded to the analysis of facts and information through a conceptual lens to infer patterns and transferable ideas (Erickson, 2002). These ideas then challenged us to view the curriculum as a vehicle for deep, conceptual learning.

Getting Started: Change Processes

Like in most other schools, our curriculum was written in terms of specific instructional objectives which list what students need to *know*. A concept-based curriculum, however, articulates what students need to *know, do and understand* (Erickson, 2006; Wiggins & McTighe, 2005). This required shifts in curriculum design and pedagogy. To facilitate this transition, RGS focused on three change processes: redesign curriculum documents, develop capacities and review practices.

Redesign Curriculum Documents

From Lesson Planning to Unit Planning In keeping with the logic of the UbD framework, the notion of a *lesson* plan was amended to that of a *unit* plan. A lesson plan only captures a slice of the overall learning outcomes for that unit—it tends to focus on the lesson objectives and activities for just one lesson within a larger unit. A unit plan records the enduring understandings, the Evidence of Learning, i.e., the assessments and the corresponding lesson activities for the entire unit or topic, which extends beyond one lesson. Thus, a change to a unit plan enables teachers to plan the learning more holistically, showing the alignment between the understandings, assessments and learning activities across several lessons in the entire unit/topic.

Accordingly, we crafted a unit plan template based on the UbD framework, reflecting the three stages. This was a significant move away from the traditional mode of stating only the lesson objectives to one that articulates what students will *do* and *understand* in terms of the overarching concepts. The template also requires that the planned assessments are explicitly stated together with the classroom activities that align with them.

Reframing the Curriculum The immediate step to a concept-based curriculum was a change from lesson planning to unit planning. To effect the change, we had to reframe the curriculum map since the unit plan reflects the conceptual understandings that frame the content and skills for only that particular topic and not necessarily for the disciplinary themes within the entire level as well as across all the grade levels. For instance, the key concepts in Year 2 history are 'colonialism', 'conflict' and independence'. These concepts frame the focus of study for that year which is Singapore's progress to independence. We needed to design a curriculum in which the conceptual understandings are indicated not just for a particular level but vertically across the grade levels. For instance, the concept of energy in Physics can be spiralled across the Year 1– Year 4 Physics curriculum.

In RGS, this change coincided with the implementation of the Raffles Programme (RP) in 2004. The school engaged Professor Joyce VanTassel-Baska (from the Centre for Gifted Education, College of William and Mary, United States) as their consultant for the new RP curriculum. Professor VanTassel-Baska recommended a curriculum design that similarly focused on concepts. Her curriculum template required the curriculum designers to identify not just the knowledge and skills but also the concept-based enduring understandings that frame them. This is a departure from a typical syllabus that only indicates the specific instructional objectives. Using her curriculum template, the curriculum teams designed their respective 6-year curricula, outlining the scope and sequence of the overarching concepts and themes in their respective disciplines. With this, *teaching for understanding* was formally integrated into the overall RP curriculum.

A couple of years later, RGS further reviewed the RP documents to sharpen the scope and sequence of the overarching concepts and themes as well as skills development. Led by the then Director of Academic Studies, the RGS curriculum Heads worked on the maps. A particular impetus for the review was the school's sense of accountability for the rigour and suppleness of the RP curriculum in the absence of the 'O' level examinations.

Today, the revised documents are termed as curriculum maps, largely influenced by the work of Heidi Hayes Jacobs (1997) in her foundational book, *Mapping the Big Picture*. As noted by the history subject head at that time, the map is a 'logical and systematic organisation of the concept-based curriculum'.

The features of the RGS curriculum map include the following:

- Overarching concepts act as curriculum organisers: The curriculum is organised around macroconcepts such as systems and change as well as discipline-focused concepts such as relationships (Geography), revolution (History), energy (Science) and patterns (Maths). These concepts are expressed as enduring understandings within the units.
- Knowledge and skills are indicated in distinct columns and spiralled across the levels.
- Formative and summative assessments are indicated and aligned to the learner outcomes.

A concept-based curriculum requires careful attention to its design features. Where necessary, we adapt curriculum frameworks and models like the UbD, thereby ensuring that our practices are backed by research and literature. At the same time, these models are adapted to the school context to arrive at a better 'fit'. For instance, when we crafted our curriculum maps, we applied both Jacobs' and VanTassel-Baska's scope and sequence principles to create a template that meets our unique needs. Based on these principles, our curriculum maps explicitly indicate the enduring understandings, knowledge and skills as well as the assessments across the grades. At the same time, we contextualised the maps to our time-tabling realities, the student profile and the national focus on technology-enhanced pedagogy. Specifically, we applied VanTassel-Baska and Wood's (2010) Integrated Curriculum Model to further align the maps to our school profile. This Model consists of the following elements: advanced content, higher-order process and product and overarching concepts and themes. In doing so, we were consciously applying curriculum elements that are deemed appropriate for high ability learners. Thus, in a Lower Secondary History Curriculum Map, a typical secondary one topic on the founding of Singapore is viewed through a conceptual lens like 'colonialism' and analysed through the use of critical inquiry into popular narratives.

Contextualisation of practice facilitates its sustainability. Research shows that when schools implement reforms without due consideration of its context, they are unable to sustain the reform (Datnow & Stringfield, 2000). Thus, we also conduct school-based research that further strengthens the theory-practice nexus as teachers reflect on their practices asking fundamental questions about what works in their specific classrooms. This will be discussed later in the chapter.

Develop Capacities

In order to implement a concept-based curriculum, teachers need to harness appropriate teaching strategies to enable students to construct their understanding and make meaning of the facts and data. A traditional fact-based approach that merely requires closed-ended responses to questions will not suffice. The teacher who wants students to have deep understanding of the topic and see the relevance of their learning to the real world is likely to do the following:

- Present a firm grounding in the facts and skills of the topic.
- Provide opportunities to make connections and see patterns across the topics and even disciplines.
- Apply pedagogical strategies that enable students to process their information critically.

In order to equip the teacher to create such learning, the school's Professional Development Plan incorporates job-embedded learning platforms for teachers. Teachers apply their learning to their practice in an ongoing manner through collaboration and training. For instance, new teachers undergo a 2-year induction programme which equips them in the core competencies such as higher order thinking strategies. After each session, their mentor, who is a Senior Teacher, provides ongoing feedback and coaching as they apply their learning to the classroom.

In the same way, the entire faculty meets in their subject-based groups to discuss the unit design and pedagogy. These weekly sessions, termed as professional learning space, habituate the teacher to focus on the *evidence* of student learning and thinking. The faculty learns from their own practice and from others in 'real time' as they collaborate, review and share their practices. Such collaboration is fundamental to curriculum reform and educational improvement (DuFour, DuFour, Eaker, & Many, 2006; Englert & Tarrant, 1995). RGS' emphasis on building teacher capacity echoes Barber and Mourshed's (2007) study on top performing school systems which notes that the quality of teachers is critical for high-performing schools.

Departments tend to have their own pedagogical preferences for concept development. For instance, the Humanities and Mathematics departments use the concept-based learning models like Taba's (1966) Concept Development and Bruner's (1956) Concept Attainment Models, respectively, to uncover conceptual understandings, while the Science department uses the 5E Learning Cycle Model to provoke inquiry. Other strategies that teachers may employ are Bernice McCarthy's 4Mat approach, Robert Swartz's graphic organisers and Richard Paul's elements of reasoning.

Review Practices

The school's culture of review and reflection contributes largely to the sustainability of its curriculum innovation.

External Review RGS seeks feedback on its curriculum from external consultants. For instance, in 2009, Professor VanTassel-Baska reviewed the RGS curriculum documents. She noted that the documents suggested high-level process and product development as well as advanced content. However, her feedback also included the following observations:

- There was insufficient evidence that the macroconcepts were uncovered in assessment and instruction.
- The potential for interdisciplinary learning was not optimised.

In response to her feedback, a series of workshops was organised on how to integrate macroconcepts into the curriculum. The Staff Development Committee also produced two working documents for teachers to refer to Macroconcepts and Their Related Generalisations and Lexicon of Terms.

The Gifted Education Branch also reviews the school's curriculum every couple of years. For instance, their feedback on one occasion prompted us to scrutinise our strategies for differentiated learning.

Internal Monitoring Process Various monitoring processes and structures provide data on the quality of teaching and learning. These include the following:

- Teachers submit their unit plans to the Heads who are expected to scrutinise the standards.
- Heads evaluate and give feedback on teaching and learning through lesson observations and work review sessions.
- Academic Studies Heads vet summative assessments, checking for their alignment to the intended outcomes.

These review processes enable the curriculum leaders to respond to emerging issues in curriculum implementation: For instance, do teachers uncover the conceptual understandings as outlined in the curriculum maps? Do teachers identify the big ideas and key concepts in their unit plan? Is the pedagogy employed in the classroom effective in uncovering these enduring understandings? Does the instruction enable information management and problem-solving in the real world?

Our review processes have recently revealed that over time, the conceptual dimension in the curriculum appears to have waned. Thus, although the enduring understandings continue to be stated in the unit plan and curriculum map, classroom instruction may not be optimising this dimension in learning. Some individuals and departments sustainably harness appropriate strategies and assessments that draw out the conceptual understandings more consciously than others. To address this issue, the teachers were provided a set of protocols to guide their discussions on unit planning, assessment and instruction during the professional learning space sessions. For example, the unit plan checklist directs the professional eye to curriculum design standards which explicitly indicate conceptual understandings. The entire faculty uses these protocols, facilitating therefore a school-wide approach to concept-based curriculum design and practice.

The three change processes—*redesign curriculum, develop capacity and review practices*—are intertwined. Essentially, they point to the fact that a concept-based curriculum requires an intentional approach to curriculum reform. The curriculum leaders need to be clear about the purpose for the change and, then, align their people development approaches accordingly. Openness to multipronged feedback lends rigour to the process enabling ongoing refinements.

Challenges Faced

Shift in Pedagogical Habits For many teachers, curriculum reform can be disconcerting as it may require them to unravel their tried-and-tested practices.

The challenges in shifting to a concept-based curriculum include the following:

- How to identify enduring understandings
- How to frame enduring understandings in terms of abstract and transferable ideas
- How to harness appropriate strategies to uncover the understandings

Teachers may tend to view factual knowledge and subject-based process skills as the ends in themselves in lesson planning and delivery. So, a typical concern is that teaching for the Big Ideas may compromise content coverage and skill acquisition. Teachers also need to think more deeply about their pedagogy so as to organise their instruction in ways that uncover the intended conceptual understandings. Without this alignment between the intended outcomes and instruction, a technically taut unit plan may remain true in theory but not in practice.

However, many teachers have also come to appreciate the value of a concept-based curriculum in enabling students to make meaning out of the voluminous body of facts and data. For instance, the then Science Head of Department, says:

> Science is about making sense of what is happening around us. It is important to have a systematic approach to making observations and gathering data. By using a system of classification, we piece information together to develop concepts. These concepts interact and overlap to form bigger concepts. For example, under the topic on Optics, through observations of light, concepts like Reflection and Refraction are uncovered so that we make sense of the phenomenon of light in the real world.

Clearly, such an approach to teaching the discipline requires a paradigm change. The Mathematics Head recalled how the mathematics teachers had to rethink the teaching of the discipline in terms of how they uncover the key concepts that can be applied to the real world and harness appropriate strategies to achieve these outcomes. For instance, they have to plan how to get their students to uncover the assumptions that underlie mathematics formula instead of merely using them to solve the problem. The Head of Mathematics Department defines this shift in thinking as 'sense making', for both teachers and students.

Monitoring We cannot assume that a school-wide approach to a concept-based curriculum automatically sustains standards in unit planning and implementation. An evolving and dynamic school context can put pressure on prevailing beliefs about curriculum design. When significant curriculum players leave the school, they also take away with them their practical knowledge and expertise so priceless to organisational culture. Thus, amidst the typical flux and flow of school, curriculum leaders have to consistently communicate the organisational intentions and aspirations for teaching and learning. We may put review processes in place, but they matter for little if we do not monitor whether the data is relevant or harnessed for improvements and whether we enforce the norms and reward good practices. There is no running away from basic supervision and evaluation processes like unit plan submissions, file checks, lesson observations and work review sessions where both curriculum leaders and teachers are held accountable for curriculum integrity. Such monitoring requires a significant investment of resources and resoluteness. But it is necessary because tardiness in doing so can lead to professional sluggishness.

Curriculum Integration and Interdisciplinarity An intended outcome of the concept-based curriculum is curriculum integration which can take place in three different forms:

- Multidisciplinary: Teachers organise the different disciplines around a conceptual understanding.
- Interdisciplinary: Teachers organise the curriculum or unit of study around a conceptual understanding to emphasise interdisciplinary skills and big ideas.
- Transdisciplinary: Teachers organise the curriculum or unit of study around student questions and problem identification (Drake & Burns, 2004).

In RGS, some teachers have adopted a multidisciplinary approach to explore a theme or concept. For instance, a team of social studies and English language teachers designed a performance task on Advocacy for Year 3 students. This approach keeps the disciplines as distinct entities.

We have not truly optimised the potential for interdisciplinary learning. As mentioned earlier, Professor VanTassel-Baska noted little evidence of curriculum integration in her review of our documents. For instance, although the macroconcept of 'system' is widely used across the disciplines, there is scant evidence of interdisciplinary learning around this concept. In the same way, although the concept of 'energy' is integral to the Sciences, its potential for transference across the Sciences is not evident. Our review processes reveal that even in research studies, which offer the most natural platform for such learning, the potential for integration is still a work in progress. Challenges to interdisciplinary learning include curriculum structures where subjects are taught in silos, with their own scope and sequence. Nevertheless, its potential merits scrutiny. One platform that the school can optimise is the performance task which is currently integral to its assessment framework. As the performance task requires students to apply their conceptual understanding to a real-world context, it gives much scope for interdisciplinary perspectives to problem-solving.

Sustainability of a Concept-Based Curriculum: Factors

Whether a reform endures largely relies on the school culture. A school culture may be defined as the guiding beliefs and expectations evident in the way a school operates (Fullan, 2007). From its inception, RGS has aspired to create an environment in which girls thrive. Generations of RGS principals and teachers are led by their belief that girls deserve a learning space that nurtures their talents, confidence and feminine identity.[2] Thus, the school constantly questions whether its curriculum meets their needs.

The following section outlines five key elements in RGS' culture which contribute to the sustainability of its curriculum reform.

[2] One of the school's current stretch goals is girls who will realise their potential and talents.

Whole-School Approach

RGS adopted a whole-school approach to developing a concept-based curriculum instead of piloting it within certain disciplines and/or levels. This process involved an attention to both 'a systematic procedure and a specificity for treating details within that plan' (VanTassel-Baska, 2003). Once we had decided on a whole-school approach, we went on to adjust the curriculum maps, unit plan template and classroom observation forms to facilitate the change. These documents act as our signposts for standards. Not only do they guide the lesson planning and practice, they also provide the language for professional conversations. When practices falter or soar, we describe them in specific terms. For instance, we may question whether a unit plan articulates the disciplinary concept(s) accurately as opposed to factual coverage alone or whether Stage 2 (evidence of learning) in the unit plan is aligned to Stage 1 (intended understandings) as well as to Stage 3 in terms of appropriate classroom instruction.

Similarly, RGS' Professional Development Plan focuses on required competencies for concept-based learning such as the Concept Development Model (Taba, 1966) and the elements of reasoning (Paul & Elder, 2012).

A whole-school approach is consistent with international evidence that shows that sustainable curriculum innovation is possible when there are systemic adjustments made to organisational structures and processes to enable the change (Elmore & City, 2009; Fullan, 2007; Harris, 2008). This conclusion is also echoed in a research report on the RP in RGS conducted by the Centre for Research in Pedagogy and Practice. It is noted that the strategic and systematic approach to the reform effort 'maintained a consistency of direction while promoting constant tailoring to the demands and opportunities of each stage of the reform process' (Taylor, Kwek, & Foo, 2009).

Fundamentally, our whole-school approach reflects the school's shared vision of its curriculum identity as one that cultivates deep learning. This vision, in turn, frames its strategic planning and policies on curriculum and professional development.

Leadership

The school's curriculum leaders are expected to know and apply learning theories. They are empowered to shape their curriculum according to its interdisciplinarity while holding true to learning theories and principles. The usual practice is that individuals or groups take the lead in a certain initiative. They then facilitate collaborative dialogues to enable the entire leadership team to take ownership of the initiative.

The development of RGS' concept-based curriculum has involved many such levels of discourse. First, the school sent three Heads for a workshop on the UbD framework. The Heads then organised department-based sessions to cascade the training to the rest of the school. Over the years, different groups of people and individuals have contributed to the curriculum integrity through their various roles. This distributed leadership approach was modelled by the Principal then who first led the change. She enabled teachers and/or Heads to assume mastery and leadership in areas they were inclined to, say, curriculum and professional development. For instance, she set up the Staff Development Committee[3] comprising teachers with an aptitude and interest in curriculum matters to provide the ballast to curriculum improvements.

In such a culture of learning, all hands are on the deck for curriculum planning and review. During the weekly professional learning space sessions, the entire faculty, including the senior management (SM), collectively designs and reviews teaching and learning outcomes. The SM's hands-on engagement with the practical realities of curriculum reform facilitates quick and relevant intervention when the need arises.

It is also important for leaders to communicate the school's intentions to the various stakeholders so as to deepen the sense of collective responsibility and shared vision. Table 9.1 shows the school's communication platforms.

Teacher Efficacy Through Collaboration

Research amply demonstrates that effective learning is linked to effective teaching (Barber & Mourshed, 2007; Cochran-Smith, 2001; Darling-Hammond & Bransford, 2005). Good teachers are learner-oriented. They develop the critical thinking skills of the students and engage them in challenging authentic tasks (McInerney & Liem, 2008). The goal of RGS' professional development is to support and nurture teachers' pedagogical practices, providing them with training, resources and feedback and simply giving them the space to grow. To build teachers' sense of efficacy, the school creates structures for teacher collaboration and job-embedded learning so that as a faculty, we assimilate the principles of concept-based curriculum and shape our pedagogical approaches (Green, 1971; Kansanen, 2000). Research shows that a collaborative culture leads to higher levels of trust and respect among colleagues, improved professional satisfaction, improved instructional practices, better outcomes for all students and school change that is maintained over time (DuFour et al., 2006; Joyce & Elmore, 1995, Joyce & Showers, 2002; McLeskey & Waldron, 2002; McLeskey, Waldron, So, Swanson, & Loveland, 2001; Waldron & McLeskey, 1998; Waldron, McLeskey, & Pacchiano, 1999).

To reap the benefits of collaboration, RGS first scheduled a weekly preparation time which has since evolved into the professional learning space, described earlier

[3] The Staff Development Committee has been renamed Professional Development Committee comprising Senior Teachers and is headed by the Head Professional Development and Director of the Centre for Pedagogical Research and Learning.

Table 9.1 Channels of communication with different stakeholders

Teachers	Parents	Students
Staff retreat	School-parents meetings	Focus-group meetings
End-of-year review	Dialogues with parents	Student congress
Staff meetings	Letters to parents	RGS intranet
Department meetings	Year 1 parents' workshop	
Professional learning space[a]	RGS intranet	
Tea with principal		
School intranet		

[a]A common block, built into the curriculum time, for teachers to meet and discuss curriculum matters

in the chapter. During this time, the entire faculty discusses the learning goals, shares observations of student learning and learns from one another. We have observed the power of this collaborative space to engender reflection and nudge inquiry into what works. Currently, the specialists are conducting research on how the professional learning space plays out in RGS.

Reflective Practice A culture of reflection contributes to the sustainability of school reform because as Dewey (1933) suggests, inherent in reflection is a sense of responsibility for the consequences of our decisions. It engages the teacher with the practice. When the teacher encounters a problem situation, he/she questions and investigates it to frame a suitable solution (Schön, 1983, 1987) rather than rely on remote recommendations by external researchers.

To harness the power of this theory-practice nexus, RGS provides a research ecosystem for teachers to inquire into their own practices. We indigenise our research so that the questions are pertinent to our specific context. In 2010, RGS set up the Pedagogical Research Lab which has since been renamed Centre for Pedagogical Research and Learning (PeRL). The research ecosystem (see Fig. 9.1) enables teachers to embark on different levels of inquiry into their pedagogical practices, evaluating their relevance and value for both teaching and learning.

Several teachers have been involved in research projects that inquire into various aspects of teaching and learning. For instance, two Geography teachers examined how their assessment design was aligned to the macroconcepts, while another teacher inquired into the way teachers give written feedback to students. PeRL researchers also conducted research on areas such as 'how the performance task contributes to teaching and learning' and 'teacher readiness in practitioner inquiry'. The findings are used to improve or strengthen practices. For instance, the performance task research indicated that this assessment mode enabled the respondents to transfer the learning to a real-world context, a skill fundamental to a concept-based curriculum. It also revealed the challenges in evaluating such an assessment mode and, hence, the value of benchmarking practices.

At this point, we are still developing the professional instinct for systematic inquiry. Many experienced teachers thrive on their tacit knowledge and make peda-

Fig. 9.1 PeRL research ecosystem

gogical decisions based on their accumulated knowledge and instincts in the classroom rather than through systematic inquiry. Such pedagogical wisdom is priceless.

However, we aspire to greater numbers of the faculty creating knowledge of practice (Cochran-Smith & Lytle, 1999) through inquiry into existing theories and research that they apply in their classroom. In-house knowledge creation can contribute to teachers' sense of professionalism and belief in their practices because they are backed by data. At a micro-level, PeRL supports teachers in their inquiry through the research ecosystem and mentoring. At a macro-level, PeRL pushes for evidence-backed decision-making processes for strategic planning.

Student Engagement The concept-based curriculum is a 'good-fit' curriculum for the gifted and talented as it complements their inherent ability to understand interrelationships and interconnectedness (VanTassel-Baska, 1986). Academically gifted and talented learners tend to be big picture learners: They see interrelationships and interconnectedness among ideas, people and environments and are able to comprehend complex interactions.

RGS teachers who consciously shape their pedagogy and classroom discourse to facilitate such learning will attest to the ability of most RGS students to embrace and, indeed, demonstrate such ways of thinking. Very often, the students themselves compel a dialogical approach to the learning, as they pose and respond to questions that uncover assumptions and clarify thinking. They tend to take their learning seriously and rise to the challenge of uncovering and deepening their understanding of overarching themes and concepts. Taylor et al. (2009) describe the RGS students as being 'eager to form pedagogical relationships' with their teachers. As practitioners, we are responsible for harnessing this potential for conceptual learning.

Conclusion

Although this account is based on a school for the highly able, we believe that a concept-based curriculum caters to all students. To think conceptually, to transfer learning and to see the big idea—these experiences are the right of every learner. No doubt, the highly able student may grasp faster and think more divergently, but every learner deserves the experience of going beyond factual coverage to conceptual understanding. This is the real world. If we lay claim to be twenty-first-century educators, we have to view all students as twenty-first-century learners who are adept not only at content mastery but are also analytical, fair-minded thinkers (Paul & Elder, 2008) who know how to access the facts for clear thinking.

We have noted the value of a whole-school approach to change, requiring concerted efforts by faculty leaders to cascade and translate the ideas into action. Of particular significance is the role curriculum gatekeepers or custodians who conceptualise and co-ordinate specific initiatives. For instance, the RGS Director of Academic Studies is expected to oversee the design, implementation and review of the school's academic programme, while the Director of PeRL facilitates teacher professionalism and inquiry so critical to its success.

Finally, school leaders must show care and respect for all their stakeholders: the teachers for their everyday role in the classroom, the parents for their support and trust and the students for being active participants in the learning process. The process of curricular change is systematically orchestrated, with the heart, one step at a time. Aspirations need to be articulated and the vision clarified with conviction and a sense of ownership. Only then can the entire school community understand and embrace the purpose and principles behind the practice.

References

Barber, M., & Mourshed, M. (2007). *How the world's best-performing school systems come out on top*. London: McKinsey and Company.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). *A study of thinking*. London: Chapman & Hall.

Cochran-Smith, M., & Lytle, S. L. (1999). Relationships of knowledge and practice: Teacher learning in communities. *Review of Research in Education, 24*, 249–305.

Cochran-Smith, M. (2001). Constructing outcomes in teacher education: Policy, practice and pitfalls. *Educational Policy Analysis Archives, 9*(11).
Darling-Hammond, L., & Bransford, J. (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco, CA: Jossey-Bass.
Datnow, A., & Stringfield, S. (2000). Working together for reliable school reform. *Journal of Education for Students Placed at Risk, 5*, 183–204.
Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process* (Rev. ed.). Boston: D. C. Heath.
Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum*. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).
DuFour, R., DuFour, R., Eaker, R., & Many, T. (2006). *Learning by doing: A handbook for professional learning communities at work*. Bloomington, IN: Solution Tree.
Elmore, R. F., & City, E. A. (2009). The road to school improvement. In M. Fullan (Ed.), *The challenge of change: Start school improvement Now!* (2nd ed., pp. 21–28). Thousand Oaks, CA: Corwin Press.
Englert, C. S., & Tarrant, K. L. (1995). Creating collaborative cultures for educational change. *Remedial and Special Education, 16*(6), 325–336. 353.
Erickson, H. L. (2002). *Concept-based curriculum and instruction : Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.
Erickson, H. L. (2006). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.
Fullan, M. (2007). *The new meaning of educational change* (4th ed.). New York: Teachers College Press.
Glasgow, N. A. (1997). *New curriculum for new times: A guide to student-centred problem-based learning*. Thousand Oaks, CA: Corwin Press.
Green, T. E. (1971). *The activities of teaching*. New York: McGraw-Hill.
Harris, A. (2008). Distributed leadership: According to the evidence. *Journal of Educational Administration, 46*, 172–188.
Jacobs, H. H. (1997). *Mapping the big picture: Integrating curriculum and assessment K–12*. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).
Joyce, B., & Elmore, B. (1995). *Student achievement through staff development: Fundamentals of school renewal* (2nd ed.). White Plains, NY: Longman.
Joyce, B., & Showers, B. (2002). *Student achievement through staff development*. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).
Kansanen, P. (2000). *Teachers' pedagogical thinking: Theoretical landscapes, practical challenges*. New York, NY: P. Lang.
McInerney, D. M., & Liem, A. D. (2008). *Teaching and learning: International best practice*. Charlotte, NC: Information Age Pub.
McLeskey, J., & Waldron, N. (2002). School change and inclusive schools: Lessons learned from practice. *Phi Delta Kappan, 84*(1), 65–72.
McLeskey, J., Waldron, N., So, T. H., Swanson, K., & Loveland, T. (2001). Perspectives of teachers toward inclusive school programs. *Teacher Education and Special Education, 24*(2), 108–115.
Paul, R., & Elder, L. (2008). *The thinker's guide to intellectual standards*. Dillon Beach, CA: Foundation for Critical Thinking.
Paul, R., & Elder, L. (2012). *Critical thinking: Tools for taking charge of your learning & your life* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.
Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
Schön, D. A. (1987). *Educating the reflective practitioner*. San Francisco, CA: Jossey-Bass Publishers.
Taba, H. (1966). *Teaching strategies and cognitive functioning in elementary school children* (Cooperative research project). Washington, DC: Office of Education; U.S. Department of Health, Education, and Welfare; San Francisco: San Francisco State College.

Taylor, P.G., Kwek, D., & Foo, A. (2009). *A study of the Raffles programme at the Raffles Girls' School (RGS), Singapore: A report for the education research funding programme*. Centre for Research for Pedagogy and Practice, National Institute of Education.

VanTassel-Baska, J. (1986). Effective curriculum and instruction models for talented students. *Gifted Child Quarterly, 30*, 164–169.

VanTassel-Baska, J. (2003). *Curriculum planning and instructional design for gifted learners*. Denver, CO: Love Publishing Company.

VanTassel-Baska, J., & Wood, S. (2010). The Integrated Curriculum Model (ICM). *Learning and Individual Differences, 20*(4), 345–357.

Wiggins, G., & McTighe, J. (1998). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development (ACSD).

Wiggins, G., and McTighe, J. (2005). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development (ACSD).

Waldron, N., & McLeskey, J. (1998). The impact of a full-time inclusive school program (ISP) on the academic achievement of students with mild and severe learning disabilities. *Exceptional Children, 64*, 395–405.

Waldron, N., McLeskey, J., & Pacchiano, D. (1999). Giving teachers a voice: Teachers' perspectives regarding elementary inclusive school programs (ISPs). *Teacher Education and Special Education, 22*, 141–153.

Concept-Based Instruction in English: Issues and Challenges

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The twenty-first century requires learners be equipped with the ability to understand and apply synergistic thinking to solve problems involving different disciplines. The contextual placement of English standards gives rise to the readiness and necessity that can make this a distinct reality in English Language classrooms across Singapore. This chapter is a call for teachers to implement a concept-based English Language curriculum.

A concept-based curriculum is encapsulated by Erickson (2002) when she indeed calls it 'teaching beyond the facts' (p. xi). It is an attempt to move beyond the level of facts, of information where students employ skills on the lower rung of Bloom's Taxonomy. A concept-based curriculum is an attempt to push the yardsticks of standards to demand a learning environment where '… students will demonstrate complex thinking, deeper understanding, and sophisticated performance' (Erickson, 2002, p. xi). It is meant to push the boundaries of expectations in light of the different capacities our students will have demanded of them in the twenty-first century.

The English Language in Singapore

Being the core lingua franca of Singapore's education system and the world's political and business engines, the decision for English in Singapore is fundamental to Singapore's achievements thus far. It is well documented and accepted that Singapore is where she is now because of a national and international ability to conduct herself in English. Without this communicative ability to engage the international platforms of governance, business, law and politics, Singapore's place within the national, regional and international communities would have been

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limited. This pragmatism continues to be clearly articulated in the Singapore Ministry of Education's 2010 English Language Syllabus Review. Given 'Singapore's transformation to a knowledge-based economy, the rapid developments in technology, the generational shift in home language and the increasingly competitive environment are some factors that make proficiency in English necessary for pupils' (Ministry of Education (MOE), 2008, p. 6). Our current developmental thrusts and evolution within altering global concerns, demographics and domains still rest on our ability to operate with the English Language. For better or worse, the most predominant reminder of our colonial legacy is guaranteed its presence for posterity.

The English Language in Singapore has enjoyed a feature of prominence. From its pragmatic adoption to the significant and influential endorsements by Singapore's former Prime Minister (Gopinathan, 1991) and the late Minister Mentor, Mr Lee Kuan Yew, the core presence of the English Language in all schools is paramount. All English Language departments in schools form the largest pool of staff and by this measure should perhaps have a centrality of focus, resource allocation and development. In 2011, the new English Language Institute of Singapore (ELIS) was launched by Mr Lee Kuan Yew himself. The institute aims to drive excellence in the teaching and learning of the English Language in Singapore schools to raise the general command of both spoken and written English amongst all our students (MOE, 2011). With these combined elements of state imperatives, the presence of professional expertise and a populace of a learning nation, the time does seem to be poised for more educational and curriculum innovation.

Concept-Based Instruction in English

A concept-based curriculum in Singapore features where practitioners possess the belief, conviction, competency, administrative support and/or sheer grit. An upward-spiralling set of curriculum documents entails that a curriculum's scope of coverage and sequence of units adhere to guidelines. The Ministry of Education in Singapore provides for and outlines the parameters within the specifics of assessment that allows teachers to be masters in the classroom. Curriculum in Singapore classrooms continues its focus on language skills and hence the classroom tends to be centred on such. Hence the possibility of the evolution to a concept-based formulation lies very much in the hands of those conceptualising, writing and guiding the implementation of curriculum.

A concept-based curriculum provides real-world relevance, transferable skill sets, a recognisable and applicable contextualisation, plausible postulations and metacognitive awareness while being a tool for further intellectual engagement and motivation. It brings learning out of the classroom into a transferable realm of applicability for the information processing and knowledge creation required by twenty-first-century demands.

With the rationale of a concept-based curriculum model so well documented and understood by the knowing community of educators (Beane, 2006; Boix Mansilla, Miller, & Gardner, 2000; Tomlinson, 2002; VanTassel-Baska, 2002; Wiggins & McTighe, 2005), the key question to surface is why this does not feature more concertedly in curriculum documents and in the classrooms. Why is that when we have a solution to an enhanced programme and an improved system for more engaged teachers, more meaningful engagement and better student performance, the implementation circumstances appear to be minimal or ad hoc? What is it that prevents a concept-based classroom from being the norm? Often times, Singapore's intense obsession on standardised testing and its use for placement implications are cited as possible reasons.

The Reality of High-Stakes Examinations

If we recognise these (potential) benefits of implementing a concept-based curriculum, what are some of the considerations that keep this from being a full-fledged reality? Perhaps one of the more readily thought-of reasons for this is Singapore's continued adoption of the GCE 'O' and 'A' Level Examinations. Examinations are a high-stakes business in Singapore and national standardised tests like these serve as a significant trophy or burden to its bearer. Crossing these threshold markers determines the educational trajectory on the various tributaries of the educational spectrum. The various avenues come with their attendant societal markers that have sprung forth in our merit-based demarcations of ability and opportunities.

The most recently released 2012 PISA rankings place Singapore at the top of the scales alongside with other top performing nations/regions like Shanghai, Finland and South Korea for the levels of literacy (OECD, 2014). These report cards and league tables serve as a guide and indicator of where educational fundamentals lie and where very conscientious nurturing of skills and talent are focused.

In the English Language examination, students need to write coherent, relevant and sustained essays; comprehend, analyse and explain discrete items; and select and summarise information. This has remained relatively unchanged much over the last few decades. Singapore still believes this to be a valid assessment tool for gauging baseline proficiency of linguistic skills and one's communicative ability. What a concept-based curriculum can do is further enhance performance and achievement levels in these high-stakes examinations for all students across the educational spectrum.

A Concept-Based Curriculum for Enhancing Performance

Given that the mode of assessment generally incorporates the accepted basic linguistic competencies, how then can we value-add performance and achievement? Where and how can teachers increase students' ability levels to attain the grades that endorse mastery? Returning to the characteristics of a concept-based curriculum and its attendant enhancement to the educational experience, its implementation and incorporation would only increase the engagement levels, augment application and boost motivation. Any of these potential outcomes alone would be adequate reason for implementation let alone the potential and likely combination of all. As such, the examinations—high stakes as they are—should not pose any potential barrier for the adoption of a concept-based curriculum. If at all, the evolution towards a concept-based curriculum should be seen as a means for enhancing performance and achievement levels, thus meeting the objectives for all stakeholders.

A concept-based curriculum that aims to heighten proficiency across all skills in the curriculum has a positive impact on learners. VanTassel-Baska, Zuo, Avery and Little (2002) investigated the treatment effect of concept-based units of instruction. They found the treatment generally positive under all conditions across treatment and comparison groups. These include gender comparisons, impact of treatment on students' proficiencies, impact of grouping models, comparisons of single-year and multi-year exposure and comparisons between low and high SES groups. Hence, empirical evidence attests to the efficacy of a concept-based curriculum as a distinct platform for enhancing performance.

Concept-Based Curriculum as a Feature of Educational Differentiation

Concept-based curriculum and instruction is generally a curriculum feature for high-ability students. Differentiation '…involves a number of curricular modifications in terms of thinking processes, student products and curriculum content' (Jacobs & Borland, 1986, p. 159). A differentiated curriculum must be one that promotes higher cognitive processes and possess instructional strategies that accommodate both the curriculum content and learning styles of gifted and talented children (Marland, 1972). In Passow's (1982) often referenced principles of differentiation, we remind ourselves of the importance of differentiation to meeting the learning needs of diverse students groups and the impact this has on student achievement and performance.

Beyond fundamental proficiency that is aimed for, concept-based approaches do require understandings for meta-level connectivity and synthesis. Regarding performance and attainment expectations for Singapore, the Ministry of Education projects that at least 20 % of the student cohort will attain a high degree of English Language proficiency. It is expected that within this group, there will be those able to achieve mastery level, placing them with the best internationally and in native-speaking nations (MOE, 2011). With classrooms containing increasing diversity in ability levels, needs and learning styles, differentiation will be necessary from many different angles no matter how homogeneity is sought. Developing a concept-based curriculum is a technique for this differentiation. Sustaining engagement and augmenting application again are features that remain fundamental at all levels of the educational spectrum. The fact that a concept-based curriculum is emerging as a feature in some of Singapore's Gifted Education Programme Schools with the attendant performance benchmarks is indicative of both its presence and effective practice. The continued peak performance of the Gifted Education Programme students in all standardised tests, especially English, is one aspect of evidence for the effective practice of a concept-based curriculum.

The Place for a Concept-Based Curriculum as a Feature of All Thinking Classrooms

Beyond the clear expectations that a concept-based curriculum can bring forth for the high-ability students, I would like to argue that there must be room for the concept-based curriculum to be in all classrooms. All classrooms should be thinking classrooms. Teaching facts and expecting information transference are hallmarks of misplaced expectations and an educational paradigm that does not serve to develop students into the thinking individuals and communities they need to be.

All educators should want their classes and classrooms to display the dimensions of thinking. In *The Thinking Classroom: Learning and Teaching in a Culture of Thinking*, Tishman, Perkins and Jay (1995) outline six dimensions towards a culture of thinking—a language of thinking, thinking dispositions, mental management, the strategic spirit, higher-order knowledge and transfer.

The concept-based curriculum would entail and demand that these are embedded within curriculum units. The conceptual explorations would already necessitate that the thinking be 'visible' (Ritchhart, Church, & Morrison, 2011). Looking deeper at the workings within classrooms, we will see further thinking elements integral to understanding. In order for concepts to be explored, teased, understood and engaged with, this visibility can be mapped with eliciting and planning for what they term 'high-leverage thinking moves that serve understanding well' (Ritchhart et al., 2011, p. 11). Some of these moves include building explanations and interpretations, reasoning with evidence, making connections and considering different viewpoints and perspectives.

Together with the often used tools of Paul and Elder (2003) who together formulated and systematised an arsenal of tools to aid us with critical thinking, a concept-based curriculum is a reality that should be in all classrooms.

The Consideration of Bloom's Taxonomy

Given the considerations above of the tools available for making the thinking classroom come alive and for thinking to be made visible, Bloom's Taxonomy thereby becomes a vehicle for planning the learning experiences that support the development of concepts. *Remembering* and *Understanding* fall within the lower rungs of the Revised Bloom's Taxonomy (Pohl, 2000), and these activities require recognition, recall and interpretation before students can be expected to use this material. Before students can begin to address the means and ways of dealing with informational material (Paterson, 2005), the core attainment of knowledge and comprehension must suffice. The higher levels of the Revised Bloom's from *Applying* to *Creating* presuppose the attainment of the earlier levels. This taxonomy provides a core basis of some of the tiers of content, process and product formulation in curriculum planning and instruction.

Concept-based instruction and curriculum can take place at all levels of the Bloom's consideration. The skills of *Remembering*, *Understanding*, *Applying*, *Analysing*, *Evaluating* and *Creating* (Krathwohl, 2002) are littered all through a concept-based curriculum. Beyond achieving these attainment levels, a concept-driven curriculum would enhance the creation of what Beane (1995) refers to as a 'coherent curriculum'. This is '…where [the curriculum] is one that holds together, that makes sense as a whole; and its parts, whatever they are, are unified and connected by that sense of the whole' (p. 3). A coherent curriculum brings forth 'a sense of purpose, unity, relevance and pertinence', and no curriculum can be coherent if students do not realise the relevance of such a programme to their everyday lives. Again we return to Tomlinson's (2002) characteristics where real-world relevance, transferable skill sets, and a recognisable and applicable contextualisation make the classroom come alive.

If the higher levels of the Bloom's Taxonomy are to be attained, it would entail a grasp and proficiency at what Richard Paul refers to as intuitive critical thinking. He states that an 'intuitive understanding enables [all] to insightfully bridge the gap between an abstract concept and concrete applications' (Paul, 1995). A thinking classroom is able 'to move back and forth comfortably and insightfully between the abstract and the concrete [would allow them] to develop and discipline their imaginations…to generate cases that exemplify abstractions' (Paul, 1995). The concept-based curriculum is well-placed to help make these and more happen.

Concepts and Conceptual Themes

According to Klausmeier, Ghatala and Frayer (1974), the word 'concept' is used to designate both mental constructs of individuals and also identifiable public entities that comprise part of the substance of disciplines. They define concept as 'ordered information about the properties of one of more things — objects events or processes — that enables any particular thing or class of things to be differentiated from and also related to other things or classes of things' (p. 1) or what Kagan (1966) refers to as 'symbolic mediators'. These serve to connect the synapses to systematically and coherently make meaning. These 'symbolic mediators' support cross-disciplinary connections. With the nurturing of English skills within a setting of advanced intellectual material and its interconnected applications, concepts and conceptual themes ground the meaningful methodology that move students towards the higher-order attainment objectives in Bloom's Taxonomy.

The English Curriculum is typically grounded in the skills students need to attain. An academic year's units may be structured thematically or topically. This allows for a sustained engagement of the attendant issues or themes where necessary, and appropriate linguistic skills can be practised and modelled along the lines of authentic examples related to the theme or topic. Theme/topics and the depth of instruction and analysis would be dependent on ability, needs and scheduling demands. The assigned tasks could simulate the contextual and situational circumstances that the theme or topic lends itself to. It is with the consideration of authenticity and applicability that the formative and summative assessments are planned. Whether it be a research report, a proposed amendment bill for parliament or a synthesised editorial, the range of text types and tasks outlined are planned with the contextual relevance of the curriculum.

Recognising that most programmes structure units from a topical and/or thematic standpoint, Erickson (2002) demarcates how themes can be topical themes such as 'Dinosaurs' or 'The American Civil War' (p. 74). Themes can be conceptual themes as in 'Dinosaurs and Extinction' or 'Conflict During the American Civil War'. The inclusion of the concept into the unit titles brings forth the transformation to conceptual themes and this incorporation increases the degree of complex and conceptual thinking in the unit of study. These instantly elevate the levels of expectations and lend itself as an automatic cline of differentiation where educators can customise for use in their respective classrooms.

The preceding discussion on concept-based curricula as a differentiating element that can further enhance performance and achievement also brings the teacher to question. A carefully and well-thought through curriculum can only see its intended outcomes in the hands of a competent educator. The teacher's understanding and belief of the curricular philosophy, instructional modelling and synthesised application are some of the fundamentals that would be essential for making a concept-based curriculum work well in the classroom.

A Concept-Based Sample in the English Classroom

The following is a sample of an English unit in a Secondary 3 high-ability classroom in Hwa Chong Institution, Singapore.[1] This unit is entitled *Science and Technology*. Having this unit couched within a conceptual theme could see it reframed as *Scientific and Technological Evolution* (Table 10.1).

The Parallel Curriculum Model (PCM) is used because its four curriculum components lend room for flexibility to address the range of styles, needs and approaches to help cater to the diverse needs in a class. Whether it is the consideration of curriculum approaches like concept attainment or Socratic questioning to tools for curriculum differentiation, the PCM naturally provides the fluidity and flexibility of implementation of any parallel on its own or in tandem.

A brief summary of the *Scientific and Technological Evolution* Unit using the format of the PCM is featured above. The PCM is the chosen model where Hwa Chong Institution has decided to frame its curriculum documents. With reference to the concept-based curriculum, the PCM serves to help articulate the conceptual scope of applicability. The various parallels (Core, Connections, Practice and Identity) help to lay out the planned curriculum. The parallels also help in differentiated tasks that allow for task and evaluation flexibility in process and mode while incorporating the core. A concept-based curriculum can be articulated in a range of formats. The PCM is the chosen framework Hwa Chong has opted for given how the parallels presuppose an explicit and clearer inclination towards differentiation of style, learner needs and evaluation tasks.

Before we consider the curriculum, there are some essential questions and essential understandings that this concept-based curriculum aims to explore. These include the conceptions of the nature of man, the value of life, the empiricism of science and spirituality and the ethical dilemmas in the face of scientific advance to name a few:

- The Core Curriculum—The core skills of persuasion and exposition have been identified here as the fundamental linguistic focus for the unit. Persuasive techniques and expository approaches in argument, rhetoric, logic and its structures are discussed and modelled. Some of the topics that can feature within the scope of Scientific and Technological Evolution include The Internet, Gene Patenting, Stem Cell Research, Cloning, Nuclear Technology and Space Exploration amongst others. Students can and should be given options for research. This Core Curriculum has knowledge and facts explored in a systematic, coherent and contextualised manner to give students the opportunities for exploration within interest domains while staying relevant to the issue at hand. The inclusion of the *Brave New World* and *Minority Report* suggestions (with the option of the mov-

[1] Hwa Chong Institution was founded in 1919. It runs a 6-year programme across student ages of 13–18. It is a consistently top-performing Singapore school for the GCE 'A' Level Examinations. Hwa Chong has been designated as a Ministry of Education Gifted Education Programme Centre since 1999.

Table 10.1 Thematic overview of the unit—scientific and technological evolution

Core curriculum	Curriculum of connections	Curriculum of practice	Curriculum of identity
Skills: Exposition Persuasion Topics: Life altering Discoveries • The Internet • Nuclear energy • Space exploration • Human genome • Gene patenting Texts: *Brave new world* *Minority report*	Interdisciplinary concepts • Order • Population • Systems • Change • Conflict Tasks analysing the causes and effects of phenomena/discovery	Essays Panel discussions Understanding the roles of: • Researchers • End users of technology • Controllers of technology • Policymakers • Entrepreneurs Crafting: • Proposals • Bill amendments • Speeches • An analysis of trend data	Analyse component processes and/or individuals involved from the stages of discovery to implementation. Analyse the decision-making process of different stakeholders. Reflect on the qualities of individuals in innovation and discovery.

ies and/or novels) will feature significantly should a Language Arts approach be preferred. Both titles in their corresponding genre representations offer a very wide scope for activities as they are very rich thematically. In themselves, they were/are foregrounding works of Literature whose resonance for us today tell of the chilling realities of scientific and technological evolution. Mary Shelley's *Frankenstein* was used as a springboard for engagement. The study of the novel served as the catalyst into the surrounding themes and concepts.

- The Curriculum of Connections—This parallel is where further related concepts of Change, Conflict, Order, Population, Systems and Values could be explored. The richness of the arena of Science and Technology opens possibilities in conceptual expansion and this is especially valuable as a tool for differentiation. Should inductive or deductive reasoning approaches be preferred, the expansion of the conceptual base would lend further developmental insights for learners. Case studies could also feature here where tasks include the analyses of the causes and effects of developing phenomena and discoveries. Because the Curriculum of Connections can potentially expand the conceptual base, the potential for interdisciplinary work here is tremendous. When students think of concepts, skills, principles and essential understandings, they apply and engage knowledge from a cross section of disciplines, cultures, periods, approaches, topics and perspectives. For high ability learners, this is the time where integration across disciplines can be highlighted. An example of what took place in this unit was the in-depth study of the human genome mapping, stem cell cloning and cryogenics. The ethical dilemmas facing scientists and policymakers were debated alongside the shifting attitudes and values as the scientific world continues its evolution. The opportunities to explore and engage with interconnectivity in the various subject domains are plentiful. Students should not see disciplines as separate and disparate but as bodies of knowledge(s) that must be able to come together in a coherent whole. Engaging in the integration might bring about the exploration collaborative techniques where multipronged approaches to problem-solving might very well be the first steps all students need to be able to adequately function outside the confines of the classroom.
- The Curriculum of Practice—This is where students can get directly involved and immersed in activities and tasks that simulate the tasks that develop the articulated skills they have to attain. The skills of persuasion and exposition are explored via a range of written tasks like essays, reports and proposals to performance tasks like speeches and panel discussions. These tasks could see the simulation of roles for contextual resonance while allowing the situational adoption to hopefully bring forth the connections between curriculum content and reality. Synthesis is fundamental here, and if we return to Bloom's Taxonomy, this is where the higher order thinking and exemplification begin. This parallel assumes and will demand that students develop and demonstrate a deep understanding of the issue at hand not by being content experts but by being able to reframe what they have into applicable modes. By doing so, students have to incorporate assessment and reflection of proposals and possibilities put forth. Systematic assessment is worked in to be in tandem with the skills demanded for in summative

standardised tests. Formative assessment allows for possibilities for exploration into the arts where poetry, drama and art allow for creative expression. These are avenues for the more aesthetically inclined to be able to synthesise, evaluate and create products to showcase these. It allows for the richness of variety and models the various means where students are able to demonstrate the levels of concept attainment, skills acquisition and engagement via a range of processes and products.

- The Curriculum of Identity—This parallel is probably the one that provides the most inroads into the metacognitive aspect of learning. It allows and calls for students to think about themselves within the context of the discipline of study, the people within and surrounding this discipline, the issues and challenges faced and potentially what lies ahead. It calls for the individual coming alive within a subject. It requires and develops empathy. It has students thinking about their learning, their own thinking. The metacognition nurtured and required is a means where the skill of thinking about one's thinking is nurtured and cultivated. In the unit, students are tasked with the reflective pauses to assess their own paths to points of view, evaluative positions and their understandings of the implications of decisions. This stems from Borkowski, Carr, Rellinger and Pressley's (1990) beliefs that metacognitive ability and its positive social psychological attributive beliefs can be explicitly developed. This is also a platform where given a context like Science and Technology, the concerns and concepts of ethics and philosophy and the place of the individual can be given further credence for exploration without running the risk of self-indulgent introspection. Tasks could include having students analyse component processes or individuals involved with the new discoveries of science and processing this into technological implementation with its associated consequences and implications. Students can analyse the decision-making processes and principles of ground-breaking individuals understanding the hard sciences with the motivations. Perhaps the inclusion of the personal qualities of these individuals warrants study too in an attempt to understand what fuels such ability, skills, passion and vision. With individual engagement at a personal level with the content, the depth of involvement helps create a culturally and socially relevant learning atmosphere that anchors the learning experience for the student. Ee, Chang and Tan (2004) call for teachers to recognise the specific roles of such motivation and self-regulation in the context of metacognitive development. As the depth of personal engagement is individually dependent, it is necessary that educators recognise, allow for and encourage the expected diversity and encourage discussion and mutual understanding.

This sampling provides an overview of the scope and depth of learning of a topic when explored through a concept-based approach. It helps students draw parallels between content and skills with the place these have in the real world. The range of activities and approaches allow for different learner dispositions, interests and preferences without compromising the essence of the conceptual theme and the skills laid out at the onset. This range also allows for flexibility and opportunities for those who prefer a more discipline-based analysis for depth or a more orbital exploration for reach and extension. Work can be guided while leaving the line of independence and negotiation flexible without any compromise of the desired outcomes. The acquisition of English Language skills is therefore contextualised and developed through a sustained engagement with a theme that is conceptually framed for its depth and breadth. The standardised assessment is the mode of an essay where the skills of exposition and persuasion are paramount. The reading and comprehension mode is where skills of analysis, synthesis and evaluation are tested. The congruence of skills mapped out throughout the concept-based curriculum is in tandem with the mandated assessment requirements.

Assessing Concept-Based Curriculum and Its Implications

All state schools in Singapore offer the GCE 'Ordinary' and/or 'Advanced' Level Examinations where English Language is a core and compulsory subject. At the 'O' Levels, the subject is known as *English Language*, while at the 'A' Levels, it takes the form of *General Paper* or *Knowledge and Inquiry*.[2] The assessment modes do not differ too drastically in that the fundamentals of a candidate's writing and comprehension abilities are core. What might differ would be the levels of difficulty and the range of thematic coverage these papers would encompass.

One might claim that because of Singapore's continued practice of adhering to standardised models of assessment, a differentiated mode with a concept-based curriculum in English does not entail an attendant differentiated mode of assessment. However, what a concept-based curriculum can help with would be to enhance achievement levels across the grade levels and the range in educational programmes. In Singapore's circumstances, a differentiated concept-based curriculum would be yet another means to heighten linguistic ability through the enhanced contextual engagement.

Significance of a Concept-Based Curriculum for Students and Educators

From the earlier characteristics outlined by Tomlinson (2002), the following hallmarks of a concept-based curriculum are as follows:

- Transferable skills and competencies attained
- Real-world relationships and the relevance of the curriculum

[2] At the GCE 'A' Level Examinations, the majority of students would take General Paper. This is a subject classified at H1 Level where it is accorded 1 unit of the 12 units students can take. If a candidate is more advanced in linguistic ability and opts for Knowledge and Inquiry, this candidate would take this H2 subject in lieu of General Paper.

- Applicable contextualisation
- Metacognitive depth
- Engagement and motivation

The brief sample shows that all these objectives (and potentially more) can be achieved by the adoption of a concept-based curriculum and instruction. Even if there are those who believe only in the fundamentals of examination scores given the significant high stakes involved, the concept-based approach will not compromise results. If anything, having these hallmarks attained would likely up test scores and bring up the levels of tangible achievement desired. Once again, the study conducted by VanTassel-Baska et al. in 2002 reported improved shifts in all performance levels researched. Perhaps this recollection of how it has worked can serve as an impetus for further curriculum evolution in this direction.

The curriculum demands of today are challenging given the increasing bodies of knowledge supplementing the traditional corpus within the various domains. New discoveries, new understandings and new applications constantly add to the 'must-haves' and 'must-dos' in a curriculum programme. Often these are done without much reduction to what was already present and this increases demands on all fronts. When a curriculum poses real-life applicability and relevance, it helps educators decide on what really is crucial. Being updated with contextual applicability beyond just academic depth and rigour will bring credence to the efficacy of updating programmes. If we are educating our young for a workforce where they are knowledge creators, strategic thinkers and thought leaders, then the applicability of all that is learnt and processed cannot stand in isolation. Heightened relevance will increase the resonance such curricula can have. This would positively impact the learning experience we give our students.

Engagement and motivation are crucial to success anywhere. The levels of perceived self-determination and its effect on intrinsic motivation have been well documented by Deci, Koestner and Ryan (2001). If educators have found a curriculum direction that by its essence and implementation enhances personal affect levels with heightened understanding and achievement, why are we not exploiting it to its fullest potential? The intangibles just might be the most challenging aspect of education for educators as so many factors influence this. If engagement and motivational considerations could be further explored with the metacognitive effects desired, this would be a potent combination for developing the resilient, curious, lifelong learner we want. Twenty-first-century competencies come to mind beyond the articulated soft skills. Where we have a means to enhance this without any compromise, again, a concept-based curriculum appears to be an/the avenue that has more room for exploration.

Challenges Faced in Philosophy and Implementation

In any innovation of curriculum, the adage of ‘If it isn’t broken why fix it?’ comes to mind. The comfort and reassurance of continually doing what we are familiar with and comfortable are easy. It gives credence to presumably what we believe in and what we have been doing. Making changes to what we have become experts in might ironically yank the carpet from right under us, and this is especially so for those of us who have somewhat perfected the art or science of helping our students achieve the grades in the high-stakes examinations.

Most notable, predictable and understandable would be the hesitant voices guiding against the perceived potential dilution of discipline-specific fundamentals. To every teacher, there will be non-negotiables in content, process and perhaps even product. Should there be calls for a concept-based curriculum and instruction, where and how would the heretofore sacrosanct elements be incorporated? This was likely the greatest challenge in planning. Working out the curriculum programme will need a thorough analysis of domain-specific fundamentals especially in consideration against a concept-based programme that does not compromise on the agreed core. Sometimes challenges in alignment might result in what Erickson (2002, p. 64) refers to as Coordinated Multidisciplinary Units rather than Integrated Interdisciplinary Units. Some might say that the Coordinated Multidisciplinary Units might be the start necessary before real integration takes place. However keeping the conceptual lens in mind would have the onset of the journey forth on a positive footing.

The costs of educational and curriculum evolution are multifold and complicated. I recognise that while there are both researched and anecdotal benefits of a concept-based curricula shift, many roadblocks feature. These hesitations would not be unfounded either. Before any change might even be conceptualised, one needs to ask why one should tamper with a system and programme that has proven viable if we are to trust the efficacies of internationally recognised standardised test scores. Recalling the Ministry of Education’s vision and current attainment levels, many would not support a change, let alone advocate one that verges on the unfamiliar and potentially challenging. No matter how evidence-based findings and beliefs might surface, change is always a challenge. The insecure, the sceptics, the cynical and the nonchalant notwithstanding the details of a mindset change and implementation nuts and bolts are nothing short of a major paradigm shift. The following section seeks to outline some of the issues to be considered and worked through for Singapore (and perhaps others too) should such a shift be considered. While schools like Hwa Chong Institution have the considerable freedom with curriculum design, this might not always be the outlook for schools across the country.

Issues in the Implementation of a Concept-Based Curriculum

Teacher Belief and Motivation

The belief of the efficacy of a programme will be its motivating and driving force opening the paths to implementation. All involved must be shown how it can value-add all that we must do, all we want to do and all we would like to do. Hence school leaders and curriculum innovators must prepare for innovation and mindset change while keeping fundamental objectives and desired outcomes in sight. As with any move away from one's comfort zone, it must be done with the view of the shared objectives of enhancing learning, performance, engagement and motivation. In Hwa Chong Institution, this was done with a combination of the climate of pedagogic experimentation and innovation, collaboration and a student profile of intellectually probing young minds.

Administrative and Leadership Support

The philosophy of a concept-based curriculum must be something shared by the entire community. School-wide acceptance, adoption and subscription to the ethos are crucial to having the institution walk the talk of true implementation and for overcoming the multitude of challenges implicit with change. School leadership will be fundamental to this. The support from school leaders and administrative heads will lay the ground for what will feature. Amongst them, the following factors must be addressed in a concerted manner.

Ethos Building With the consensus comes the development of a common language and direction. Leadership and management must involve themselves with educators to build the ethos of innovation and innovating curriculum for increasing relevance.

Curriculum and Thought Leadership No curriculum innovation would be possible without the clear visioning of thought leaders and curriculum leaders with the foresight and the content and pedagogic confidence to see this through. These are necessary components before clarity of a concept-based academic programme can be set in motion. Curriculum leaders are necessary to provide instruction and pedagogic guidance and mentorship for the emerging steps to change take shape.

Staff Development Time must be set aside for formal teacher training. Beyond theory, there must be opportunity for teachers to work with the theory and see it in action. Sessions should be spaced out with adequate time for follow-up and reflection while planned closely enough to sustain interest and professional applicability. Co-teaching as a practice might bridge gaps and demonstrate interdisciplinary marriages to close gaps. This and more could be the manageable pedagogic adjustments for overall development.

Systematic Curriculum Revamp Bite-sized teams embarking on pilot programmes on a smaller scale would be one suggestion for moving the engine while minimising the stalling possibilities. Groups must work within and outside subject domains. Student input should be sought for negotiable avenues for curriculum flow.

Thinking Time Often said and sometimes promised, this provision of thinking time is crucial. It appears ironic that we have to schedule in time to think, but perhaps all the demands of one's time might just mandate that time is scheduled for thinking and reflection. Teachers will not be able to innovate and plan change effectively if any programme has not received adequate thought and reflection. Administrations should formally schedule time dedicated for this. Beyond what management might see as empty time, this would be time well-accounted for in the longer-term considerations of the intangibles of what teachers bring into their classrooms.

As with all aspects of curriculum innovation and evolving practice, these issues and more will not be the only ones to plague us. It will be the belief and conviction of a sound and 'defensible programme' (Renzulli, 1977) that brings us forwards.

My Reflections on Implementing a Concept-Based Curriculum

My attempt at implementing a concept-based English unit raises the precise concerns, issues and challenges I have sought to outline above. Here are some of the fundamental questions/issues I have pondered over, discussed with colleagues and continue to think about:

Student Performance and Achievement

My students have been selected through intense testing and are clearly of a high-ability profile with generally sound fundamentals. They did attain high achievement levels at both our internal standardised tests and the state-wide national examinations. How much of this is due to their innate abilities and hard work? How much of their success in the English Language can be attributed to their exposure to a concept-based curriculum?

Student Profile

Were my students already predisposed towards a conceptual framing to help guide their thought processes? Did they already come with the propensity to navigate the complexities of higher order thinking interactions and navigate them comfortably? Implementing this, I was working with students who were by and large very quick and comfortable with such intellectual navigation. Their responses and quickness to the uptake clearly fuelled my motivation levels to continue with the concept-driven curriculum. How confident am I that there will continue to be this multiplier effect across the spectrums within the microcosm of Hwa Chong?

Expanding the Student Impact

The considerations of my localised Singapore implantation aside, the efficacy of VanTassel-Baska et al.'s (2002) findings repeatedly surface. If we have seen how students across the spectrums have benefitted, why can we not bring these strategies to more students? Techniques and strategies are often not specific to any one demographic and concept-based curriculum certainly is no exception. Why are we not bringing some of these strategies that have worked for the high-ability students (and more) to others?

The Professional Community

With the challenges I faced in implementation, how much support did I receive and how much professional development and mentoring did I need to see this through? How do we create a community of practitioners who have the similar beliefs and can come together to provide both the professional and psychological support for the continued thrust to gain momentum and fruition? Perhaps the question should not be how we might do this but how we must go about setting the professional communities up. There would be no sustainability or any long-term systemic continuity.

Sustainability Concerns

Colleagues will come and go and roles within organisations change. How can there be continued support and help to sustain the interest levels amongst colleagues who are navigating the daily demands of the classroom? How much does a programme depend on individual beliefs and competencies vis-à-vis a systemic and institution-wide adoption for sustainability? Without a critical mass of expertise within a supportive political and administrative climate, truly calibrated and systemic evolution will be hard to come by. In Erickson's (2006) succinct crispness:

> Curriculum and instruction models that set up a synergistic interplay between the factual and conceptual levels of thinking are critical to intellectual development. The sophistication of the intellectual dance across synaptic divides in the brain determines the quality of the performance. As educators, we are responsible for the design of the dance.

Conclusion

Keeping curricula relevant, engaging and motivating appear to be some of the greatest challenges for curriculum planning and instruction today. Concept-based teaching as a philosophy is not new but we are at the baby stages of implementation. The interest and experimentation is indicative of a wider belief of its benefits for all educational levels. Wearing both the administrative and educator caps, I see the challenges of implementation, consensus building and nudging change within established practices that have yielded success. Perhaps what is needed now is the will of the administrators, the passion of the curriculum innovators and the drive of realisation of how this will not only enhance our key performance indicators but keep us relevant. More importantly, we do need to prepare our students for a contextual world of uncertainty where only perhaps certain universal concepts have their enduring presence. With the outlined truths of this implementation and the overwhelming truths of change management, it will ultimately be the leadership strength and the will of the masses that must forge the synergy of the paradigm shift.

References

Beane, J. A. (Ed.). (1995). *Toward a coherent curriculum: The 1995 ASCD yearbook*. Alexandria, VA: Association for Supervision and Curriculum Development.

Beane, J. (2006). *Middle years curriculum: From rhetoric to reality* (3rd ed.). Melbourne, Australia: Hawker Brownlow Education.

Boix Mansilla, V., Miller, W. C., & Gardner, H. (2000). On disciplinary lenses and interdisciplinary work. In S. Wineburg & P. Grossman (Eds.), *Interdisciplinary curriculum — challenges to implementation* (pp. 17–38). New York: Teachers College Press.

Borkowski, J. G., Carr, M., Rellinger, E., & Pressley, M. (1990). Self-regulated cognition: Interdependence of meta-cognition, attributions and self-esteem. In B. J. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 53–92). Hillsdale, NJ: Lawrence Erlbaum Associates.

Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research, 71*, 1–27. doi:10.3102/00346543071001001.

Ee, J., Chang, A., & Tan, O. S. (2004). *Thinking about thinking: What educators need to know*. Singapore, Singapore: McGraw-Hill Education (Asia).
Erickson, H. L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.
Erickson, H. L. (2006). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.
Gopinathan, S. (1991). Education. In E. C. T. Chew & E. Lee (Eds.), *A history of Singapore* (pp. 268–287). Singapore: Oxford University Press.
Jacobs, H. H., & Borland, J. (1986). The interdisciplinary concept model: Theory and practice. *Gifted Child Quarterly, 30*(4), 159–163.
Kagan, J. (1966). A developmental approach to conceptual growth. In H. J. Klausmeier & C. W. Harris (Eds.), *Analyses of concept learning* (pp. 97–116). New York: Academic.
Klausmeier, H. J., Ghatala, E. S., & Frayer, D. A. (1974). *Conceptual learning and development: A cognitive view*. New York: Academic.
Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice, 41*(4), 212–218.
Marland, S., Jr. (1972). *Education of the gifted and talented* (Vol. 1: Report to the Congress of the United States). Washington, DC: Office of Education (DHEW). Retrieved from http://files.eric.ed.gov/fulltext/ED056243.pdf
Ministry of Education. (2008). *English language syllabus 2010.* Retrieved from http://www.moe.gov.sg/education/syllabuses/english-language-and-literature/files/english-primary-secondary-express-normal-academic.pdf
Ministry of Education. (2011). *English language institute of Singapore (ELIS) to play key role in strengthening the teaching and learning of English*. Retrieved from http://www.moe.gov.sg/media/press/2011/09/english-language-institute-of-singapore-launch.php
Organisation for Economic Co-operation and Development. (2014). *PISA 2012 results in focus*. Paris: OECD. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf
Passow, A. H. (1982). Differentiated curricula for the gifted/talented. In *Curricula for the gifted: Selected proceedings for the first national conference on curricula for the gifted/talented* (pp. 4–20). Ventura, CA: National/State Leadership Training Institute on the Gifted and Talented.
Paterson, K. (2005). *Differentiated learning: Language and literacy projects that address diverse backgrounds and cultures*. Markham, ON: Pembroke Publishers.
Paul, R. W. (1995). *Making critical thinking intuitive*. Dillon Beach, CA: Foundation for Critical Thinking.
Pual, R. W., & Elder, L. (2003). *The miniature guide to critical thinking: Concepts and tools*. Dillon Beach, CA: Foundation for Critical Thinking.
Pohl, M. (2000). *Learning to think, thinking to learn*. Melbourne, Australia: Hawker Brownlow Education.
Renzulli, J. S. (1977). *The enrichment triad model: A guide for developing defensible programs for the gifted and talented*. Mansfield, CT: Creative Learning Press.
Ritchhart, R., Church, M., & Morrison, K. (2011). *Making thinking visible: How to promote engagement, understanding, and independence for all learners*. San Francisco: Jossey-Bass.
Tishman, S., Perkins, D. N., & Jay, E. (1995). *The thinking classroom: Learning and teaching in a culture of thinking*. Boston, MA: Allyn & Bacon.
Tomlinson, C. (2002). Foreword. In H. Lynn Erickson (Ed.), *Concept-based curriculum and instruction: Teaching beyond the facts* (pp. 7–10). Thousand Oaks, CA: Corwin Press.
VanTassel-Baska, J. (2002). *Curriculum planning & instructional design for gifted learners*. Denver, CO: Love Publishing.

VanTassel-Baska, J., Zuo, L., Avery, L. D., & Little, C. A. (2002). A curriculum study of gifted-student learning in the language arts. *Gifted Child Quarterly, 46*, 30–44. doi:10.1177/001698620204600104.

Wiggins, G. P., & McTighe, J. (2005). *Understanding by design* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Processes and Issues in Concept-Based Curriculum for the Humanities

Sheau Yang Yak-Foo and Kar Boon Koh

Introduction

Although humanities programmes offered by schools in Singapore typically include subjects like geography, history, music and art, this chapter will focus only on how a concept-based curriculum unit in geography can be carried out and what the essential elements of such a unit are. The chapter will also illustrate how the design of such a unit ensures ample opportunities for high ability learners to strengthen their intellectual capacities. The implications of implementing such a unit will also be highlighted, and these include the likely challenges that will be encountered and the suggestions that can help manage them.

The Context

To nurture and develop high ability learners (HALs) in Singapore, the Ministry of Education implemented the Gifted Education Programme (GEP) in 1984. This was a centrally run programme that catered to learners from Primary Four to Secondary Four. In 2004, this programme was decentralised at the secondary school level and the Integrated Programme (IP) was introduced. The IP is one that allows university-bound learners to skip the General Cambridge Examination at the "Ordinary" Level (GCE "O" Level) to take the General Cambridge Examination at the "Advanced" Level (GCE "A" Level) at the end of the 6-year programme.

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Raffles Institution (RI) became one of the few secondary schools which had the autonomy to develop its own school-based gifted education programme to meet the needs of its high ability learners (Sum, 2008). RI now provides a 6-year seamless IP, known as the Raffles Programme (RP), which builds on the principles of the Integrated Curriculum Model by VanTassel-Baska (1986), Understanding by Design by Wiggins and McTighe (2005), as well as the concept-based instructional unit design by Erickson (2007). These frameworks were chosen because of their emphasis on the use of concepts. As part of the curriculum framework for this programme, macroconcepts such as systems, change, model and scale are used as organisers to enable the bridging of various disciplines.

This chapter will highlight the frameworks used in the design of a concept-based curriculum for geography under the RP, the elements used in a concept-based unit of instruction, the importance of such a curriculum, as well as the concerns and challenges of using such a curriculum.

Concept-Based Curriculum in Geography

Although there is not much research done in the discipline of geography in terms of concept-based curriculum, numerous practitioners are already making use of concept-based curriculum (Geographical Association, 2006).

In fact, geography education has over the years experienced a shift from memorisation of facts to the acquisition of competence in geographical reasoning, with a focus on causal relations and principles (Gregg & Leinhardt, 1994). Concepts in geography stand for economies of thought that are essential in the shift away from the perception that geography is merely a mass of memorised fact (Rawling, 2009). The truth is, in the twenty-first century, where information is readily available in huge amounts, learners need to discern the important from the unimportant, the essential from the frills. As such, they have to learn beyond facts and achieve deep understanding of a discipline. At the same time, they need to be equipped with the skills to think conceptually, critically and creatively and to solve problems. In fact, not only are higher levels of thought necessary in the absorption, comprehension and extension of concepts, the ideas should also be revisited repeatedly through the application of deductive and inductive thinking in order to achieve complete understanding (Avery & Little, 2003). Because concepts allow learners to construct systems of ideas that can be applied to new situations, they also encourage the transfer of knowledge learnt in one context to other situations (Gilbert & Vick, 2004).

In the Singapore context, learners are often clear about the key geographical and content concepts as stated in the syllabus document, but they may not have received explicit instruction to help them understand these concepts as key or enduring understandings or generalisations. For learners to see the subject as a tool they can use for reasoning and problem-solving, it has to be taught in a way that connections can be made (Gregg & Leinhardt, 1994). For example, in the "O" level geography syllabus, learners can benefit immensely if they are shown how main concepts such as "Green Revolution", "productivity" and "soil" work together in a broader sense.

To do that, there is a need for the design and implementation of a concept-based curriculum. Such a curriculum seems particularly suited for high ability learners (HALs), who have high readiness for conceptual thinking and the capacity to cope with the in-depth exploration of knowledge at the conceptual level (Renzulli, 1977). These learners also possess the intellectual sophistication to manipulate and handle conceptual schemata (Gallagher, 1985; Sternberg, 1985) and "unusually keen powers to see and understand interrelationships" (VanTassel-Baska, 1986). In other words, for this group of learners, merely teaching geography as discrete topical concepts is inadequate—the use of macroconcepts can provide these learners with the "connective tissue" with which to link their understanding to other topics or even subjects. A concept-based curriculum will provide them with the opportunity to apply concepts, generalisations and principles to new knowledge (Erickson, 2002) and facilitate the exploration of the content at a much deeper level using the language that a practitioner would use in the discipline (Schill & Howell, 2011). Erickson and Lanning (2014), who found that learners' test scores improved after the use of a concept-based model, argue that when learners have to apply the facts and skills learnt on a conceptual level, the content learnt is processed at a deeper level in their brain, and this enhances retention and deep understanding.

A concept-based curriculum also equips learners with the power to think geographically (Jackson, 2006) and has the potential to increase student autonomy through its more learner-centred and concept-based enquiry (Winter, 2011). The constant interrelating of form and content in a concept-based curriculum also encourages connections to be made across different content areas. Such an epistemological concept model cultivates HALs' level of comprehension and appreciation of knowledge as systems instead of individual parts. In other words, exposing learners to macroconcepts, generalisations, themes and principles within and across domains of knowledge enables them to internalise knowledge that could be applicable in the future. Over time, learners will have developed conceptual systems in their brains that help with the processing of new information, especially when this concept learning process involves authentic experiences that are relevant to the learners and applicable in the real world (Erickson & Lanning, 2014). All this makes concept-based curriculum a good fit for HALs. In fact, according to VanTassel-Baska (1986), this epistemological approach to curriculum for HALs has received much support from many researchers in the field (Hayes-Jacob, 1981; Maker, 1982; Tannenbaum, 1983; Ward, 1961).

From Theory to Practice

An Eclectic Approach to Concept-Based Curriculum Frameworks

As mentioned earlier, the design of the Raffles Programme involved principles from three frameworks—the Integrated Curriculum Model (ICM) (VanTassel-Baska & Wood, 2010), the Understanding by Design framework (Wiggins & McTighe, 2005), as well as the concept-based unit design (Erickson, 2007). These frameworks contain key components or "organisers" that help in selecting and organising content that is meaningful for the learners and which answer questions such as "How important are certain concepts and skills?" and "How can we organise learning experience at suitably abstract levels to accommodate the capacities of gifted learners?". They focus on the understanding of concepts, principles and transferable ideas that arise from the study of topics and facts, and because they are complementary to one another, RI decided to combine the three frameworks in 2013. Elements from all three frameworks were therefore included in the design of the unit of instruction featured in this chapter.

Because of the learners' readiness for more advanced content material, content acceleration is often applied for the content mastery dimension, which focuses on the acquisition of skills and concepts within a domain of inquiry. This dimension is one of several curriculum dimensions that help to cultivate deep understanding of a discipline from the Integrated Curriculum Model (ICM) framework (VanTassel-Baska & Wood, 2010). For the concept-based units designed by the geography team in the RP, the high-ability Year One learners were ready to be taught content meant for upper secondary learners. The units were also designed with an emphasis on the acquisition of skills that aid in the development of a high-quality product—worksheets and tasks were designed to assist learners in their own construction of knowledge instead of merely focusing on facts. The advanced content knowledge, the manipulation of information at complex levels and the organisation of learning experiences around major issues, themes and ideas provided opportunities for higher order thinking and processing (VanTassel-Baska & Wood, 2010). This concept-based focus helps to alleviate the problem of content overload that learners often struggle with. This is especially important in the case of curriculum for HALs as there is a perception that such learners need a large amount of complex factual information in a discipline. The truth is, without the support of a conceptual framework, even highly motivated learners would struggle to remember all of the facts. In fact, Wiggins and McTighe (2005) posit that the focus in learning should be on the understanding of "big ideas" and core processes within the content standards. This approach is supported not just by Erickson (1998) but also Reeves (2002), who calls for a focus on transferable concepts and processes to prioritise content.

Another framework that was used in the design of the units is called Understanding by Design (UbD). This model focuses on identifying what the learning goals or desired outcomes are before designing a curriculum unit, assessment and classroom instruction. The approach is used for all the subjects in the RP because it enables teachers to think more conceptually and hence teach more conceptually. More relevant to our discussion of concept-based curriculum, the UbD approach also places much emphasis on concept-based "enduring understandings", which are similar to what Erickson (2007) calls "generalisations". In addition to essential understandings, another key feature of such an approach is the use of performance tasks for assessment. A performance task is one that demonstrates what learners must know, understand and be able to do in the unit. According to Wiggins and McTighe (1999), it is important to include a culminating performance task in a concept-based curriculum because the idea is to set up success by teaching with the end in mind.

Another framework that has had a huge influence in the design of the unit of instruction in this chapter is Erickson's concept-based unit design (Erickson, 2007). In order for learning to go beyond factual content and related processes and skills, principles and concepts have to be incorporated too so that the curriculum becomes a concept-based three-dimensional one. This approach also allows for the scaffolding of thinking, which results in understandings with greater depth.

In short, elements of the three frameworks were included in the RP chiefly because a concept-based curriculum can not only help learners overcome the fear of tackling huge amounts of factual information, but more importantly, it can also help them achieve holistic learning through enhancing their ability to relate to complex real-life world issues. It provides more space for learners to explore, experiment and discover as they work with the concepts (instead of only facts) and the task of forming generalisations that make sense to them. There is of course the added advantage of allowing teachers greater flexibility with less prescription in the teaching and learning of the subject (Firth & Winter, 2007).

Essential Understandings and Generalisations

Because the terminology used in the Understanding by Design framework and Erickson's concept-based unit design can be a source of confusion for teachers, there is a need to define and explain the terms "essential understandings" (EUs) and "generalisations". Wiggins and McTighe (2005) define an EU as an enduring and often abstract idea that can be supported by various examples which learners can remember over time. Erickson (2002) defines a "generalisation" as a timeless, transferable statement about the relationship between two or more concepts. In truth, although the two terms may be perceived to be interchangeable, there is a subtle pedagogical difference between them in practice, which will be elaborated on in the following paragraphs.

Generalisations tend to allow for further development and greater exploration of depth of knowledge. The approach to be used depends on the purpose of the lesson. For example, if the purpose of the lesson is to check the learners' content learning and differentiate the abilities of the learners, Erickson's generalisation is preferred. The reason is that under this approach, initial generalisations can be further developed and the reasoning sharpened to higher levels of sophistication with the asking of "how?" and "so what?" (2007). The highest level, Level 3, provides the greatest depth of key understanding, and this detailed elaboration and depth is what is required at RI for high-stakes examination excellence in Singapore. In addition, Erickson's approach to assessment with the use of provocative, conceptual and factual questions (e.g. essay writing, structured questions and performance tasks) provides the opportunity for learners to think more deeply, as well as for marking to be based on level response, which facilitates the differentiation of student abilities.

If the teacher's intention is to introduce a new topic and elicit general, open-ended discussions, both EUs and initial generalisations are good tools because at this stage, learners can easily express their points of view through using simple statements about the concepts concerned. These statements can stimulate learners' thinking and provide them with room for exploration. However, using these less sophisticated statements as the focus in assessment may lead to challenges in differentiating learners' abilities because their relative superficiality may not sufficiently reflect learners' content learning for the purpose of assessment.

In other words, the choice of whether or not to further develop the EUs and initial generalisations into higher-order, more in-depth understandings depends on the objective of the lesson. In the following section, an example of how generalisations and other tools are used in a concept-based unit in geography will be discussed.

An Example: A Concept-Based Unit in Geography

The topic Geography of Food involves the macroconcept of systems, which is appropriate because the topic involves elements of a system—there are inputs, processes and outputs. This concept of systems is reinforced throughout the units in Geography of Food (Green Revolution, high-tech farms in Singapore).

One intradisciplinary concept-based unit developed, intended for Year One learners, is entitled "Is There Enough Food for Everyone?" and it involves the main concept of food security. Sub-concepts which are involved in this unit also appear in other topics in geography.

Critical Content and Key Skills

It should be noted that in the design of a concept-based unit, teachers should bear in mind the important role that critical content and key skills play. Critical content includes fact-based topics that are part of the requirements in the syllabus, but instead of being the end in mind, critical content serves as a tool for understanding essential understandings and generalisations. The fact is, in order for learners to be able to handle the macroconcept adeptly, they must know the factual content and micro-concepts well.

For this unit, basic content such as the differences between the levels of food consumption in developed and less-developed countries and the reasons for these patterns, factors affecting the intensity of food production, developments in food production and benefits and threats to new technology, is covered. The key to the concept-based unit is the use of concept-based strategies to synthesise all this content for the learners.

Topic and Developing Concepts for Deeper Learning

As mentioned earlier, the understanding of concepts is more important than the study of fragmented topics. As such, in this unit, the macroconcept "systems" is chosen to organise facts in the "Geography of Food" topic. "Systems" is an appropriate and natural macroconcept with which to work in this unit because farming involves a system of inputs, processes and outputs. The macroconcept encourages learners to think more deeply when they process the critical facts in terms of their relationship to the ideas of "systems". As a result of this deeper intellectual process and the opportunity for deep thinking to be transferred to something learners can relate to on a personal level, there is prolonged retention of the factual information. For example, learners' understanding of the dynamics of input and output as part of a system may become even clearer when they realise that their time spent on the learning and revision processes can also be seen as the input and their examination result the output. According to Erickson (2007) and Jacobs (1997), having such a lens through which knowledge is viewed allows for synergy to be created when the factual and conceptual processing centres in the learners' brains are set up. Table 1 shows some of the concepts learners were introduced to in this unit (Singapore Examinations and Assessment Branch, 2011).

Table 1 Concepts covered in unit

Concepts and sub-concepts	Agricultural/food production systems (higher-order concept)
	Green Revolution (higher-order concept—a phenomenon, case study)
	Food consumption (process/pattern)
	Intensification (in food production process)
	Productivity (output per unit area/labour per unit area)
	Relief (natural inputs)
	Soil (natural inputs)
	Demand (human inputs)
	Technology (human inputs)
	Capital (human inputs)
	Government policy (human inputs)
	Intensification (sub-concept, can be an outcome of greater demand from a smaller piece of farm land)
	Eutrophication/salinisation/water pollution (negative output from overuse of chemical fertiliser input)

Source: Geography GCE Ordinary Level Syllabus (2235)

One of the ways to introduce the idea of concepts to the learners is through the inductive concept-development method proposed by Hilda Taba (1966). This interesting method has proved very useful in the introduction of concepts to the learners at RI and in helping them arrive at their own generalisations. Generalisations gleaned from the exploration of concepts can help learners organise the messy and confusing knowledge of the world in a way that makes managing and understanding the knowledge an easier task. The exploration of concepts also helps to prevent learners from understanding knowledge as merely prescribed facts or technical competencies (Winter, 2011). This approach supports the notion of constructivism, a school of thought heavily influenced by Vygotsky (1978), and fosters critical thinking and deep understanding through connection making, which can help learners in their ability to comprehend interrelated concepts and apply concepts in multiple contexts (Erickson, 2002).

The Hilda Taba way of concept development helps learners to experience the self-discovery process that enables them to construct their own knowledge and allows them to have greater ownership of knowledge, hence enhancing their ability to internalise and retain it. Throughout the 6 years of the Raffles Programme, this method is taught explicitly and repeatedly across the disciplines. Because of the explicit knowledge and use of this strategy, learners can be introduced to and explore abstract concepts in different topics and subjects.

Graphic Organisers

Graphic organisers are another tool that learners are given to help them organise the ideas they have. After an introduction to the idea of concepts, learners are sometimes given a graphic organiser with which to organise the terms they have come up with. For example, for this unit on Geography of Food, the organiser would include inputs, processes and outputs, all of which make up a system. Then as the unit progresses, they will be given organisers that are more advanced and which also involve elements and boundaries. This enables learners to visualise the complexity of a system. Graphic organisers are no doubt useful tools that help learners process, organise and integrate information. According to Gallavan and Kottler (2007), learners experience increased motivation, display speedier short-term recall and exhibit more long-term achievement with the effective use of graphic organisers in social studies. In addition, graphic organisers can help learners to summarise and manipulate information such that the learning of geographical terms, structures and functions become more manageable and memorable even with the increasing amount of content to be covered. Concept learning is enhanced when learners are better able to visualise the complexity of a system and visualise the "big picture" or "pattern" of all the parts involved in a system.

Developing Generalisations for the Unit

There are three levels of generalisations (Erickson, 2007) and scaffolding thinking that can help learners achieve generalisations that are more sophisticated. The initial generalisations crafted by the learners are merely an introduction to an essential understanding of a topic and they tend to lack the depth required for the study. More scaffolding is required to reflect more sophisticated thinking. Therefore, in addition to the initial attempt at constructing generalisations and the introduction of graphic organisers, learners are provided with guiding or essential questions (e.g. What are the trends and challenges in the production of food crops?) along the way to aid them in their exploration of the generalisations at a deeper level.

Guiding the learners to write generalisations by scaffolding thinking helps to deepen their understanding of the topic. Such deep questioning by teachers plays a major role in creating a conducive environment for concept-based learning—the teacher can empower the learners when he or she questions and raises potential issues that inspire them to discuss and debate these issues (VanTassel-Baska, 1986). Such questioning can be done through the use of open-ended, essential questions that relate to the "how" and "why" of the generalisation, which challenge thinking and elevate the level of the discussions (Erickson, 2002). They can also help learners discover patterns and build personal meaning in the new knowledge they acquire.

For this topic on the food production system in Geography of Food, the generalisations are crafted based on the concepts of "Green Revolution" and "technology" and they explicitly reflect the macroconcept of "systems". At the most basic level of generalisation, critical concepts such as system, man-made, inputs, processes, outputs, need and food are included. The following illustrates the various levels of generalisations.

Level 1 Food production is a man-made system that requires both human and natural inputs in order to carry out farming processes; and that results in food as output to meet the consumption needs of society. At the first level, the generalisation helps learners to understand the "big idea". But in order to elevate the learners' thinking to the second and more complex level, scaffolding has to be provided so that the generalisation can answer the "how" of the idea. More concepts, in this case, technology and population growth, are added to the second level of generalisation.

Level 2 Food production systems that have introduced more advanced technology (inputs) result in more efficient processes and higher amounts of food output. This is known as intensification. However, the undesirable impact (outputs) to people and the environment include soil salinisation and eutrophication. One such example of food intensification is the Green Revolution. To challenge the learners to greater complexity, the generalisation at the final level not only includes two more concepts of appropriate technology and sustainable food production system, but it also helps learners understand the significance or effect of the relationships between the various concepts and see how the goal of a food production system involves both benefits and trade-offs. In other words, it answers the "so what" of the idea.

Level 3 Increasing understanding of the damaging outputs from various food production systems can lead to better farming management in terms of inputs and processes. These systems constantly involve complex decision-making that can be affected by economic (supply and demand), physical (climatic change), social (rapid population growth) and political (food policy) inputs. Appropriate technologies help to achieve sustainable food production systems that result in benefits for different groups of people (farmers, consumers) and the environment at different scales. The generalisation at the third level helps to contextualise the knowledge and facilitate the relevance of this knowledge to the lives of the learners. The learners realise that their personal food preferences affect the food production systems on a larger, national or even global scale. This contextualisation helps the learners understand the complexity and dynamics of food production systems and how they are affected by global food consumption patterns and trends as well as their food choices at a personal level.

For this unit, there is an additional emphasis on how the use of "systems" in rice growing (Green Revolution) can be transferred to high-tech farming in Singapore. Field visits to local high-tech farms and talks by local food production scientists help learners connect knowledge to the real world, thus enhancing deeper understanding. Through these experiences, learners learn how the constraints of limited land for local food production can be overcome with better thought-out government food policy and advanced technology. The crafting of generalisation at these levels increases the potential for the concepts to be explored in greater depth and breadth by helping learners uncover the "so what's" in the topic of study when they synthesise the factual examples and summarise the learning. In addition, because the macroconcept, which is also found in other disciplines, is also included in the generalisation, learners are better able to relate what is learnt about the subject to other topics or disciplines.

Tools for Conceptual Understanding

Concept Maps In addition to the use of inductive concept development, graphic organisers and scaffolding learners' thinking in the development of more sophisticated generalisations about the topic, concept maps also play an important part in a concept-based curriculum. In fact, for this unit, they are used as part of assessment, as Avery and Little (2003) suggested. Concept maps are a powerful tool that enhances learning and evaluation for learners because they help to communicate the structure of complex ideas and represent propositional linkages within systems of related concepts (Novak, 2010). These maps are more process-oriented and learner-centred, therefore they tend to promote learners' construction of meaning and "intellectual ownership"; studies have reported that the author of the map reaps the greatest benefit of concept mapping (Kinchin, 2000). Often, the most valuable learning comes from the "process", not the "final" products. Huai (1997) supports this idea as he argues that through the process of constructing the concept maps, the

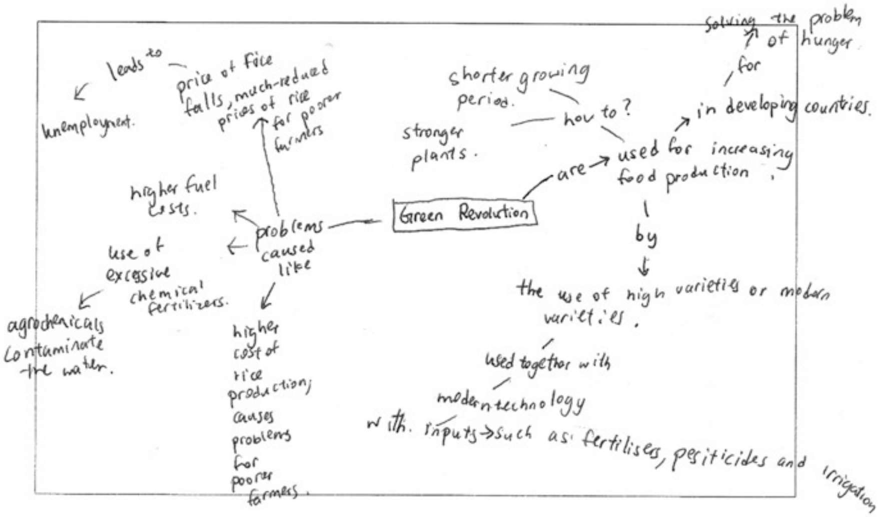

Fig. 1 An example of a concept map drawn by a student

student is made aware of the knowledge that he/she possesses and gaps to be filled, as well as the personal learning strategies utilised; in other words, the construction of concept maps could increase the student's metacognitive awareness and the repertoire of metacognitive strategies because of the enhanced attention to deficient procedures and the possible ways to compensate for them. The complexity of the maps to be constructed can range from very simple—showing just the skeleton/framework—to more complicated ones containing a lot more details when the learners are more ready.

Furthermore, the process of constructing such concept maps encourages visible thinking. Because the construction of a concept map can reveal much about the perceptions of a map's author and highlight the personal relevance of a topic to the author, it can be a useful tool not just in helping the teacher understand the prior knowledge that needs to be activated during the learning process but also in the assessment of the level of understanding of a topic. Therefore, concept maps form part of the assessment in this unit, and below is an example demonstrated by a student (Fig. 1).

Guiding Questions Another way to assess the conceptual understanding of learners is through the use of guiding questions that are open-ended and that aim to develop learners' thinking from concrete to abstract levels. Erickson (2007) suggested the use of three types of questions: factual questions (f), conceptual questions (c) and provocative questions (p). While factual questions are necessary for development of critical content, conceptual and provocative questions encourage learners to develop an inquisitive mind and look beyond the remembering of facts in their learning as they seek more complex and in-depth understanding. In fact, these questions present three levels of understanding for the learners—at the first level, the questions relate only to facts; at level two, the conceptual questions demand a knowledge of facts and an understanding of concepts that are supported by carefully selected facts; at level three, the provocative questions not only require conceptual understanding supported by facts but also the ability to arrive at a conclusion and to justify a stand with the use of macroconcepts such as the "scale" of impact and the analysis of the importance of inputs, processes and outputs.

For example, typically in this unit, learners are given the opportunity to first clarify concepts such as "sufficient food", "staple food", "need" vs "greed" and "wastage of food" before challenging the notion of whether a sufficient amount of food for everyone in the world means everyone is able to have access to the food. This is then followed by an exploration of other causes of "insufficient food" for the world, such as the exponential rate of population growth.

Some examples of the guiding questions that can be used for assessment are as follows:

- What are the necessary conditions to support the Green Revolution? (f)
- Which conditions (physical factors such as relief, soil, climate; social factors such as education level of the farmers; political factors such as support from the government in terms of capital inputs, technology; economic factors such as the supply and demand for rice in the local/foreign market) do you think play a more important role in the success of the Green Revolution? Explain your answers. (f and c)
- Who should provide for these conditions (the individual farmers, the government, the non-governmental organisations (NGOs), charity organisations)? Explain your answer. (c and p)

The learners' responses would be a good indication of the level of conceptual understanding they have developed for the unit and provide feedback for the teacher for potential content/conceptual gaps to be filled.

Deductive Concept Development Another way to check for learners' understanding of concepts is through the use of deductive concept development. Sometimes, generalisations are also taught deductively. Learners are given the generalisation without having to construct it themselves, but they are to apply the definition to different situations or design different experiments to prove that the definition is correct. For example, when learners are given the generalisation of "Different elements of a system have different degrees of influence over the system", learners may come up with "Governments may have a greater influence over the successful implementation of the Green Revolution for poor farmers as they can provide the necessary inputs and prevent increasing income gap between the poor and rich". This deductive thinking process can be used to check if learners are able to apply what they have learnt to other contexts. In other words, deductive concept development is more often used to assess learners' understanding and ability to apply. Table 2 illustrates examples of how generalisations can be applied to other contexts in geography.

Table 2 Application of generalisations to rice farming

Generalisations of "systems"	Generalisations to be applied to rice farming systems
Systems exist in the natural and man-made world for a purpose	Agriculture is a human/man-made system that is created by man to satisfy our need for food. However, most agricultural systems, especially traditional form of farming, are highly dependent on the physical systems such as the weather system/hydrological systems, etc.
A system's properties are determined by how the elements within the system interact and how they respond to input from outside	A traditional rice farming will benefit from irrigation (outside the system, high-yield researched variety as part of technological input) that can provide optimum conditions for elements such as high-yield seeds, hot/wet weather and clayey soil to interact and provide higher outputs/yield
Complex systems are made up of different sub-systems	Rice farming system is made up of sub-systems such as the irrigation system, human labour system, climatic system and land-soil system. It is also affected by the political system, economic system and education system of a country
	The issue of whether there is sufficient food in the world is a complex issue, as other sub-systems (both physical and human systems) such as economic system/political system are involved

Performance Task Finally, as mentioned earlier, according to Erickson (2007) and Wiggins and McTighe (1999), it is important to include a culminating performance task in a concept-based curriculum. For example, for the performance task of this unit conducted a few years ago, learners were given the group task of creating a book or comic strip for children aged 8–9 years old with the purpose of explaining to the target audience the concept of food security in Singapore. The learners did the research and collected data on the origins of various ingredients of local dishes. The task was authentic and it gave learners a glimpse of how farming as a system could affect individuals—learners had to visit supermarkets to find out about the food sources of their favourite dishes, conduct interviews and present information to target audience in any format they chose. In this way, learners are better able to see the link of the newly acquired concepts (such as "intensification" of local farm production and the government's input in ensuring food security) in real-life settings, which can enhance understanding and retention.

To conclude this section on the intradisciplinary concept-based unit of instruction, here is a summary of the strategies and tools used:

- The use of inductive concept development to help learners construct clearer understanding of concepts
- The use of graphic organisers as a tool for viewing the concepts (both macro and micro) at a glance
- The writing of generalisations by scaffolding thinking
- The use of concept mapping as an assessment tool for pre- and post-tests
- The use of guiding questions as an assessment tool

- The use of deductive concept development to check learners' ability to transfer their conceptual understanding
- The use of performance task as an assessment tool—using alternative products from performance tasks that are contextualised and authentic to prove the occurrence of transfer and application

Benefits of Concept-Based Curriculum

The application of a concept-based curriculum in the unit described has reduced the need to force-feed information and facts because the focus on concepts and the work with generalisations enable teachers to "teach less" and learners to "learn more".

Macroconcepts, in particular, can help learners make connections more easily, because they are ubiquitous. For example, what learners learn in geography about the macroconcepts of change and systems can easily be applied to other areas of their lives. As mentioned, learners are sometimes asked to write and apply generalisations in the context of geography. This approach can be applied to other subjects and situations (e.g. self, family) as well so that teachers can check for transfer. The following are some examples:

- System generalisation: All parts of a system are interconnected; manipulating one will directly or indirectly affect another.
- Application to another subject (science): Changing the variables in a science experiment will affect the outcome of the experiment. Changing the value of an unknown variable in a math equation will affect the answer.
- Application to a personal situation: I have always thought that if I put in extra hours (input) to prepare for my examination, I will be able to achieve better grades (output). But my teacher reminded me that if I do not improve my learning strategies (process), then the input may not directly affect output in the desired manner.

Many of the learners enjoy constructing meaning and creating generalisations because it allows them to relate to ideas at a deeper and more personal level. This ownership of knowledge can help to enhance retention and internalisation. Generalisations help learners see the "big picture" instead of only the "nitty-gritty" of a situation or problem. When one is being conceptual, there is likely to be more clarity, logic and organisation in one's thinking.

This ability to think conceptually is a lifelong skill, and it is essential because of its potential to help learners see patterns, make connections, and understand that concepts are transferable and can be applied to other areas or situations. In other words, training learners to learn conceptually can help them develop their ability to think deeply and solve complex problems. While learning conceptually may be challenging at first, it is a skill worth acquiring. As long as there is sufficient scaffolding, even learners who are not accustomed to concept-based learning can benefit from it.

Implications of a Concept-Based Curriculum

Need for Suitable Teacher Training

Although a concept-based model of curriculum allows learners to have a unified view of a field of inquiry, its effectiveness is highly dependent on the teacher's competency in implementing the curriculum. Not only do teachers have to possess in-depth knowledge of one discipline, but they must also be able to make appropriate connections to other disciplines and maintain a consistent vision in terms of the exploration of concepts (VanTassel-Baska, 1986). In other words, teachers should display professionalism through their selection of concepts for the subject, their understanding of the processes involved in concept formation and their design of an appropriate curriculum for the learners (Winter, 2011). Indeed, the importance of the role of the teacher in learners' concept formation in a concept-based curriculum cannot be undermined.

The teacher training provided for a concept-based curriculum is thus crucial in the implementation of the curriculum, because in addition to deep content knowledge, the teacher must be skilful in effecting the various strategies to take the learners to increasingly sophisticated levels of understanding. Although training opportunities for teachers teaching HALs are aplenty in Singapore, training that is not customised to cater to the specific needs of the teachers tends to be less beneficial (VanTassel-Baska, MacFarlene, & Feng, 2006). It is therefore important to identify the needs of the teachers before exposing them to various approaches in curriculum design so that they will be able to make the appropriate professional judgement in teaching.

Need for Adjustment of Teachers' Mindset

For a concept-based curriculum to be fully embraced by the teachers, it is vital that the mindset of teachers be changed in order to promote concept-based learning. In fact, according to VanTassel-Baska and Stambaugh (2006), the middle management (teachers, curriculum heads and in-house teacher trainers) may seem "insignificant and less powerful" compared to the school leaders;; who play a major role in decision-making and policymaking processes, but they are, in fact, important players that are likely to "propel initiatives for gifted learners forward within the context of school goals" that can result in the successful implementation of a concept-based curriculum.

When concept-based curriculum was first implemented at RI, some teachers had to experience a change of mindset—from relying on a more traditional, two-dimensional curriculum that focuses on facts and skills to working on a three-dimensional one that has an added dimension of concepts, principles and generalisations. The interdisciplinary nature of a concept-based curriculum and the teacher's initial lack of familiarity are some possible reasons for the discomfort some teachers felt initially, although this was mitigated by the various types of professional development programmes provided by the school.

Need for the Recognition of Challenges in the Curriculum-Writing Process

On top of being open to such a curriculum, teachers also need to be realistic about the process of preparing such a curriculum—not only does it require a very good understanding of the learners' needs and the syllabus requirements, it also requires numerous decisions to be made during the tedious and time-consuming rewriting of syllabus into generalisations with key concepts. At RI, although the training that the teachers underwent helped them to understand the benefits of the new curriculum, there were many new things to be learnt, and the process of getting teachers used to the new curriculum took a while. In particular, writing the curriculum using the UbD template for every topic meant that teachers from the curriculum planning team not only had to identify the kind of concepts to be included in the curriculum, but they also had to weave the selected concepts into meaningful key understandings (KUs). Because concepts abound in the school curriculum, it was difficult to decide and justify their inclusion or exclusion. In fact, this can lead to the possibility of teachers becoming too fixated on the selection and justification of the concepts to be included, thereby neglecting the development of real geographical understanding (Winter, 2011).

Even after the selection of concepts, it was a mentally stimulating and time-consuming task to craft the KUs, especially when coupled with the teaching workload. It was therefore essential that teachers shared resources and held discussions when crafting the KUs. The truth is that KUs always seem to be a work in progress, so that teachers are constantly trying to improve on them.

Greater collaboration among educators, however, will no doubt achieve the desired objectives that will motivate learners and meet their needs.

Need for a Refocus on the Learning Process Instead of Merely Examination Excellence

For a successful implementation of a concept-based curriculum, learners need to discover the joy of the learning process. However, some learners' unwavering focus on examination excellence can prove to be a challenge in the implementation of a concept-based curriculum—instead of enjoying the processes of learning in a concept-based curriculum or lesson, these learners may prefer one that they think will serve them well in getting desirable grades. Often, their perception of an "effective" lesson is one that merely provides them with the facts and skills required for an examination—it may not stimulate their thinking to a higher order.

The reason for this preference could be that high-stakes examinations in Singapore are seen as being critical to one's future, and therefore learners in Singapore often focus more on academic results instead of the process of learning (VanTassel-Baska et al., 2006). A shift in the mindset of parents and learners is necessary before learners can be truly motivated and engaged in learning. This can be brought about by a better understanding of the benefits of a concept-based curriculum. Should this happen, the overemphasis on examination excellence may be reduced.

Conclusion

Learning in the twenty-first century is not just about learning facts, and this is something all teachers should know. It is the responsibility of the teachers to help learners become more self-directed and self-motivated, to evaluate their own decision-making skills and to make the necessary adjustments to the strategies when needed. As such, a concept-based curriculum, with its emphasis on principles and generalisations, is an appropriate way of helping learners to be independent and critical thinkers.

Although conceptual learning must be truly embraced by teachers, before there can be any success in the implementation of any concept-based curriculum (Giddens & Brady, 2007), adapting such a curriculum does not mean having to learn a brand new set of pedagogies or strategies. A whole-school approach for teacher training and concept-based curriculum writing, such as that undertaken by RI, will help the curriculum take flight.

A concept-based curriculum that is guided by best practices and a good understanding of the learners will no doubt provide the learners with skills that will equip them with the "wings" necessary to soar in their quest for knowledge.

References

Avery, L. D., & Little, C. A. (2003). Concept development and learning. In J. VanTassel-Baska & C. A. Little (Eds.), *Content-based curriculum for high-ability learners*. Washington, DC: Prufrock Press.

Erickson, H. L. (1998). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.

Erickson, H. L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.

Erickson, H. L. (2007). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.

Erickson, H. L., & Lanning, L. A. (2014). *Transitioning to concept-based curriculum and instruction: How to bring content and process together*. Thousand Oaks, CA: Corwin Press.

Firth, R., & Winter, C. (2007). Constructing education for sustainable development: The secondary school geography curriculum and initial teacher training. *Environmental Education Research, 13*(5), 599–619. doi:10.1080/13504620701659079.

Gallagher, J. J. (1985). *Teaching the gifted child* (3rd ed.). Boston: Allyn & Bacon.

Gallavan, N. P., & Kottler, E. (2007). Eight types of graphic organizers for empowering social studies students and teachers. *The Social Studies, 98*(3), 117–128.

Geographical Association. (2006). *Using key concepts and big ideas to plan curriculum sequences for the Where Will I Live? project*. Retrieved from http://www.geography.org.uk/download/GA_WWILKeyConceptsandBigIdeas.doc

Giddens, J. F., & Brady, D. P. (2007). Rescuing nursing education from content saturation: The case for a concept-based curriculum. *Journal of Nursing Education, 46*(2), 65–69.

Gilbert, R., & Vick, M. (2004). The knowledge base for studying society and environment. In R. Gilbert (Ed.), *Studying society and environment: A guide for teachers* (pp. 80–92). Melbourne, Australia: Thompson Social Science Press.

Gregg, M., & Leinhardt, G. (1994). Mapping out geography: An example of epistemology and education. *Review of Educational Research, 64*(2), 311–361.

Hayes-Jacob, H. (1981). *A model for curriculum and instruction: Discipline fields, interdisciplinarity, and cognitive processes*. Unpublished doctoral dissertation. Columbia University, New York.

Huai, H. (1997). Concept mapping in learning biology: Theoretical review on cognitive and learning styles. *Journal of Interactive Learning Research, 8*(3/4), 325–340.

Jackson, P. (2006). Thinking geographically. *Geography, 91*(3), 199–204.

Jacobs, H. H. (1997). *Mapping the big picture: Integrating curriculum & assessment, K-12*. Alexandria, VA: Association for Supervision and Curriculum Development.

Kinchin, I. M. (2000). Using concept maps to reveal understanding. *School Science Review, 81*(296), 41–46.

Maker, C. J. (1982). *Curriculum development for the gifted*. Rockville, MD: Aspen Systems Publication.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations*. New York: Routledge.

Rawling, E. (2009). *GTIP think piece—Planning and developing the curriculum part 1*. Retrieved from http://www.geography.org.uk/gtip/thinkpieces/developingthecurriculum1

Reeves, D. B. (2002). *Making standards work: How to implement standards-based assessments in the classroom, school, and district*. Englewood, CO: Lead + Learn Press.

Renzulli, J. S. (1977). *The enrichment triad model: A guide for developing defensible programs for the gifted and talented*. Mansfield Center, CT: Creative Learning Press.

Schill, B., & Howell, L. (2011). Concept-based learning. *Science and Children, 48*(6), 40–45.

Singapore Examinations and Assessment Branch (2011). *Geography GCE ordinary level syllabus 2235*. Retrieved from https://www.seab.gov.sg/content/syllabus/olevel/2014Syllabus/2235_2014.pdf

Sternberg, R. J. (1985). *Beyond IQ: A triarchic theory of human intelligence*. New York: Cambridge University Press.

Sum, C. W. (2008). *Policy and implementation paradigm for gifted education in Singapore*. Paper presented at the Seminar on Policy and Implementation Paradigm for Gifted Education, Taipei, Taiwan.

Taba, H. (1966). *Teaching strategies and cognitive functioning in elementary school children*. San Francisco, CA: San Francisco State College.

Tannenbaum, A. J. (1983). *Gifted children: Psychological and educational perspectives*. New York: Macmillan Publishing Company.

VanTassel-Baska, J. (1986). Effective curriculum and instructional models for talented students. *Gifted Child Quarterly, 30*(4), 164–169.

VanTassel-Baska, J., MacFarlene, B., & Feng, A. X. (2006). A cross-cultural study of exemplary teaching: What do Singapore and the United States secondary gifted class teachers say? *Gifted and Talented International, 21*(2), 38–47.
VanTassel-Baska, J., & Stambaugh, T. (2006). Project Athena: A pathway to advanced literacy development for children of poverty. *Gifted Child Today, 29*(2), 58–63.
VanTassel-Baska, J., & Wood, S. (2010). The Integrated Curriculum Model (ICM). *Learning and Individual Differences, 20*(4), 345–357.
Vygotsky, L. S. (1978). Interaction between learning and development. In *Mind and Society* (pp. 79–91). Cambridge, MA: Harvard University Press.
Ward, V. S. (1961). *Finding the gifted: An axiomatic approach*. Columbus, OH: Charles E. Merrill.
Wiggins, G., & McTighe, J. (2005). *Understanding by design* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.
Winter, C. (2011). Curriculum knowledge and justice: Content, competency and concept. *Curriculum Journal, 22*(3), 337–364. doi:10.1080/09585176.2011.601627.

Working with Concept-Based Curricula for Mathematics

Chee Wee Tan

Objective

The purpose of this chapter aims to address some of the challenges of delivering a concept-based curriculum in a typical mathematics classroom in a secondary school in Singapore, as well as documenting some of the teaching strategies that educators can use to promote conceptual understanding in students.

Background

The definition of mathematics as a discipline has changed and evolved over time. One that has stood for centuries was by Greek mathematician and philosopher Aristotle, who defined mathematics as the science of quantity. Indeed, early works in the discipline had been focused in counting (arithmetic) and measurement (geometry) and were widely used in fields such as construction and navigation in ancient times.

It was not until the nineteenth century that new abstract areas of mathematics were studied, such as analysis (calculus), non-Euclidean geometry and set theory (logic). Subsequently, the definition of mathematics varied from one scholar to another in varying perspectives. For example, Russell (1903) claimed that mathematics was, essentially, symbolic logic. However, not all share the same view. Sawyer (1955), for example, focused on observations of patterns and structure, and he defined the discipline as the classification and study of all possible patterns.

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Understanding the Structure of Mathematical Knowledge

Mathematical knowledge refers to the relationships between theorems, concepts and sub-concepts that seek to explain how the world functions in its nonliving form. We see mathematical knowledge as an important tool in several fields including physical science, accounting, economics and statistics. It is also widely applied in engineering, medicine and research in social sciences. Without mathematical knowledge we would not be able to make everyday decisions such as the amount of money we spend or even understand the days and months on the calendar or know how to construct buildings and machines to become the modern society we are now.

Literature and research on the structure of mathematical knowledge have been limited or otherwise vague. Michener (1978) described in his report *The Structure of Mathematical Knowledge* that mathematical knowledge comprises theorems and proofs, and relations between theorems, showcasing examples that highlight the application of the theorems and concepts which contain ‘mathematical definitions and pieces of heuristic advice’ (p. 5) when he was in the Artificial Intelligence Laboratory in Massachusetts Institute of Technology (MIT). He introduced the three representative spaces of mathematical knowledge: *Results-space*, which comprises results (theorems) together with relationships of logical support—such as how one theorem is used to support another; *Examples-space*, which comprises illustrations of theories in various different ways such as ‘start-up examples’ and ‘counterexamples’; and *Concepts-space*, which comprises definitions and heuristic principles and how concepts are related in what he termed ‘pedagogical ordering’, in which one concept is necessary for another.

In his book *Social* Constructivism *as a Philosophy of Mathematics*, Ernest (1998) wrote about how different scholars viewed mathematical knowledge differently. He shared how knowledge is classified into two forms: *a priori* knowledge which ‘consists of propositions which are asserted on the basis of reason alone, without recourse to observations of the world’ (p. 2), while *a posteriori* knowledge consists of propositions inferred based on empirical observations.

He mentioned how different scholars attempted to define mathematical knowledge based on varying beliefs. For example, Frege (as cited in Ernest 1998) reasoned that mathematical knowledge could not be based on empirical observations. Much of his reasoning came from his work on arithmetic, where he postulated that arithmetic is derived from logic, a set of fundamental truths which stem from a set of mathematical arithmetical definitions. On the contrary, there are occasions where mathematics requires ‘non-logical rules of inference and axioms such as the principle of mathematical induction and the axioms of infinity and choice’ (p. 16).

Through what have been described above, it is important for educators to keep an open mind that the learning of mathematical knowledge, hence, is not a single-route process. One inference from the differing opinions by scholars past and present on the definition of mathematical knowledge is that mathematical knowledge need not be taught solely through deductive methods, where known concepts are introduced which are then followed by the applications. Students can also learn inductively where they discover a concept by generalising through looking at patterns. It is believed that inductive methods of learning mathematical knowledge could bring about growth in the knowledge itself, as well as promoting higher order thinking in learners (Sriraman 2004).

Modern Views on Mathematical Knowledge for Teaching

In Tunstall's (1993) thesis on *The Structure of Knowledge for Mathematics*, he highlighted a lack of a model for the structure of knowledge for mathematics that is accepted and used by mathematics educators in curriculum development and delivery. He argued that the existence of a model would guide educators in 'dealing with the organisation of mathematical knowledge in their role as stewards of the discipline' (p. 2).

In his attempt in coming up with a structure of knowledge for the discipline, he invented a model of three 'faces' of knowledge as represented by sides of a cube. The three faces of the cube comprise:

- Major Processes: A set of 11 hierarchal levels of processes which aims to describe the level of mathematical thinking, from the most simplistic level of representing mathematics (use of symbols to represent mathematical statements) to the most advanced level of adapting and applying (to derive new processes).
- Knowledge Content Areas: A division and/or union of major concepts in mathematics including logic, number theory, algebra, geometry and analysis where one sub-discipline may be 'dependent upon parts of those that might precede it as an elementary foundation without pretending to wholly contain them' (p. 26). For example, the sub-discipline of logic is thought to be a fundamental content for all other sub-disciplines due to its role as a key ingredient in the argument and soundness of the theories and concepts.
- Dominant Technologies: The use of three types of technologies in the understanding of the discipline — computers and calculators, tables and charts and manipulatives and tools. It is explained that these instruments of mathematics technologies are used in aiding students to construct mathematical knowledge.

Tunstall then seeks to explain how the model is valid, comprehensive and useful for mathematicians and mathematics educators to organise and make connections between the topics of mathematical knowledge and aid in the learning of mathematics for students.

Taking a generic approach to subject knowledge, Erickson (2007) derived her version of a knowledge structure which is applicable across all disciplines, not just mathematics. According to Erickson, the various levels of the structure are defined as such:

- Topics: An organisation of facts related to specific people, places, situations or things

- Facts: Specific examples of people, places, situations or things
- Concepts: Mental constructs that overarch different topical examples and meet these criteria: timeless, universal, abstract, different examples that share common attributes
- Generalisations: Two or more concepts linked in a relationship that meets these criteria— generally universal application, generally timeless, abstract, supported by different examples. Enduring essential understandings for a discipline
- Principles: Two or more concepts linked in a relationship, but they are considered the foundational truths of a discipline
- Theories: Explanations of the nature or behaviour of a specified set of phenomena based on the best evidence available

Erickson further pointed out that the structure of knowledge for mathematics is much more conceptual than that of other disciplines such as history, in the sense that 'mathematics is an inherently conceptual language of concepts, sub-concepts and their relationships'. This means that the teaching of mathematics requires sufficient emphasis on conceptual understanding of the mathematical knowledge, and not simply focusing on procedural understanding, which can help to increase conceptual understanding but only up to a certain limit (Rittle-Johnson and Alibali 1999).

The works of Tunstall and Erickson, though different, seek to categorise how mathematical knowledge should be structured for teaching mathematics in an educational context. Tunstall in particular emphasised mastering the levels of major processes using the appropriate technologies in the various sub-disciplines such as Algebra and Analysis. Erickson's model focuses more on how knowledge should be taught in order to form deep enduring understandings by creating linkages between factual knowledge and conceptual knowledge.

From the above recommendations on how mathematical knowledge can be organised and taught, the attention then turns to how much mathematical knowledge educators need to possess in order to be effective classroom teachers. Interestingly, research done by several scholars including Begle (as cited in Ball et al. 2001) and Monk (as cited in Ball et al. 2001) showed that teachers' repertoire of mathematical knowledge has a threshold effect on students' achievement in mathematics, such that advanced knowledge in mathematical knowledge does not necessarily or significantly produce a corresponding improvement in students' achievement. Instead, the ability to impart mathematical knowledge through the use of proper pedagogies and teaching strategies is necessary to ensure that students have enduring understandings about the discipline and not simply picking up the procedural skills of solving mathematical problems. This would then seek to redress the current situation where students find mathematics complicated and difficult and is 'no more than a set of arbitrary rules and procedures to be memorised' (Ball et al. 2001, p. 434).

Mathematics Education in Singapore

In Singapore, mathematics education is guided by a framework covering the development of five domains — concepts, skills, processes, attitudes and metacognition, where mathematical problem-solving is the central focus, and this framework sets the direction for teaching, learning and assessment in all schools in Singapore from primary to the 'A' levels. The different levels of syllabuses are classified according to topics and subtopics in arithmetic, algebra, geometry, measurement, trigonometry, statistics, probability and calculus. Students are exposed to the different topics and subtopics in all levels (although advanced topics in calculus are usually covered in the upper levels), and hence the level of abstraction and generalisation becomes deeper as the students progress in their years in school.

At the heart of the framework is the ability to solve real-life mathematical problems. To support this, students are expected to be equipped with not only the mathematical knowledge of concepts, processes and skills but also to possess the right attitudes such as perseverance and appreciation of the discipline, as well as metacognition—the ability to reflect about one's own thinking and learning.

While the framework provides the ideal scenario for mathematics teaching and learning, the actual delivery in schools does not always follow as such. With a tight timeframe for curriculum delivery and a content-heavy syllabus, much focus is placed on the skills and procedural knowledge as these are deemed critical for students to know how to solve problems because of the way they are being assessed in the school and national exams. It is also easier to determine whether a child has understood a particular concept by having him evaluate a problem and see if he is able to attain the correct solution. It is then assumed that students will internalise the concepts through demonstration of how concepts are applied. For example, the topic of indices seeks to address how numbers can be represented and compared using the laws of indices (concepts). Students then apply these laws on new problems, and their understanding is assessed by how well they are able to solve questions requiring the application of those concepts.

Very often, mathematics educators do not distinctively separate between concepts and facts when delivering lessons in the classroom. In many cases, facts and concepts are taught simultaneously, because facts are examples of how mathematical concepts work, while concepts are actually the generalisations of those facts. For example, in the teaching of differentiation in Calculus, the first derivative of a function comes from the concept of limits:

$$f'(x) = \lim_{\delta x \to 0} \frac{f(x+\delta x) - f(x)}{\delta x}.$$

This concept transcends across all types of functions. It also involves other subconcepts such as slope and, of course, functions. Using this concept, the first derivative of many functions can be found, such as:

$$f(x) = x^2 \Rightarrow f'(x) = 2x$$

$$f(x) = \ln x \Rightarrow f'(x) = \frac{1}{x}$$

$$f(x) = \sin x \Rightarrow f'(x) = \cos x.$$

A mathematical concept such as first derivative is hence used to generate a non-exhaustive list of mathematical facts.

It is always a challenge to teach mathematical concepts in the classroom because very often it involves deep thinking and time for the learner to understand how the concept works. Without the deep understanding, the learner often resorts to memorisation of facts, so that when a new situation arises, whereby the problem is not in the same 'form' as one of those facts that he memorised, he is not able to apply the concept properly and will have difficulties following up with the solution.

With the varying nature of problems in mathematics and a whole repertoire of heuristics to problem-solving, true conceptual understanding may not be attained even if the child is able to obtain the correct answer. For example, the application of the null factor law (principle/concept) in solving quadratic equations has become a procedural skill in secondary school students, and students, if given sufficient practice, would have little problem applying the skill. However, do they really know the concept behind how the principle works? One can extend the problem to cubic equations or polynomial equations of higher order, and it is not surprising that even when presented in the factorised form, some students may not know that the same principle (null factor law) can be applied to solve a similar type of question. So, while students can rely on hard work put into the many hours of drill and practice, they may stumble when faced with extensions of problems and may not know how to respond accordingly, even though the principle and concepts that underlie the questions are similar.

To address this lack of ability in transferring of knowledge to new situations, educators should devise lesson activities which help students to discover the concepts through inquiry learning or inductively exploring a variety of examples where the concepts would be applicable. Instead of spending time working on similar types of questions, students can be exposed to a wider variety of problem-solving situations, thus broadening the scope where the concept can be applied. Through regular reference to the use of concepts in problem-solving, rather than specific facts or formulae, students can better appreciate what they are learning and are intellectually stimulated in the classroom.

Challenges to Delivering a Concept-Based Curriculum

One of the ironies of the teaching of mathematics in schools is that while the discipline is innately concept-based, teachers are often focused on delivering procedural-based lessons where learning objectives require students to use facts and skills to

Table 1 Learning objectives for matrices

Time allocated	Content/learning outcomes
1 week	Algebra III (Unit 4/Matrices)
	At the end of the topic, students will be able to:
	Present information in the form of a matrix of any order
	Define equal, zero, identity matrices
	Find unknowns in equal matrices
	Perform addition and subtraction on matrices of the same order, as well as scalar multiplication
	Perform matrix multiplication on small order matrices
	Find determinant of a 2×2 matrix
	Understand singular and non-singular matrices
	Find the inverse of a 2×2 non-singular matrix by formula
	Express a pair of simultaneous linear equations in matrix form and *solve* the equations by inverse matrix method
	Solve word problems involving the sum and product of matrices and interpret the data in the given or computed matrices

solve a variety of problems or scenarios. It is not uncommon to see lists of procedural skills as explicit expectations when one looks at teachers' schemes of work. Table 1 is an example of a set of learning objectives for the topic on Matrices.

Notice the predominant usage of verbs ('present', 'perform', 'find', 'solve'), which shows mostly procedural knowledge and assumes that the learner already understands the concepts behind these skills. So why are learning objectives biased towards the know-how to perform a skill to obtain an answer? One of the reasons is likely because of the way students are being assessed in the subject. A look at the various national mathematics examination papers, such as the 'O' Level Mathematics and 'O' Level Additional Mathematics is evident. Most questions expect the candidate to know how to apply (a set of) formulae in a sequence of steps to obtain the solution. In other words, students are assessed based on their ability to solve questions from various mathematical topics, rather than their understanding of the concept. In a competitive environment such as Singapore where grades are highly regarded by parents and students alike, it is no wonder that many have resorted to use 'successful methods' such as drill and practice in order to improve students' performance in solving different types of questions. However, while many would still adopt the good old advice that 'practice makes perfect', such methods do not necessarily guarantee deeper understanding of the topic, as the learner may not see the manifestation of the concept in the numerous solutions. As a result, the performance of the learner may waver when new topics, using extensions of the same concept, are taught.

Understanding mathematical concepts requires learners to understand connections between underlying principles and theories (the 'why') more than being able to apply the skills in solving problems (the 'how'). With the pressure of having to complete a set of syllabus and learning objectives, educators often find themselves more likely to instruct their students in the classroom to apply mathematical formulae (or facts) to solve a wide range of questions, than developing insights and providing opportunities for new understandings (Schwartz 2008). Summative assessments such as common tests and examinations serve little to test the learner's understanding of concepts but rather the ability to apply a set of mathematical procedures to obtain explicit solutions to a set of mathematical problems.

Because the learning of mathematical concepts requires deep thinking and not mere rote memorisation, it is imperative that the learner be given sufficient time to understand and internalise the concept so that he appreciates how the mathematical facts are obtained or derived. The time taken for this internalisation process can differ from one individual to another depending on each individual's preferred learning styles and background of knowledge.

According to psychologist Piaget's (cited in McLeod 2009) theory of cognitive development, when a new piece of knowledge (or concept) is introduced, the learner will need to first assimilate the information into his existing 'knowledge bank' and possibly change old information into new ones (as in to accommodate). This means that two learners with differing knowledge banks because of unequal prior exposure will potentially take different routes as well as time to fully assimilate and organise the new knowledge with his existing knowledge bank. Hence, a child with greater exposure at a younger age compared to his peer will potentially learn the new concepts faster, as he would have developed an existing schema, making it easier to adapt, as compared to someone who has to create a schema from scratch.

This theory from Piaget is of particular significance if we visit the structure of knowledge as proposed by Michener (1978), when he suggested that mathematical concepts are built on previous ones, rather than isolated pieces of knowledge. To have deep understanding of the concept, a learner will need to adapt the concept into his existing Concepts-space. If one is merely memorising new concepts as if creating new schemas, he is not really growing his Concepts-space and will not fully appreciate nor understand the application of it in unconventional circumstances.

In the classroom, teachers should therefore create ample opportunities for students to assess if they have grasped the essence of the concepts introduced. For example, a series of well-crafted, thought-provoking questions that challenges a student to verbalise the concept in his own words could be an indicator to the teacher of the student having fully comprehended the concept in its most fundamental form. This is even more important in a classroom of students with varying prior exposure or 'knowledge banks'. Thought-provoking questions therefore allow the teacher to assess conceptual understanding before moving on to a new topic or concept. More strategies will be mentioned in the subsequent sections of this chapter.

Another challenge to teaching conceptually in the classroom is the varied learning preferences of the students. It is widely accepted that learners of different learning preferences require different kinds of stimuli to keep them engaged in the task (Tomlinson 2005). This may be attributable to multiple intelligences, as described by Gardner (1993). Some learners, for example, tend to be more visual, while some are more logical. The visual learner is able to understand better from diagrams and pictures or animations, while the logical learner is able to reason out abstractions.

As a result, the classroom may not provide every individual the right type of stimuli to pick up concepts, as usually the teacher has to accomplish other goals in the lesson itself, such as completing the lesson objectives, going through homework, etc. This means that two different learners with different learning preferences may be hampered in picking up new concepts in the same amount of time.

Gardner suggested that the delivery of content knowledge should be customised as much as possible to suit the different learning styles of learners. Classroom settings should be redesigned in creative ways to allow different types of learning to take place. While some may be contented with self-study and research (intrapersonal intelligence), some learners prefer group discussions, sharing and presentations (interpersonal intelligence), and educators need to create such an environment. These are also supported by Tomlinson (2005) who advocated differentiated instruction to meet the diverse abilities (readiness) of learners.

Having many students with differing 'knowledge banks' in the same classroom also poses a huge challenge for the classroom teacher trying to teach conceptually. Vygotsky's zone of proximal development (ZPD) (1978) provides an insight into the development of knowledge in a learner. According to the theory, one needs to identify a learner's current level of knowledge before providing scaffolding to assist him in being able to master a set of skills or knowledge. In the mathematics classroom, this can be done by performing pop quizzes or asking well-crafted questions to determine a learner's existing knowledge of concepts, so that his ZPD can be determined, and the teacher then acts as an expert to provide teaching moments to expand the learner's existing knowledge, through direct delivery of concepts, coupled with activities to allow the learner to successfully apply them. Eventually, when the learner is able to independently apply the new concepts on questions tasked by the teacher, he would be said to have grown in his knowledge capacity. Clearly such efforts to build a learner's conceptual understanding in mathematics are best achieved through the use of specific tools, and some of these are presented next.

Concept-Based Learning in the Mathematics Classroom: Tools for the Teacher

In this section, I share and elaborate some of the strategies that encourage deep learning in students and tackle some of the challenges faced by the teacher in a concept-based learning environment as listed above, including the problems related to the transfer of knowledge.

Tool 1: Teaching Mathematics Conceptually

The classroom teacher in the concept-based learning environment is not merely delivering content. The most typical scene in the classroom today is that concepts are taught mostly through deductive methods, where a new theorem or a new formula is introduced before students get to know how they are applied in examples. This takes away the opportunity for students to develop their own understanding. To teach conceptually means that the teacher would be acting as a facilitator to help and guide students to construct knowledge and concepts to encourage deep links between what they know and what they are learning. The learning environment of the class must be one of open-mindedness, where every individual has a chance (prompted if need be) to be heard, so that there are opportunities for anyone to clarify and to learn from one another's perspective. When the environment is well set up to promote learning and teaching, it is then up to the teacher to pace the lesson such that the concepts are delivered in a manner which is engaging to the whole class.

To initiate concept-based learning in the classroom, it is important to know the readiness of every individual, including his learning style. Although this is easier said than done, given a classroom of 25–35 students of varying abilities and giftedness, the most common mistake, in my experience, is that when teachers assume that every student in the classroom has the same background knowledge, ability and learning style. Hence, the challenge to the classroom teacher would be to ensure that every individual is engaged in his or her own zone of proximal development, where instruction can be differentiated. Hence, equipped with such nuanced knowledge of the learner, the highly gifted and able can be provided with enriched or advanced materials to deepen their understanding of a topic or concept in their own time while the rest of the class is given the time to figure out the foundational concepts at their own pace with the teacher. Most teachers would have realised that gone are the days when students sit passively listening to the teacher standing at the front lecturing continuously, especially given competition from digital devices. Disengaged learners and teacher-driven lecturing in front of the whole class do not promote conceptual understanding of the discipline.

A good start to a concept-based mathematics lesson would be to begin with a recap of the previous concepts that might form the prerequisites for the lesson or to introduce a scenario where students do not yet know how to solve or even understand the problem. Students can then begin to recall previous concepts learnt. Sometimes, it may be necessary for the teacher to spend a considerable amount of time revising the previous concepts if it is found that (a) the students may not have yet fully understood the prerequisites or (b) there are several sub-concepts involved prior to learning new ones.

It is important to provide sufficient scaffoldings in concept-based learning. From Vygotsky's theory of ZPD, we learn that the teacher must provide sufficiently challenging tasks for the student to perform such that he is able to develop and expand his capacity to work independently. This can be emphasised after a new concept is introduced, when students are given the opportunity to clarify their doubts, to view the concept from different perspectives and to apply the concept on more structured and direct questions. Time must be set aside within the classroom to all of these. It is not healthy to rush through concepts and focus on the application immediately, without ensuring that students understand how the concepts work. Concepts introduced should be well-linked to previous concepts or sub-concepts so that students appreciate that it is an extension, or a synergy of several sub-concepts, and not merely as another formula which they are required to memorise.

Tool 2: Use of Conceptual Lens

For example, in the teaching of logarithms, students should recognise and understand the connection between logarithms and indices, where the latter was learnt earlier, so that they do not treat the two as separate, mutually exclusive, topics. This is an example where the use of the conceptual lens of *relationship* can help students to integrate the facts and understandings under a broad idea. Besides introducing the direct relationship between the two as

$$y = a^x \Leftrightarrow x = \log_a y,$$

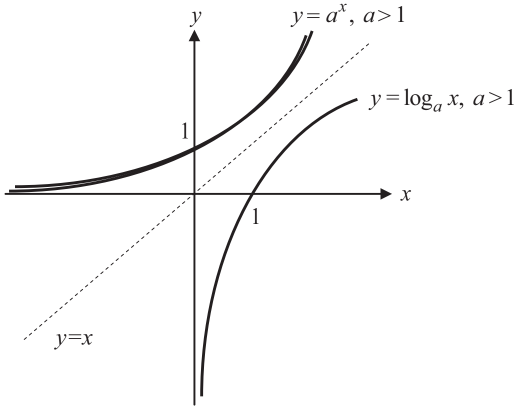
time should be given to recognise the conditions behind each of the variable, such as

(a) Why do we consider only when $a > 0$ and a cannot be 1?
(b) Why is $y > 0$?

Understanding these conditions will allow students to see how the two are related at a deeper level, instead of the two equivalent equations. Once they are able to see the two topics as being related, they can better understand the rules that govern each of them and also the similarities between the two sets of rules, such as:

Laws of Indices	Laws of Logarithms
$a^m \times a^n = a^{m+n}$	$\log_a(xy) = \log_a x + \log_a y$
$a^m \div a^n = a^{m-n}$	$\log_a(x \div y) = \log_a x - \log_a y$

Students should know and understand how the laws of logarithms can be derived using the laws of indices, so that they can see that the two topics are actually similar. Additional relationships between the two can also be shared and discussed when introducing exponential and logarithmic graphs, such as that shown in the following diagram:



If students are able to understand the linkage between the two concepts, they are able to better relate one concept to another, which makes learning and understanding more meaningful. Students no longer memorise the two graphs as separate functions but rather as a pair. Indeed, the use of conceptual lens in teaching helps students to create connections and synergise factual and conceptual levels of thinking (Erickson 2007).

Tool 3: Use of Socratic Questioning to Test Mathematical Understanding

It is quite common to hear classroom teachers asking students questions that return yes-no replies, or responses which are closed-ended, leaving no further room for thinking or discussion. To ensure that students understand the concepts, teachers need to use good questions to trigger thinking and inquiry in the students' minds.

Socratic questioning is a powerful tool for educators to pose questions that provoke deep thinking in learners. It is a process where the teacher 'poses a carefully constructed sequence of questions to students to help them improve their logical reasoning and critical thinking' (Tomlinson et al. 2002, p. 55). In a classroom, usage of Socratic questioning technique to create a Socratic dialogue between teacher and students is one way of engagement, where both parties have a chance to clarify and verify concepts and knowledge. In short, Socratic questioning provides students with opportunities to clarify their thinking, challenge assumptions and look for evidence in their argument. It is also a strategy used to seek alternative viewpoints and perspectives from other students in the class and for the students to discover implications and consequences from their understanding of the concepts. Last but not least, good questions actually allow metacognitive development to take place, where students question their own questions and whether they are aware of what they know or not already know.

When Socratic questioning is used often in the classroom, students are not merely absorbing information from the teacher but are constantly processing and finding linkages between the responses and the questions and forming connections with existing knowledge. They also have a better understanding of the conditions and applications of the concepts and are thinking critically. Knowing how to apply the concept then becomes intuitive, and students find more meaning in their learning.

Some examples of Socratic questioning in the mathematics classroom include:

1. Why did you apply this formula?
2. What assumptions did you make for your formula to work?
3. Is there another way to solve the problem?
4. What can you generalise from the set of results?
5. Why are we considering the different approaches to solving this question?

It is in such a classroom where the teacher and students are engaged in Socratic dialogue that high level of intellectual exchanges can take place. The teacher must be skillful enough to pose questions that are pitched just sufficient to elicit responses from the students without giving away too much of the ‘answers’ and also to be patient to wait for students to think through the questions before they are able to give their response.

Because of the time needed to engage in deep thinking and dialogue, this is often not used in the typical classroom, especially when there is a wide range of abilities in the students in the same classroom, as some students may not be able to understand or grasp the meaning behind the questions, or if the questions are quickly answered by students of higher ability in the classroom, leaving others still figuring out the question. Hence, Socratic questioning is still best done with a small group of students with similar abilities so that they can ‘catch on’ each other’s thoughts to refine and deepen their own understanding. Another concern is the lack of opportunity to engage in Socratic dialogue due to the need to complete the syllabus within a set limited time. Teachers often shorten the time for questioning or resort to getting the higher-ability students to provide quick responses, in hopes that the rest of the class would be able to assimilate the ideas quickly.

Tool 4: Assessing Mathematical Understanding Through Formative Means

Using good Socratic questioning techniques, teachers can determine if the students actually understand the concepts in class. However, if time is a constraint, it is then important to have some form of formative assessment where students are able to check for their understanding in their own time and pace.

Existing methods of testing of mathematical knowledge have been limited to mainly procedural skills. This is evident in the ‘O’ and ‘A’ levels where questions expect students to apply formulae to obtain solutions as the final outcome. While it may be difficult to overhaul the summative assessment such as the national examinations, formative assessment modes can be used as a tool to promote deeper conceptual understanding in learners. This can be done by phrasing questions differently in homework assignments where more open-ended questions can be posed. Below shows two different types of questioning:

(a) Write 3.20449 to 3 significant figures.
(b) What is the difference between writing 3 and 3.0 (2 s.f.)?

It can be seen that (a) only requires the learner to use a mathematical fact (or rather, a skill) to obtain the answer, while (b) requires the learner to fully understand the concept of numbers and estimation before being able to answer the question fully.

Enrichment exercises could be provided for the high ability learners to deepen their conceptual understanding and explore a wider range of applications. These exercises, in the form of challenging problem-solving questions, keep them excited about their learning and prevent boredom in the subject. Teachers can also encourage these students to take part in a range of mathematics contests where they can pit their knowledge against the most challenging questions in, for example, the Mathematical Olympiad.

The exposure to non-routine questions often found in these contests will widen their comprehension of the mathematical concepts, and the students will also get to see how concepts can be applied in complicated and complex situations. Some of these non-routine questions can also be incorporated in the classroom when time permits, where students can be split into groups, and the teacher can use problem-based learning strategies to get the students to work together towards solving real-world problems.

Reflections of a Concept-Based Teaching and Learning Practitioner

Teaching a concept-based curriculum can be extremely rewarding when we see the wonderment in our students' eyes or in their articulation of the concepts when justifying their reasoning and logic in problem-solving. However, just as there are rewards, there are as well many challenges to keeping concept-based teaching and learning in the classroom alive. Clearly, the focus on national examinations, the lack of classroom time due to the ever-increasing diversity of activities and changing of focus in schools and the wide range of ability of students in a classroom can hinder teachers' efforts to promote concept-based learning in the classroom. While many of these challenges are beyond the control of the classroom teacher, it is still possible to encourage conceptual learning in students if the teacher can adopt some of the tools mentioned above in order to teach conceptually.

As an educator for the gifted and talented for more than a decade, I still find myself resisting the urge to rush through the curriculum in order to complete the set of lesson objectives at the expense of deep learning. And there are times when planning a good concept-based lesson proved to be challenging with the varied ability of the students in the class. The most accomplished moments for me, on the other hand, were the times when the students (and myself) appear engaged in deep discussion about the knowledge and concepts through the use of Socratic questioning.

I believe that while there may be a need to meet the immediate expectations of the school examinations, the eventual goal in education is to imbue in students the right attitudes to learning and constructing knowledge, and that has to start with affirming their conceptual understanding and ensuring that they have a good foundation to handle more complex problems in the future. I have a great sense of satisfaction when my students are able to relate concepts together, to see the underlying knowledge involved and able to make connections to a variety of mathematical problems, routine or non-routine. Ultimately, the best acknowledgement of our good work comes in seeing them engaged in lessons that ignite their enthusiasm and passion for learning and understanding the world around them. As Nelson Mandela once said, 'Education is the most powerful weapon which you can use to change the world.' And we need our future generation to embrace learning the right way as a first step to a better world.

References

Ball, D. L., Lubienski, S. T., & Mewborn, D. S. (2001). Research on teaching Mathematics: The unsolved problem of teachers' Mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed.). New York: Macmillan.

Erickson, H. L. (2007). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.

Ernest, P. (1998). *Social constructivism as a philosophy of Mathematics*. New York: State University of New York Press.

Gardner, H. (1993). *Frames of mind: The theory of multiple intelligences* (2nd ed.). New York: Basicbooks.

McLeod, S. A. (2009). *Jean piaget*. Retrieved from http://www.simplypsychology.org/piaget.html

Michener, E. R. (1978). *The structure of mathematical knowledge*. Massachusetts Institute of Technology Artificial Intelligence Laboratory. Retrieved from http://hdl.handle.net/1721.1/6928

Rittle-Johnson, B., & Alibali, M. W. (1999). Conceptual and procedural knowledge of Mathematics: Does one lead to the other? *Journal of Educational Psychology, 91*(1), 175–189.

Russell, B. (1903). *The principles of Mathematics*. Cambridge, UK: University Press.

Sawyer, W. W. (1955). *Prelude to Mathematics*. Harmondsworth/Middlesex, UK: Penguin.

Schwartz, J. E. (2008). *Elementary Mathematics pedagogical content knowledge: Powerful ideas for teachers*. Boston: Allyn and Bacon.

Sriraman, B. (2004). Reflective abstraction, uniframes and the formulation of generalizations. *Journal of Mathematical Behavior, 23*(2004), 205–222.

Tomlinson, C. A. (2005). *How to differentiate instruction in mixed-ability classrooms* (2nd ed.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Tomlinson, C. A., Kaplan, S. N., Renzulli, J. S., Purcell, J., Leppien, J., & Burns, D. (2002). *The parallel curriculum: A design to develop high potential and challenge high ability learners*. Thousand Oaks, CA: Corwin Press.

Tunstall, P. M. (1993). *The structure of knowledge for Mathematics* (Doctoral dissertation). Retrieved from http://hdl.handle.net/2346/22616

Vygotsky, L. V. (1978). *Mind and society: The development of higher cognition*. Cambridge, MA: Harvard University Press.

Processes and Issues in Concept-Based Curriculum for Science

Christopher Tzy Yung Tan and Adrian Loo

Introduction

The teaching and learning of science should be treated as an active inquiry, with students as authentic investigators in the process of making meaning of the world they are living in. Thus, science should be taught in a way that shows a strong emphasis on science concepts, on the examination and analysis of authentic problems and on the integration of science with other disciplines. In his book *The Taxonomy of Significant Learning*, Fink (2013) argues that the act of making new connections gives learners intellectual power when they understand the connections between different things. It is in the interest of developing such powerful forms of learning that has led us to explicate in this chapter the importance of focusing on conceptual development in classroom science. At the same time, we share the use of specific strategies to foster deeper conceptual understanding and their outcomes in our own attempts to adapt the regular Chemistry and Biology curriculum as we taught high-ability Year 11 and 12 learners. We also reflect on how other possible concept-development strategies[1] can be successfully utilised in the lecture-tutorial-based learning environments that are typical at the pre-university level. Additionally, the benefits accrued by the use of such concept-development strategies in getting our learners to think more deeply and critically when learning in the discipline are discussed. It must be noted, however, that throughout this chapter, we have leveraged on our own experience of teaching Chemistry and Biology, although in our opinion,

[1] We encountered some of these strategies during professional learning and master's level curriculum development modules that we undertook as we went about adapting curriculum to meet the needs of high ability learners in the school.

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most of such strategies are easily adapted and just as beneficial when teaching other sciences as well.

Developing an Understanding of Scientific Concepts

Experts have consistently pointed out that highly able students and those who are intellectually gifted in the sciences display a readiness to engage in inquiry and intense curiosity about the world around them (Clark, 2002; Renzulli et al., 2002). They are often eager to participate in more concept-based work in science. These gifted learners would need a curriculum that is sufficiently advanced and challenging, offering a sequence of tasks that extends their knowledge base (Renzulli & Reis, 2009). The curriculum should also provide opportunities for original investigations in science, using authentic real-world problems as a basis for further conceptual understanding and a more profound appreciation for the nature of science. The science curriculum should also allow these high-ability students to study scientific concepts which can help them to see the connections within the scientific areas of their interest as well as across to other fields of study (Feldhusen, 1988; VanTassel-Baska, 1998; VanTassel-Baska & Stambaugh, 2006).

According to VanTassel-Baska and Stambaugh (2006), one of the key components necessary to curriculum development work that seeks to marry principles of the science standards to curriculum principles for gifted students is the greater focus on deepening students' understanding of scientific concepts. With numerous fragmented pieces of information and a knowledge explosion in this world, it is pertinent for more effective organisation of subject matter through major concepts, so that it forms part of the knowledge base for our students (Kwon & Lawson, 2000; VanTassel-Baska, Bass, Ries, Poland, & Avery, 1998). The teaching of concepts allows students to connect scientific facts to larger ideas, scientific principles and other disciplines. Given the easy accessibility to knowledge and scientific discoveries in this century, the ability to connect facts to ideas and principles is an utmost important skill to acquire. Concepts provide important scaffolds with which students can learn about core ideas in science that do not change, although their applications may change (VanTassel-Baska, 1998). As such, organising the information into major concepts can help students to understand more deeply the bigger ideas which govern scientific thought and to prepare them well for future scientific exploration.

Concept-Based Instruction and Curriculum

When it comes to learning, students can encounter a number of different concepts in their lives. Concept-based education or concept-based instruction is a novel teaching strategy that allows students to organise various units of study to help them gel and integrate new types of information in such a manner that they are able to see and identify a number of patterns, situations or even connections between facts and concepts or ideas. In essence, with concept-based instruction, the student will learn to ask a significant question to himself: "Why should I learn this?"

Curriculum writers agree that one key feature of quality curriculum for high-ability students is that it uses concepts in its design, organisation and implementation (Hockett, 2009; Kaplan, 1994; Tomlinson et al., 2008; VanTassel-Baska, 1986). Erickson (2002) defines a concept as "a mental construct, an organising idea that categorises a variety of examples" (p. 56). Concepts are timeless, universal, abstract and broad. The National Science Education Standards (National Research Council, 1996), adopted across most schools in the United States, for example, are classified according to four clusters of concepts: system, order and organisation; evidence, models and explanation; change, consistency and measurement; and form and function. These organise the understandings and processes that students need to develop over the course of their science education, serving as an overarching framework for the larger set of factual data that they are expected to learn.

There are numerous reasons cited for taking a concept-based approach to organising curriculum. Concepts bring coherence to curriculum, facilitate the development of expertise and are vehicles for thinking in the ways of a discipline (National Council of Teachers of Mathematics (NCTM) (NCTM), 2006; National Research National Research Council, 1998). They assist the learner in examining the nature of a subject, in making intra- and interdisciplinary connections and in seeing patterns (Bruner, 1960; Erickson, 2002; National Council of Teachers of Mathematics (NCTM) (NCTM), 2000). Integrating concepts into curriculum also expedites learning new knowledge by helping students connect new knowledge with old knowledge, by transferring understandings to new situations and retrieving previously learned knowledge quickly (Erickson, 2002; National Council of Teachers of Mathematics (NCTM) (NCTM), 2000; National Research Council, 1998).

A Concept-Based Approach to Science Curriculum

The science curriculum should be organised around a concept-based approach to learning. In a concept-based approach, learning can start with the big ideas that we want our students to understand. Looking at a topic through a concept gives the study a focus. When teachers base their instruction on concepts, they can expect their students to learn more than just facts. Instruction based on conceptual generalisations is an effective way for students to genuinely understand topics, but more importantly, it is an effective way to teach students to think.

Concept-based curriculum and instruction are important for several reasons. The type of thinking required by students to be successful in the twenty-first century extends beyond rote memorisation of facts to higher-order critical thinking. A curriculum organised around concepts provides natural categories or organisers for students' thinking. A concept-based approach moves away from low-level knowledge and comprehension and encourages deep learning through analysis, synthesis and evaluation. Concept-based instruction necessitates that students assimilate information, as opposed to accumulating it—as required by learning based on facts. Succinctly, a concept-based approach teaches beyond the facts (Erickson, 2002). This can be observed especially in fields of Biology and Biochemistry where the pace of scientific discovery has led to an explosion of new knowledge encompassed in a large body of details and processes. A student endeavouring to undertake a study in such fields would clearly have to approach it conceptually. Because information in the world is expanding at a rate far greater than any one person can accumulate it, learning cannot stay fact focused. Education rooted in a concept-based curriculum allows teachers to reduce the number of topics—because many topics exemplify the same concepts and conceptual understandings. For example, in Chemistry, the study of the periodic table, chemical reactions and chemical thermodynamics, which includes the discussion of entropy and the flow of energy, lends itself well in the unifying concepts of system, order and organisation. Similarly, topics like solubility, phase changes and properties of solutions demonstrate the concepts of equilibrium. In addition, the concept of models can give students a framework and help them to appreciate how theoretical predictions estimate and explain the molecular and chemical systems at hand. Making connections and comparisons across the scientific disciplines will help high-ability students see these concepts in the larger context of science beyond Chemistry.

Concept-Based Teaching and Learning of Science

When teachers base their instruction on concepts, they can expect their students to learn more than just facts. During a concept-based unit of study, students are given many examples of concepts. Through these examples of concepts from the topic, students notice common elements. Discussion, guided by carefully planned and also spontaneous questions, helps students to inductively form generalisations. A generalisation is a statement that shows a relationship between two or more concepts.

Clearly, the formation of a generalisation by students requires student engagement and thought, and this is an important outcome that science teachers should strive for in their lessons. Furthermore, the students' ability to generalise and arrive at concepts inductively using examples from a topic illustrates the students having achieved deeper understanding, which in turn allows for future learning. Instruction based on achieving conceptual clarification and generalisations is an effective way for students to genuinely understand topics, but more importantly, it is an effective way to teach students to think.

Example of Concept-Based Teaching: The Concept of Chemical Bonds

One example of concept-based teaching that has been experimented in Chemistry tutorials has been in the learning of chemical bonds. From our experience, chemical bonding is often taught as a topic rather than conceptually, so curriculum developers classify substances, based on a list of properties, into four different groups of lattices (ionic, molecular, covalent and metallic) and elaborate on and discuss each of these structures based on the chemical bonds that exist between the particles. These types of chemical bonds (ionic, covalent and metallic bonds) are often discussed as different entities. According to Hurst (2002), this oversimplified presentation misleads Chemistry students and may actually cause learning impediments. Taber and Watts (2000) point out that students are expected to acquire some familiarity with the theoretical frameworks of Chemistry and to develop some level of proficiency in applying their knowledge regarding chemical bonds in order to produce valid scientific explanations. Presenting the bonds as different entities, as is often done in textbooks, can be misleading and it may fail to represent the key unifying ideas in Chemistry, thus resulting in very disjointed understanding of the discipline.

An approach which teachers of highly able learners can adopt, as proposed by Nahum, Mamlok-Naaman, Hofstein and Krajcik (2007) in the teaching of chemical bonds and the structures and properties of substances with different lattices, is to use a similar conceptual model to describe all bonds. This is done from a submicroscopic level (understanding of the principles that are common to all types of chemical bonds between two atoms in the gas state) and only then progressing towards the microscopic and macroscopic levels (structures and properties of molecules and clusters, which involve much greater complexities). This approach is based on an understanding of the common principles and concepts suggested for *all* chemical bonds (such as electrostatic attractions; bond strengths, electron densities and overlapping of bonding orbitals) and then using these ideas to explain the structures and properties of molecules and lattices. Such an approach is consistent with Hurst (2002), who concluded that the bonding theory and related concepts need to be taught in a uniform manner.

According to this approach, the focus is on the bonds that *might* be formed between two atoms. On the one hand, all chemical bonds (including hydrogen bonds and van der Waals bonds) are presented using the model of interactions between two atoms in the gas state. The idea is to bring across to students the concept of continuous bond strengths of chemical bonds. On the other hand, there is emphasis on the importance of the ability of students to distinguish between different bonds by their lengths, energies and other important characteristics such as directionality. Thus, although all these bonds can be presented on a continuous scale of bond strength, students should acquire a qualitative understanding regarding the strength of these bonds and their characteristics.

One example of building a qualitative understanding of bond strength is reflected in getting students to understand the unique nature of the hydrogen bond and recognise the situations in which it might occur. More specifically, if the hydrogen bonds between water molecules in the liquid state and the polar covalent bonds between hydrogen and oxygen in a single molecule of water are discussed, students should be able to explain the following: firstly, the common principles and concepts regarding the hydrogen bond and the polar covalent bond, i.e. both bonds are directional and can be explained by the equilibrium point at which the repulsive and attractive forces are equal, and, secondly, the hydrogen bond between an oxygen atom on one water molecule and the hydrogen atom on an adjacent water molecule is much longer and as a result is much weaker (based on Coulomb's law) than the polar covalent bond between oxygen and hydrogen in a single water molecule. These different bond strengths result from different energy balances. Consequently, the energies required for breaking each bond are largely different, and this is reflected in the properties of water. By using such a coherent conceptual model for all bonds, our students' ability to apply their knowledge of chemical bonds in a variety of contexts improved, and this aligned well with their learning performances. In fact, over the 2-year course of study, this systematic approach fostered in both students and teachers a much deeper understanding of the underlying key concepts of bonding that resulted in a firmer grasp of chemical properties and reactions later in the course.

Another Example of Concept-Based Teaching: Mental Models of Chemical Bonding

Studies have shown that many students, when it comes to learning abstract chemistry concepts like atomic structure or chemical bonding, showed a preference for realist (e.g. space filling) models of atoms and molecular species (e.g. Harrison & Treagust, 1996; Pereira & Pestana, 1991; Taber, 1998, 2001; Taylor, 2002). There is a need to emphasise the inadequacy of simple models of chemical bonding and to be comfortable to draw on the more sophisticated advanced mental models for chemical bonding that possess more explanatory power. High-ability students should be made to see clearly that in certain situations or contexts, the simplistic models, such as octet rule for bonds to form, are no longer adequate to fully explain the bonding and structures of the substance concerned (such as benzene). For such students, it is good to introduce the limitations associated with the use of simple models at an early stage and to bring in more advanced representations like the molecular orbital theory. Such an approach is supported by Taagepera, Arasasingham, Potter, Soroudi and Lam (2002), who claim that effective comprehension and thinking require a coherent understanding of the organising principles.

It may be good to point out to them that the sophisticated abstract mental models of chemical bonding do more than just describe the bonding in substances. Clearly, such models underpin much of chemistry and are used to develop other concepts such as spectroscopy and the use of reaction mechanisms or reaction schemes. According to Coll and Treagust (2001), complex models of chemical bonding should not be removed from the curriculum simply because students prefer to use simple models. It was observed that exposing our high-ability students very early to such complex models allowed them to appreciate the limitation of simpler mental models and the beauty of more complex models in offering better explanations to the observed phenomena in chemical substances. Concepts such as systems, change and scale all provided important scaffolds when unpacking mental models and therefore allowed relatively deeper level of learning of the core ideas of science. Restructuring the science curriculum to emphasise science learning around complex mental models allows gifted and talented students to learn at deeper levels instead of just fundamental ideas.

Using Questioning as an Instructional Strategy for Concept-Based Teaching

Asking the right questions in class is often seen as a way to engage learners in the lesson. However, such questions play another important role of helping students better understand and to relate concepts in the studying of science. One example involves asking higher order thinking questions while carrying out Chemistry experiments, which is especially important to high ability learners who may need to be further challenged in regular lessons. For example, when studying the properties of aqueous solution of aluminium (Al^{3+}), iron (III) (Fe^{3+}) and chromium (III) (Cr^{3+}) ions, students may be asked to compare and derive the similarity in their acid property. Questions such as "Why are they acidic?", "What happens when solid sodium carbonate (Na_2CO_3) is added to an aqueous solution containing aluminium (Al^{3+}) ions?" and "Why does the addition of acid cause the precipitate to dissolve?" require learners to explain, analyse and evaluate, thus pushing learners to go beyond mere procedural knowledge. Coming up with answers to these questions requires an understanding and a good grasp of the concepts of bonding, acid–base reaction and equilibrium and making accurate connections in these topics.

Similarly, before carrying out qualitative analysis, students can be asked to predict expected observations and give reasons for their predictions before they carry out the tests. Hence, before aqueous ammonia is added to an aqueous solution of magnesium (Mg^{2+}) ions, learners could be asked "What do you expect to see immediately?" and "What happens when this is followed by the addition of solid ammonium chloride (NH_4Cl)?". Such questions provide high ability learners with opportunities to connect specific experimental phenomena to more theoretical concepts in Chemistry. From experience, when students were required to make such predictions, they had to link what is observed in the experiment with their understanding of equilibrium and solubility product. Additionally, learners' concepts of equilibria and solubility were reinforced through connections made by what they see in the laboratory.

In laboratory work, besides giving students chances to practise laboratory skills, it was also beneficial for high ability learners to conduct some experiments which extended over a period of two or three weeks. Such extended laboratory investigations required high ability learners to work with multiple concepts or with multistep processes. This challenged high ability learners more, requiring them to integrate concepts into a single laboratory report, and gave them a chance to mirror what mature chemists do in the real world. Having a greater overlap of experiments with lecture topics also reduced the burden of remembering disparate facts for students. Concept-focused instruction given in the laboratory, when it is well developed, can help reduce the lecture time on the topic. Giving learners opportunities to work with interactive software and molecular models at the beginning of the laboratory session also gives learners time to develop fresh insights and ideas, resulting in better synchronisation of the concepts learned in the laboratory and lecture.

While the account so far has described the use of explicit concept-focused instruction, mental models and questioning as it was explored with our group of learners, other concept-building activities such as looking at misconceptions and relevance can be valuable. The next section looks at some examples of their use in the chemistry classroom.

Concept-Building Activities: Conceptual Change and Misconceptions

Learners' misconceptions should also be taken into consideration in the developing of science curriculum. Several researchers have shown that instruction based on conceptual change can be effective at changing students' chemistry conceptions (Basili & Sanford, 1991; Ebenezer & Gaskell, 1995). In general, conceptual change has been described as part of a learning mechanism that requires the learners to change their conceptions about a phenomenon or principle either through restructuring or integrating new information into their existing schemata (Hewson, 1981). Posner, Strike, Hewson and Gertzog (1982) describe the conditions of conceptual change and a four-step model for a conceptual change. The steps involve: (1) learners becoming dissatisfied with their existing conceptions, (2) the new conception being intelligible, (3) the new conception being plausible, and (4) the new conception being fruitful. When these conditions are met and the steps followed, students can experience conceptual change. Given this, there needs to be an appropriate learning environment in the science classroom for students to make sense of science and use science to make sense of the world. The methods and strategies used in such an environment should guide students towards a deeper understanding of science and how it works.

These steps can provide teachers with useful guidelines in developing understanding of the concept of acids and bases, especially when it comes to its role in the topic of aqueous equilibrium as well as organic acids. Teachers can slowly call on learners to clarify their misconceptions in a stepwise manner and as a result, build deeper conceptual understanding of the reactions and properties of acids, bases and salts. Having students to engage in more hands-on activities rather than just feeding them theories from lectures can also build greater conceptual understanding. Hence, organising activities that encourage students to use their prior knowledge and experience about acids and bases, and then getting them to apply the newly acquired concepts in a variety of situations such as going through laboratory practical activities (i.e. going from what is known to what is unknown), provides for new ways to reconstruct old concepts and make ways to move from superficial to deeper understanding.

In fact, students' conceptual misunderstandings about the concept of the acids and bases generally originate from their experiences in everyday life. It is therefore worthwhile to spend more instructional time on developing a more nuanced understanding of the complex process of neutralisation (during titration) and related concepts, by unpacking the acid–base titration curve to point out clearly what species are present at each stage. The learners' conceptual understanding can be also checked and reinforced through the use of various titration plots using different combination acids and bases with different strengths. Nakhleh and Krajcik (1993) have also shown that the use of different technologies, such as microcomputer-based activities, could be good teaching tools for building conceptual links in learners. Given today's learners' familiarity with the digital world, such tools could also be incorporated into lessons to help learners clear their misconceptions.

Making Chemistry Relevant

One of the challenges in the teaching of Chemistry to high-ability students, in our experience, is to make the subject relevant to them, and this is especially a challenge for teachers when exploring more advanced concepts in the discipline. In the process of emphasising conceptual understanding in the subject, there is a need to enable students to see the relevance of such understanding and appreciation of the nature of science to the real world. According to Holbrook (1994), we need to find ways to initiate teaching based on societal situations and then develop the conceptual learning that allows students to appreciate the relevance of the science. To achieve relevance there is a need to go beyond the simple inclusion of societal links. Hence, concepts such as atomic structure, chemical bonding or redox reactions are examinable topics in the A-level syllabus for Chemistry, yet in daily life, the improvement of the quality of air and the need to find alternative sources of water may be potentially more relevant starting points for the teaching of such topics. In other words, it is important to place more emphasis during concept-based teaching on the relevance of the concepts in the chemistry curriculum to the real world.

Relevance of these concepts can be related to the processes and products we utilise in society, which can then be extended to how we utilise scientific principles to solve a problem or make a decision. Over time, each learner should be able to innately link the concepts learned with the way they are applied in diverse contexts such as the home and the natural environment. They may also begin to realise how these concepts can become a part of their future career within society. Building a positive attitude towards the learning of chemistry is more important, and for this to happen, there is a need to provide opportunities for learners to identify and resolve real-world issues that require the use of scientific knowledge. For high-ability students, connecting their conceptual understanding of Chemistry with issues in society and incorporating these insights into the making of rational decisions geared towards societal concerns will ensure higher relevance of this science in each learning encounter. Having looked at the examples of concept-based learning in Chemistry, the next part of this chapter looks at its use in the teaching of Biology.

Concept-Based Biology Education: Preparing for a New Biology for the Twenty-First Century

Even as educators plan for richer learning experiences in the teaching of Biology, there is no escaping the fact that as a science, Biology has contributed significantly to the phenomenal expansion of scientific knowledge in the last century. Advances fuelled by capabilities in molecular tools have seen an unprecedented increase in knowledge (DiCarlo, 2006). This "explosion" is best epitomised by the Human Genome Project and emergent fields such as Mechanobiology, Lipidomics, Proteomics and Pharmacogenomics and the list goes on. In 2009, the US National Research Council publication entitled *A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution* (National Research Council, 2009) says it most succinctly: the field of Biology is steam-rolling into a whole new territory, one in which researchers and educators must anticipate and be prepared for if societies are to get any returns from advances in life science. Labov, Reid and Yamamoto (2010) describe the "New Biologist" as not a scientist who knows a little about all disciplines, but rather as one who has deep knowledge in one discipline and a working fluency in several. Therefore, the sort of classroom experiences needed for deep knowledge is not one which is overly packed; instead it should be one that deals with fewer concepts but that treats each concept with greater depth. Clearly, the focus is that learning should be on conceptual understanding. In fact, this "shift in the goals of science teaching from students simply creating a knowledge base of scientific facts to students developing deeper understandings of major concepts within a scientific discipline has been underpinning most science education reform movements in the last 20 years" (Tanner & Allen, 2005, p. 112).

Concept Maps and Meaningful Learning in Biology

Meaningful learning occurs when the learner interprets new information by relating it to and incorporating it with existing knowledge and then applies the new information to solve novel problems. Each concept does not stand on its own, but instead has a relationship with many others for meaning. It is for this reason that a concept map can be used to enhance meaningful learning (Briscoe & LaMaster, 1991; DiCarlo, 2006). A concept map is a non-linear diagrammatic representation of meaningful relationships between concepts. The concepts are linked by words that describe the relationships or connections between the concepts (DiCarlo, 2006). Such a form of learning is especially important in a scenario of expanding knowledge as we have today in Biology, so that new concepts must be linked to existing ones for any meaningful learning to take place. A student who tackles the new concepts without linking will of course not get the big idea and be lost at some point naturally. A poignant example is the topic of evolution. Evolution in the past was taught in two broad conceptual frameworks and these were the Darwinian and neo-Darwinian concepts. The first dealt with natural selection and speciation, while the latter incorporated concepts in Mendelian genetics. The two were then linked by the Hardy–Weinberg theory. In contemporary evolutionary studies, the expanding fields of phylogenetics and molecular evolution have become significant in the topic and have revolutionised our understanding of both the organisation of life and how it has changed over time. On top of that, a student has to assimilate an understanding of biogeography and the study of fossil records into an understanding of how life evolved. The relationships between traditional classification and modern phylogenetics, natural selection versus neutral theory, natural selection, fossil records and biogeography have made the study of evolution one of the more challenging topics in the "A" levels. On the whole, students' understanding is enhanced when they realise that as a theory, the theory of evolution is made up of many concepts, old ones linked to new ones and all linked to how life on earth has changed. A concept map approach to this study has been found to be the most suitable, as it explores the connections rather than an approach that is focused on discrete facts and rote learning.

Besides the forthright use of concept maps, conceptual learning can be advocated for demonstrating the genuine usefulness of the topic. This creates meaning and ensures that learning is interest-driven. Hence, Herron, Parr, Davis and Nelson (2010) designed a theme-based instruction for sickle-cell anaemia that connected diverse concepts such as genetics, biogeography and cell biology into a thematic unit. Sickle-cell anaemia is a topic personally relevant to students in the United States as 80,000 Americans suffer from the disease, and African Americans show an 8 % gene frequency of the allele. However, the way this disease is presented to learners tends to be oversimplified and often obsolete. Generally, Herron et al. (2010) postulated that teachers would agree that students would respond positively to topics that demonstrate genuine usefulness. They went on to write the unit with connections to various other concepts such as evolution, biochemistry, ethics and epistemology. What was interesting in this study was that such a conceptual way of teaching Biology actually enhanced the teachers' own understanding of the links between the concepts further.

As was mentioned earlier, at the heart of concept-based learning is conceptual change. Biology educators Tanner and Allen (2005) point out that due to the step-wise nature of testing and checking competing conceptualisations, the learning becomes personal and well integrated into students' own frameworks for understanding. In fact, conceptual change is very much the way that a scientist learns in the laboratory, which is a far cry from the way teachers approach classroom science. One way of checking on learners' conceptual understanding has been put forth by Anderson, Fisher and Norman (2002), who developed a Conceptual Inventory of Natural Selection (CINS) that employs known alternative conceptions as "wrong answers" in a multiple-choice assessment tool. Such assessment tools can be useful for instructors to understand which misconceptions are prevalent, why students had the wrong concept, and how instructors can be allowed to facilitate conceptual change.

Learning Biology Conceptually: Real-World Scenarios

To enable deep conceptualisations, learners need to analyse the relationship between real-world problems and implications for understanding connections between science and society. Problem-based learning scenarios encourage learners to go beyond the collection of facts to solve problems creatively and apply concepts. Done in a group, PBL can be highly interactive and can facilitate peer learning (DiCarlo, 2006). In the United States, the Science Education for New Civic Engagements and Responsibilities (SENCER) was initiated in 2001 with funding from the National Science Foundation (Labov et al., 2010). One of the main aims is to improve science education by focusing on real-world problems and, by so doing, extend the impact of this learning across the curriculum to the broader community and society. The model courses include modules on food consumerism, biomedical issues of HIV/AID and even addiction, all of which provide a direct link between science and postmodern dilemmas that affect us today.

One example that has been used by the authors focuses on gifted learners studying the impact of food technology and its long-term impact on humans. Students were asked to make connections between diseases caused by technology, advances for growing food, food shortages, genetic alteration of foods and that of fertilisers on the environment. Here, several concepts needed to be linked in order for students to come up with representation, and students had to work in make-believe scenarios. The process resulted in important insights as students began to see how they had to focus less on content knowledge and instead consider processes such as the ability to think, reason, analyse and communicate in order to solve the problem. This real-world problem-solving allowed learners to conceptualise using a constructivist approach and therefore is envisaged to prepare them for the workforce later, where content they have learnt may have increased manyfold or become obsolete.

Challenges of Concept-Based Approach: Meeting Student Needs

Perhaps one of the biggest challenges facing teachers adopting the concept-based approach would be time constraints and the fine balance the teachers have to make between expounding and connecting various concepts and the need to cover all the standard learning outcomes as spelled out in the syllabus. The teacher will need to provide opportunities for students to explore science concepts by imbedding them in relevant contexts. It is more likely for students to learn and retain core concepts when they are placed in the rich environment of modern research topics. While substantial amounts of time should be used to portray fundamental concepts as applied to modern real-world problems, care must be taken not to create a false comfort zone for students who may learn the context but not have a firm grasp of the concepts. A balance is required when using context as the stepping stone to firm concept learning. This allows students to see the excitement of current research in science and the necessity of understanding science well.

Challenges of Concept-Based Approach: Assessing Learning Outcomes

Assessments have their place in studying the effectiveness of instructional strategies. Gauging the effectiveness of teaching and learning in the concept-based approach involves more than just exams and course evaluations. Assessments have to be formative in nature, and they need to help the learner modify their thought processes in light of the ongoing concept acquisition. The formative assessments should also provide information for making course corrections leading to more effective teaching and learning. For example, if the teacher notices that some students do not understand a lesson, he/she can stop and review or ask the students to discuss what is not being understood. The teacher uses that information to modify the lecture or class activity based on student input. The difficulty, especially in higher education, is the lecture is interrupted, and material covered decreased.

Nevertheless, it must be pointed out here that there is no benefit in covering more material when students do not understand what is being said. DiCarlo points out the greater challenge would be the mindset of educators themselves who are apprehensive about making the change and question "What about content mastery?" (2006). It is better to cover less, work for deeper understanding of fundamental concepts and promote long-term fusing of new ideas onto the student's conceptual framework. In addition, the time spent helping students to reason through an issue develops their intellectual processing skills so that they will become better independent learners and achieve long-term retention of concepts and skills. To enhance the students' learning, the teacher could at the beginning of a topic use a pretest in order to determine the current level of understanding achieved by all students. Doing so can also

Table 1 Conceptual questions

Heat is given off when methane burns in air according to the equation:
$CH_4 + O_2 \rightarrow CO_2 + 2H_2O$
Which of the following is responsible for the heat being given off?
(a) Breaking carbon, hydrogen and oxygen bonds gives off energy
(b) Forming carbon–oxygen and hydrogen–oxygen bonds gives off energy
(c) Both breaking and forming bonds give off energy

provide an opportunity for opening the classroom dialogue leading to increased communication and learning.

However, a bigger challenge in assessing learning in the concept-based approach is to come up with the appropriate performance tasks which can effectively assess the students' understanding of the concepts while allowing the students to demonstrate their acquisition and organisational schema of disciplinary knowledge in the topic. Furthermore, the choice of skills to be tested will also determine the type of performance task being set. Performance tasks are also difficult to carry out because they are quite resource dependent. In this respect, educators have since trialled ways of using summative assessments to address this challenge. Concept-based examinations, both in structured response formats (usually multiple-choice type) and unstructured response formats (usually short answer or free response), are being used as effective tools in assessing students' conceptual learning and understanding as well as the level of chemistry misconceptions they hold.

Therefore, it has been suggested that the use of a list of questions that draw attention to core concepts, such as the Chemical Concepts Inventory (CCI) (Mulford, 1996), can be used to check student's misconceptions. Hence, a common question that students taking A-level Chemistry courses encounter is the topic of combustion, and they often learn that the heat produced during burning is due to bond breaking and bond formation. The point of a conceptual focus in the questions therefore comes by way of offering three distinct options, as shown in the example on the combustion of methane in Table 1.

The three options focus on three different ideas, and in this regard, the learner, in answering such a question, would have to differentiate the role that bond formation and bond breaking have on the energy given off during combustion.

As the laboratory is an essential component of education in the sciences, students are expected to gain from their laboratory experience and learn to ask questions about both techniques and patterns of thinking that lead to specific conceptualisations. However, assessing laboratory knowledge remains a challenge, especially since the assessment should be based on relevant demonstrable laboratory knowledge rather than through theoretical knowledge. One way to enable such assessments is to get students to design experiments that have real-world linkages. An example of such an assessment[2] (Cuadros & Yaron, 2005), available as a web resource for teachers today, involves getting students to plan experiments that test soil samples for arsenic, a highly toxic pollutant found in well water in Bangladesh. A large portion of the rural population in this Third-World country depends on wells for their drinking and personal needs. Teachers get students to carry out the virtual experiment, using a downloaded app. However, the activity also makes clear that the actual testing for arsenic concentration in drinking water in the real world is better addressed by testing for arsenic concentrations in the soil, which is considerably higher than that present in groundwater.

Getting students to plan the experiment and then carry out their plan provides them with an opportunity to integrate different concepts in chemistry (stoichiometry, limiting reagents) in an attempt to solve a tangible real-world problem at hand. The process of assessment can also be helped along by employing computer-based resources, such as applets, which takes the strain of real-time monitoring and assessment of all students in a chemistry laboratory in one sitting. Yet another way of assessing the planning process can also involve viva voce assessments that are conducted after the students have planned and carried out their plans.

Making Connections with Gifted and Talented Learners and Science Education

Appropriate science education curriculum that promotes high-quality learning is desirable for gifted and talented learners, along with all other learners. Access to such learning should be given for all learners demonstrating a strong desire for a challenging science curriculum in schools. Gifted and talented learners must be challenged using teaching strategies that cause these students to use critical thinking skills, focus on resolving science problems that impact society and use technology as a focal point to resolve science issues that require inquiry into science systems, change and scale. A rigorous and appropriate science curriculum which is relevant to the twenty-first century is necessary to prepare our high-ability students well to meet the challenges of the world and to contribute effectively for the betterment of our societies. Understanding relevant scientific concepts, applying the appropriate scientific research processes and tackling ethical issues of science and technology are but a few important skills and knowledge we hope our highly able learners can acquire.

[2]Adapted with kind permission from Dr. Cuadros and Dr. Yaron. ChemCollective, Gravimetric Determination of Arsenic Info, 2005, Jordi Cuadros and Dave Yaron.

References

Anderson, D. L., Fisher, K. M., & Norman, G. J. (2002). Development and evaluation of the conceptual inventory of natural selection. *Journal of Research in Science Teaching, 39*(10), 952–978.

Basili, P. A., & Sanford, J. P. (1991). Conceptual change strategies and cooperative group work in chemistry. *Journal of Research in Science Teaching, 28*(4), 293–304.

Briscoe, C., & LaMaster, S. U. (1991). Meaningful learning in college biology through concept mapping. *The American Biology Teacher, 53*(4), 214–219.

Bruner, J. S. (1960). *The process of education*. Cambridge, MA: Harvard University Press.

Clark, B. (2002). *Growing up gifted: Developing the potential of children at home and at school* (5th ed.). Columbus, OH: Merrill.

Coll, R. K., & Treagust, D. F. (2001). Learners' mental models of chemical bonding. *Research in Science Education, 31*(3), 357–382.

Cuadros, J., & Yaron, D. (2005). *Gravimetric analysis of arsenic*. Retrieved from the Chem Collective website: http://chemcollective.org/activities/info/75

DiCarlo, S. E. (2006). Cell biology should be taught as science is practised. *Nature Reviews Molecular Cell Biology, 7*(4), 290–296.

Ebenezer, J. V., & Gaskell, P. J. (1995). Rational conceptual change in solution chemistry. *Science Education, 79*, 1–17.

Erickson, L. (2002). *Concept-based curriculum and instruction: Teaching beyond the facts*. Thousand Oaks, CA: Corwin Press.

Feldhusen, J. F. (1988). Developing units of instruction. In J. V. T. Baska, J. Feldhusen, K. Seeley, G. Wheatley, L. Silverman, & W. Foster (Eds.), *Comprehensive curriculum for gifted learners* (pp. 112–150). Boston: Allyn & Bacon.

Fink, L. D. (2013). *Creating significant learning experiences: An integrated approach to designing college courses*. San Francisco: Wiley.

Harrison, A. G., & Treagust, D. F. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching chemistry. *Science Education, 80*(5), 509–534.

Herron, S. S., Parr, J., Davis, B., & Nelson, P. (2010). Theme-based instruction: Making conceptual ties with the Sickle cell story – Incorporate genetics, bioethics, proteomics, and more through the study of SCD. *The American Biology Teacher, 72*(7), 422–426.

Hewson, P. W. (1981). A conceptual change approach to learning science. *European Journal of Science Education, 3*(4), 383–396.

Hockett, J. A. (2009). Curriculum for highly Able learners that conforms to general education and gifted education quality indicators. *Journal for the Education of the Gifted, 32*(3), 394–440.

Holbrook, J. (1994). Scientific and technological literacy for all – The role of educators. *Science Education International, 5*(3), 10–16.

Hurst, M. O. (2002). How we teach molecular structure to freshmen. *Journal of Chemical Education, 79*(6), 763.

Kaplan, S. (1994). *Differentiating core curriculum and instruction to provide advanced learning opportunities*. Sacramento, CA: California Association for the Gifted.

Kwon, Y. J., & Lawson, A. E. (2000). Linking brain growth with the development of scientific reasoning ability and conceptual change during adolescence. *Journal of Research in Science Teaching, 37*(1), 44–62.

Labov, J. B., Reid, A. H., & Yamamoto, K. R. (2010). Integrated biology and undergraduate science education: a new biology education for the twenty-first century? *CBE-Life Sciences Education, 9*(1), 10–16.

Mulford, D. R. (1996). *An inventory for measuring college students' Level of Misconceptions in first semester chemistry. (Masters)*. West Lafayette, IN: Purdue University.

Nahum, T. L., Mamlok-Naaman, R., Hofstein, A., & Krajcik, J. (2007). Developing a new teaching approach for the chemical bonding concept aligned with current scientific and pedagogical knowledge. *Science Education, 91*(4), 579–603.

Nakhleh, M. B., & Krajcik, J. S. (1993). A protocol analysis of the influence of technology on students. Actions, verbal commentary, and thought processes during the performance of acid-base titrations. *Journal of Research in Science Teaching, 30*, 1149–1168.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (NCTM). (2006). *Curricular focal points for prekindergarten through grade 8 mathematics: A quest for coherence*. Reston, VA: National Council of Teachers of Mathematics.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press (US).

National Research Council. (1998). *How people learn: Brain, mind, experience, and school*. Washington, DC.: National Academies Press.

National Research Council. (2009). A new biology for the 21st century: Ensuring the United States leads the coming biology revolution Retrieved from National Academies Press. www.nap.edu/catalog.php?record_id=12764 (0309144884). Retrieved December 26, 2010, from National Academies Press (US) National Academies Press. www.nap.edu/catalog.php?record_id=12764

Pereira, M. P., & Pestana, M. E. M. (1991). Pupils' representations of models of water. *International Journal of Science Education, 13*(3), 313–319.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211–227.

Renzulli, J. S., & Reis, S. M. (2009). The schoolwide enrichment model: A focus on student strengths & interests. In J. S. Renzulli, J. E. Gubbins, K. S. McMillen, R. D. Eckert, & C. A. Little (Eds.), *Systems & models for developing programs for the gifted and talented* (3rd ed., pp. 323–352.). Mansfield Center, CT: Creative Learning Press, Inc.

Renzulli, J. S., Smith, L. H., White, A. J., Callahan, C. M., Hartman, R. K., & Westberg, K. L. (2002). *Scales for rating the behavioral characteristics of superior students (Revised)*. Mansfield Center, CT: Creative Learning Press.

Taagepera, M., Arasasingham, R., Potter, F., Soroudi, A., & Lam, G. (2002). Following the development of the bonding concept using knowledge space theory. *Journal of Chemical Education, 79*(6), 756.

Taber, K. S. (1998). An alternative conceptual framework from chemistry education. *International Journal of Science Education, 20*(5), 597–608.

Taber, K. S. (2001). Building the structural concepts of chemistry: Some considerations from educational research. *Chemistry Education Research and Practice, 2*(2), 123–158.

Taber, K. S., & Watts, M. (2000). Learners'explanations for chemical phenomena. *Chemistry Education Research and Practice, 1*(3), 329–353.

Tanner, K., & Allen, D. (2005). Approaches to biology teaching and learning: Understanding the wrong answers—teaching toward conceptual change. *Cell Biology Education, 4*(2), 112–117.

Taylor, N. (2002). Mental models in chemistry: Senior chemistry students'mental models of chemical bonding. *Chemistry Education Research and Practice, 3*(2), 175–184.

Tomlinson, C. A., Kaplan, S. N., Renzulli, J. S., Purcell, J. H., Leppien, J. H., Burns, D. E.,… Imbeau, M. B. (2008). *The parallel curriculum: A design to develop learner potential and challenge advanced learners.* Thousand Oaks, CA: SAGE.

VanTassel-Baska, J. (1986). Effective curriculum and instructional models for talented students. *Gifted Child Quarterly, 30*(4), 164–169.

VanTassel-Baska, J. (1998). *Planning science programs for high-ability learners* (EC Digest #E546). Retrieved from the ERIC Clearinghouse on Disabilities and Gifted Education website: www.hoagiesgifted.net/eric/e546.html

VanTassel-Baska, J., Bass, G., Ries, R., Poland, D., & Avery, L. D. (1998). A national study of science curriculum effectiveness with high ability students. *Gifted Child Quarterly, 42*(4), 200–212.

VanTassel-Baska, J., & Stambaugh, T. (2006). *Comprehensive currciulum for gifted learners* (3rd ed.). Boston: Pearson.

Curriculum Evaluation

Chwee Geok Quek

What Is Curriculum?

In the curriculum evaluation literature, there appears to be no consensus on what curriculum is. The term 'curriculum' is used by different stakeholders to mean different things. It is not uncommon for teachers to equate curriculum to 'the syllabus', the content, the topics and the knowledge to be taught at each grade level. 'Curriculum' has also been variously used by educators to mean the 'prescribed' teaching materials for use across grade levels. In environments when teachers have academic standards (criteria to determine achievement for a particular subject area at a particular grade level) to adhere to, the standards *are* the curriculum (Erickson, 2007). Consequently, parents tend to equate curriculum to what is to be covered in (high-stakes) tests and exams. A common question asked of teachers during parent-teacher meetings or through email these days is 'Will this be tested? If not, why are you teaching it?' It is probably true that the testing tail wags the curriculum dog especially in systems where success is inextricably tied to student performance in standardised exams and international studies.

How do experts see curriculum? Erickson (2007)) wrote that 'a curriculum is a coherent, teacher-friendly document that reflects the *intent* (emphasis in original) of the academic standards' (p. 48). To Grundy, curriculum is 'a programme of activities (by teachers and pupils) designed so that pupils will attain so far as possible certain educational and other schooling ends or objectives' (Grundy, 1987). Kerr (1968) wrote that curriculum refers to 'all the learning which is planned and guided by the school, whether it is carried on in groups or individually, inside or outside the school'. Yet others define curriculum as 'what happens in the classroom and what people do to prepare and evaluate' (Kelly, 1999, 2009), however, opines that

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'curriculum must embrace all the learning that goes on in school whether it is expressly planned and intended or is a by-product of our planning and or practice' (p.11). Stenhouse (1975) defined curriculum as 'an attempt to communicate the essential principles and features of an educational proposal in such a form that it is open to critical scrutiny and capable of effective translation into practice'. Bobbitt (1918) sees curriculum as a set of experiences which learners must have to acquire the skills that are needed to 'live life'. Besides what has been planned, and 'taught', Kelly (2009) asserts that what is received by the students is equally important. This alludes to a distinction between the planned and espoused curriculum, the enacted curriculum and the received curriculum.

In this chapter, curriculum refers to the knowledge and skills that learners will acquire as a result of well-planned instructional activities and learning experiences designed to enable them to meet set learner outcomes.

What Is Evaluation? What Is Curriculum Evaluation?

The definition, purpose and methods of evaluation are as diverse, and to a large extent, the conceptions of the purpose reflect the methodology of evaluation. The Joint Committee on Standards for Educational Evaluation (1994) defined evaluation as 'the systematic investigation of the worth or merit of an object (programme, project, intervention)'. Scriven (1994) makes a distinction between worth and merit; worth measures if the object is essential in contributing to the school's mission (Are targets set valuable?), while merit measures if what the school seeks to do (through the object) meets established standards of excellence (Is the curriculum in place the best to achieve the set targets?). To Scriven, curriculum evaluation ought to consider both worth and merit, and the findings ought to be used to guide programme improvement and future planning. Weiss (1998) defines evaluation as the systematic assessment of a programme or policy against some set of standards, with a view of improving that programme or policy. To Patton (2008), the purpose of evaluation is to produce useful information for programme improvements and decision-making, and he advocates the use of utilisation-focused evaluation to improve programmes. For evaluation to inform decision-making, the evaluation must be designed and implemented in such a way that the findings can indeed make a difference to decision-making about programme improvement, and the way to do this is to ensure that the findings will be used by intended users. Stake's (2003) advocacy of responsive evaluation (responsiveness to key issues recognised by the team being evaluated) as a service to clients will probably enhance the chances of the findings being utilised. The idea of 'improving' is also evident in Eisner's view of evaluation as a means to improve educational processes. Questions he feels ought to be on the minds of evaluators should include 'Are the children being helped by the form of teaching they are experiencing?' and 'Are they forming habits of mind conducive to further development?' Questions such as these require the use of educational criteria (Eisner, 1985). The notion of the use of educational criteria implies the need for some kind of (numerical) rating to judge how well the evidences gathered are aligned and how effective they will be to help achieve stated goals. Curriculum evaluation therefore is the process by which one attempts to gauge the value and efficiency of the curriculum. The purpose of the evaluation varies depending on the conceptions of the evaluation team, the team being evaluated and the body commissioning the evaluation.

Objectives, Goals, Philosophy and Rationales for Conducting Curriculum Evaluation for Schools

To Marsh and Willis (2003), the purpose of conducting curriculum evaluation is straightforward: to improve teaching, to examine effects of new curriculum and to justify school practices. To understand the last purpose first—justify school practices, perhaps a reference to the academic standards and school reform movement in the USA—would be helpful. School reform which includes curriculum, instruction and assessment helps schools achieve standards that they want students to attain, and the curriculum that is designed is thus based on the standards that have been set by the community. Since the curriculum determines what students learn, when they learn it and how well they learn it, the purpose of curriculum evaluation therefore is to collect evidence about the curriculum; make judgements about it, based on established criteria; and use the findings of the evaluation to inform decision-making like professional development for teachers to improve teaching and to enhance the intended effects of the curriculum enacted. Unlike other types of evaluation (e.g. impact/outcome evaluation), the purpose of curriculum evaluation is not to prove school achievement (Cronbach, 1963; Stufflebeam, 1983) but to improve curriculum. It is formative evaluation (Stufflebeam, 1983).

A development analogous to school reform in the USA would be the changes in the education landscape in Singapore in the last two decades. With the vision of Thinking Schools Learning Nation (Ministry of Education & Singapore, 1997), Teach Less Learn More (Ministry of Education & Singapore, 2004), master plan for the infusion of information and communications technology in the curriculum and the concomitant devolving of control from the Ministry of Education to schools even in areas of programme and curriculum development, there is now impetus for schools and stakeholders to examine the effectiveness of curricular innovations arising from the initiative to offer learners multiple pathways to achieve their potential and curriculum developed to fill the 'white space' arising from Teach Less Learn More. Questions common on the minds of schools include the following: What have we done well? What is working but can be better or improved? What needs to be dropped? What needs to be added?

To meet the needs of the schools being evaluated, the philosophy adopted for the curriculum evaluation is probably more democratic than bureaucratic. The approach is descriptive rather than prescriptive. The evaluation serves to offer rich information about the characteristics of the curriculum (as seen by an external party) to the stakeholders, to facilitate the exchange of information among different stakeholder groups and to ensure accessibility to the evaluation findings. Any judgement made, and judgement is inevitable in any evaluation, is made with a view to help the stakeholder see the gaps in their curriculum and the areas to prioritise attention. For instance, to determine the extent to which the curriculum will produce positive and educationally appropriate outcomes for students, the evaluator must identify and describe the curriculum and its objectives first and then check its contents for comprehensiveness, breadth, depth, quality and timeliness.

In the belief that the curriculum is not just a rigid scope and sequence, the evaluation team will communicate to the school being evaluated the request for other documents that will enable the team to see and document the quality of the curriculum.

The approach adopted is an evidence-based approach: rating scales, rubrics and criteria used are based on what extant literature says are hallmark features of quality (concept-based) curriculum. The criteria are then used to evaluate and pass judgement on the quality of the curriculum. The criteria chosen are perceived by the evaluation team to be paramount to the end result: the design of the curriculum with respect to the quality of coherence within subject disciplines within each grade level and across different grade levels (Are important topics missing, and are topics appropriately scoped and sequenced?) and with respect to (the quality of the) learning goals and learner outcomes, instructional activities and questions, differentiation and other provisions for more advanced learners, use of information technology, connections within and across disciplines and assessments and assessment modes (as reflected in a variety of student products).

For example, is there alignment between the course content and the espoused goals, between the instructional activities and the learner outcomes, and are these in turn aligned to assessments? Does the curriculum give pupils a practical knowledge about the topics being taught? Are instructional materials aligned to standards, and do they build on pupils' existing knowledge (Bransford, Brown, & Cocking, 2000), and are they appropriately pitched for gifted and high ability learners? Do teaching and learning activities equip pupils with twenty-first century competencies and prepare them to be future-ready scholars and leaders? Are the assessments worthy, and do assessment tasks encourage pupils to use their own reasoning and thinking to find solutions to real-world problems in a realistic way? Do assessments require pupils not only to offer solutions to posed problems but also to problem-find and articulate how solutions are formulated? The exercise is dedicated to serving the information needs of curriculum developers, teachers implementing the curriculum and decision-makers (Campbell, 1969; Cronbach, 1982; Rossi, Freeman, & Lipsey, 2006). Cognizant of the importance of a strong relationship with the school being evaluated, the evaluation team is acutely aware of the sensitivities of the school and tries as best to situate the curricular innovation and experimentation in the context of the school and to identify and understand the reasons for weak spots (local expectations, values and resources) in order to make recommendations that will be more palatable to the constituents. The evaluation team also acknowledges that the evaluation is inevitably influenced by the values of those involved in the evaluation exercise while at the same time emphasising that the findings are based on careful consideration of evidence gathered from the documents submitted for the evaluation exercise.

It can be argued that curriculum evaluation is a form of ipsative (Bracken, 2004) assessment. The purpose of the evaluation is to help the school see if its curriculum has made improvements, compared to its own previous curriculum, not compared to the curricula of other schools.

What Are the Criteria in Evaluating Concept-Based Curriculum?

What is concept-based curriculum? Why do schools want to have a concept-based curriculum? What are the outcomes that the school hopes to achieve? These questions are important for framing the evaluation questions.

Applebee's (1996) discourse about curriculum reflects the intended outcomes of a concept-based curriculum (even though he does not even mention 'concept-based' curriculum) and what students ought to be exposed to, to engage in, in order to 'experience transformation through schooling'. He argues that curriculum, 'rather than stressing knowledge as a body of information to be mastered, should conceive of knowledge as action, of activity in cultural practices, traditions of discourse through which students are enculturated to the values of academic disciplines'. The curriculum should therefore 'create opportunities for students to enter and take part in disciplinary practices through appropriate activity, particularly the conversation through which disciplinary practices are developed' (p. 9). What to Applebee is 'typical curricula' is what we would consider to be concept-based curriculum. To him, curricula should not consist of 'catalogues of items, collections of information, sequences of events, and episodes of occurrences'. He argues that curriculum ought to be organised to enable students 'to integrate knowledge through participation in an extended conversation, to discover interrelationships across all of the elements in the curriculum', and as new elements enter into the conversation, 'they provide not only new contexts for exploring or redefining the established topic, but new perspectives on other elements in the conversation, and on the topic itself'. Such conversations have four key characteristics:

- They are built around language episodes of high quality.
- They have an appropriate breadth of materials to sustain conversation.
- They include a variety of parts that are interrelated.
- They include instruction that is geared to promote students' entry into the curricular conversation through such processes as instructional scaffolding (p. 77).

When there is a shift in the curricular focus from bodies of knowledge to be mastered to questions and themes that form the basis for conversations, students get to manipulate and synthesise what they have learnt, and assessments will shift from knowledge of a subject to knowledge-in-action, focusing on students' ability to define interesting questions, express a clear point of view, gather evidence and structure arguments according to disciplinary conventions. Assessment thus emphasises students' developing abilities to enter disciplinary conversations.

In her book *Concept-Based Curriculum and Instruction for the Thinking Classroom*, Erickson (2007) echoes the importance of disciplinary conversations and makes a distinction between factual (discrete, basic elements in a discipline) and conceptual (relationships between basic elements in a larger structure like concepts, principles and generalisations) levels of knowledge and argues that curriculum and instruction should be designed to integrate factual-conceptual thinking. The curriculum should give students experience of being practitioners in a discipline, and to achieve this, over and above teaching critical content, teachers need to develop disciplinary ways of knowing, understanding and doing and to apply these in new contexts to solve new problems, create new products or propose new ideas.

Eisner's (1969) concept of 'expressive objectives' (which he later changed to expressive outcomes) conveys very much the same features of what we would expect to see in a concept-based curriculum. An expressive objective does not specify the behaviours of students who have been exposed to some teaching and learning activities. Instead, an expressive objective identifies a scenario in which students have to work, a task in which they have to engage, but what exactly students need to do is open to their interpretation. An expressive objective also provides both teacher and student the choice to explore, defer and focus on what appeals to them. To Eisner, an expressive outcome serves as a theme around which earlier understandings and skills can be brought to bear, and through which those understandings and skills can be applied, and expanded to new contexts. When invited to bring their own thinking to a study, students are more likely to make personal meaning and thus become more engaged.

One can therefore expect a concept-based curriculum to be anchored in concepts, not to be crowded by excessive subject content focusing predominantly on factual knowledge, and to adopt student-centred pedagogy based on inquiry instead of frontal teaching dedicated to delivery of a body of content. One would also expect to see activities that generate discussions based on probing questions posed by students, tasks that challenge students to express their opinions, synthesise their learning and apply their understandings to new, novel contexts.

Questions About the Concept-Based Curriculum

What questions about the curriculum would the evaluation team ask to identify curriculum strengths and weaknesses?

Macro Documents

Bybee et al. (1990) have described very clearly how the specific details of the curriculum fit into the framework:

> A complete framework provides information needed to make decisions about the content, the sequences of activities, the selection of instructional strategies and techniques that are likely to be effective, appropriate assessment practices and other specifics of the curriculum… A framework is like the broad sketches of an architect's plan. The framework gives an initial picture of the programme and is based on certain specifications. The architect's plan has to fulfill certain requirements. At the same time, the more specific details are left to the contractors and the carpenters. Everyone knows there will be modifications as the framework is developed and implemented, but there should be some fidelity to the original intentions, specifications, and design. (p. 86)

Philosophy/Rationale

Is there an overall framework that spells out the rationale for adopting this concept-based curriculum and describes the design of the curriculum as well as the approaches adopted in its design? Is it clearly stated in a macro curriculum document the philosophy undergirding the design of the curriculum?

Can the philosophy/rationale be discerned from a macro document, e.g. curriculum map? Is there a scope and sequence document that coherently documents knowledge, skills and understandings within and across grade levels? Is there mention of an assessment plan to monitor and check student progress?

Higher order thinking skills are integral to all content areas and everyday life experiences (Paul, 1992; Paul & Elder, 2001). Students demonstrate their understanding of advanced content by making generalisations from the concrete to the abstract and vice versa and synthesising information within and across disciplines (Erickson, 2007; Van Tassel-Baska, 2003; Wenglinsky, 2000). Good instructional practice for the gifted and high ability emphasises the importance of concept development, thinking and reasoning and problem solving (Van Tassel-Baska, 2003). More highly able learners are motivated when engaged in learning basic skills in context rather than in isolation, functioning consistently at high levels of thinking, making connections among disciplines, solving real problems, presenting products to real audiences and dealing with ambiguities and behaving like professionals in the field (Tomlinson, 1999) when given materials and tasks designed to encourage inquiry learning, critical and creative thinking and higher order questioning. The curriculum should provide opportunities for independent study to equip learners with the prerequisite skills for effective research and develop these skills to a sophisticated level (Reis & Renzulli, 1992). Students should be required to use appropriate and varied research techniques to gather evidence from multiple sources, interpret, draw inferences and make conclusions from them. They also should be given the opportunity to communicate their research findings to relevant audiences (Van

Tassel-Baska & Little, 2003; VanTassel-Baska & Stambaugh, 2006). Besides whole-class instruction and discussion, there will be structured activities and questions to allow students to discover ideas individually. There will also be opportunities for individual or group learning and choice of material and task to accommodate individual or subgroup differences (Van Tassel-Baska, 2003). Assessment is at the heart of a successful curriculum as it enables pupils to recognise achievement and areas for improvement and provides teachers with evidence on ways to shape and adapt their teaching to meet student needs and aspirations. An evaluation of the curriculum would need to ensure coherence and alignment between assessments and instructional goals, learner outcomes as well as teaching activities.

To ascertain if some of the above features are present in the concept-based curriculum, questions about content, process, product and assessment can include the following:

Content

- Does the curriculum incorporate critical knowledge of the subject area? Is the curriculum organised around concepts and principles key to the discipline? Does the curriculum address the concepts, ways of learning and ways of knowing that are unique to the discipline? Is there a good balance between content, concepts and skills and between factual, conceptual and procedural knowledge?
- Is the curriculum developmentally appropriate and organised to optimise teaching instruction and learning?
- Has the curriculum been expanded and extended in breadth and depth? Is there too much focus on coverage? Is there alignment between course content and the goals?
- Are extensions made for the top pupils in the subject discipline?
- Have key concepts for the discipline been identified? Are they concepts (and not merely topics)? Are distinctions made between macroconcepts that transcend subjects and subject-/discipline-specific concepts? Are concepts taught in depth, and are conceptual links made across levels? Is spiralling evident, i.e. concepts dealt with greater complexity and sophistication?
- Are enduring understandings and essential questions meaningful, worthy and appropriate?
- Are concepts and big ideas used to make meaningful connections within and across disciplines? Have concepts and conceptual understanding been used to reduce content and to integrate curriculum?
- Are there real-life applications to reinforce connections and deepen understanding?
- Are teaching resources and materials sufficiently comprehensive and divergent to promote conceptual understanding? Are resources—human, material, fiscal and community—well tapped to enable attainment of outcomes set?

Process

- Do instructional strategies used promote student-centred learning, inquiry, exploration and investigation?
- Is there evidence of explicit teaching and deliberate infusion of higher order thinking skills, both critical and creative?
- Is consistent attention paid to developing intellectual dispositions and habits of mind?
- Are instructional strategies and models used to develop critical and creative thinking abilities clearly stated?
- Are teaching activities planned for generative conversations about issues key to the discipline? Are multiple perspectives explored? Are opportunities provided for constructivist learning, knowledge construction and risk taking, individually and in teams?
- Are the learning experiences designed to generate targeted performances appropriate? Which experiences need to be eliminated, and which need to be revised or expanded? What new experiences need to be designed?
- Are opportunities created for guided independent work and independent work? Is there collective deliberation of issues to engender consensual understanding?
- Do resources and materials used help to promote student thinking and engage them in the subject being taught?
- Is technology tapped to engage learners, promote independent learning and extend the learning community beyond the classroom?
- Is grouping by aptitude, ability and interest employed?
- Is due attention paid to foster habits of mind, intellectual dispositions and moral decision-making?

Assessments and Products

- Are tasks assigned important and relevant to the discipline? Are assessments linked to learner outcomes and aligned to essential questions? Do they probe conceptual understanding?
- Do assignments reflect high expectations and elicit products and performance of high quality and standard? Are there rubrics and exemplars to show pupils what is expected? How appropriate are the performance standards and benchmarks?
- Are pupils encouraged to demonstrate learning and understanding using different types of products? Do pupils have a choice in the type of assignments and the mode of presentation? Do pupils get to develop their own criteria for evaluation?
- Are tasks linked to the real world, meaningful to pupils and authentic (Purcell, Burns, Tomlinson, Imbeau, & Martin, 2002)?

These questions can be used to develop a rubric to provide schools with an indication of the state of health of the curriculum. The questions suggested above can be translated into statements. The curriculum identifies clearly critical knowledge (factual, conceptual, procedural) for the subject. The team can decide the number of bands in the rubric—should it be an odd or even number? For those who avoid an odd number rubric, the reason is usually because of the belief that it could encourage the tendency to gravitate towards the centre. Those who do not use an even number rubric are likely those who feel that it does not provide a clear picture of strengths and weaknesses. Whatever the number of bands used, the band descriptors must convey clearly where the school stands in the key dimensions being studied. Descriptors could range from beginning, developing and proficient to advanced or 'needs improvement', 'meets expectations' and 'exceeds expectations'. It is also recommended that 'not applicable' and 'not observed' be included, as not all the dimensions and criteria in the rubric would apply to all subject areas. 'Not observed' would be checked if a criterion applies but is not evidenced in the documents. A 'not observed' denotes absence of a feature while 'needs improvement' denotes quality of the feature observed.

Suggested Process Used to Evaluate Concept-Based Curriculum

Curriculum evaluation is commonly based solely on the written curriculum. It is therefore important that the curriculum documents be clearly written to convey its intent and communicate the nature of learning within a subject within and across grade levels.

Judgements are made on the basis of systematic analysis and interpretation of documents submitted to the evaluation team. To get a sense of the 'received curriculum' through written documents, the evaluation team would also request the school to submit sample student products as well as a sample concept unit. Since the purpose of the evaluation is to provide the school with information to help it improve its curriculum, the evaluation team will go back to the school to ask for additional written documents if important information cannot be gleaned from what has been submitted. To ensure consistent interpretation and application of the rubric, evaluators of all subject areas will have undergone training in the use of the (common) rubric.

Who Does the Evaluation?

For each subject area, it is ensured that the evaluator has deep content knowledge and has experience/expertise in developing concept-based curriculum. All the curriculum documents (including student products, end of term examination papers, etc.) submitted by the school would be perused by evaluators who are content specialists.

After the subject expert has completed his/her evaluation, the report is then read by his department head. Take science, for example. Three individuals would have been assigned to evaluate biology, chemistry and physics. All three reports would then be read by the science department head. The head's role is to check for consistency within each report and to provide additional insights, based on his reading of all three curriculum documents. He/she then discusses his/her evaluation with each individual evaluator, and the final individual science report is the product of this discussion. The head also checks if potential for intradisciplinary connections has been optimised. He/she then synthesises the major findings for the science curriculum and provides an 'overall report' for the sciences. In addition to highlighting strengths, all reports will include recommendations on priority areas to work on and next steps. The same process is followed for the different discipline areas. All the reports, both individual subject reports and 'overall' discipline reports, are then read by one evaluator whose role is to read the documents and the reports. This final evaluator asks questions to improve the clarity of the report if the writing is not clear. As the majority of schools organise instruction by subject thus encouraging an isolated and independent approach to teaching, it is unlikely that any one person in the school would have read all the curriculum documents. More often than not, the final evaluator is the only person to have done that and is thus in a unique, privileged position to comment on areas and issues that rise above disciplinary boundaries. He/she not only gets to see the overview of the curriculum but also how it is enacted in different ways to different degrees in different disciplinary areas. Some of the questions he/she would ask include the following:

- Is there alignment between what each subject department is doing and what the school seeks to attain through a concept-based curriculum?
- Is there coherence among the subjects in the effort to promote enduring understandings?
- Have all subject departments tapped on the concepts and big ideas as connective tissue to promote interdisciplinary understandings? He/she can also cite concrete evidence where potential for conceptual links can be made across grade levels within a subject and across subject areas.

The final evaluator will prepare a brief and succinct written report to highlight the salient findings culled from all the individual subject and department reports, commend the school for the identified strengths and make specific recommendations for refinements and improvements. Accompanying this report would be a visual summary of the relative strengths and weaknesses of each subject to help decision-makers literally *see* at a glance areas to focus on for the next curriculum review. This visual is not given to all teachers because it is not meant to pit one subject department against another nor one subject against another in the same department. The feedback is given to generate learning and provide some direction for changes, not to deliver absolute judgements of good or bad. For each subject area, they can compare their current ratings with those of the previous evaluation as per purpose of ipsative assessments. The visual would look something like Fig. 1.

Not Applicable (NA)	Not observed (NO)	Needs improvement 1	Meets expectations 2	Exceeds expectations 3

	Biology	Chemistry	Physics	Math	Geography	Etc.
Content						
The curriculum identifies clearly critical knowledge (factual, conceptual, procedural) for the subject						
Process						
Product						
Assessment						

Fig. 1 Visual summary of relative strengths and weaknesses

Communicating the Evaluation Findings

Before the written report is given to the school, a meeting will be set up for the entire evaluation team to meet with key personnel (decision-makers) from the school. At this meeting, the leader of the evaluation team will do an oral presentation—stating upfront the rationale for the evaluation, the evaluation process, the evaluation team and the assumptions of the team. This is done in the belief that the school personnel will use the findings if they understand and feel ownership of the evaluation process and findings (Patton, 2002). The key personnel are also advised not to use the evaluation to judge individual staff members. The 'meat' of the presentation is deliberately structured to reflect positive findings (to be affirming in the feedback) and highlight areas that need most attention (feedback for incremental improvements). In complimenting the school, evidence of good and best practice is cited with due credit. For instance, 'The science team has done a great job of…' However, when criticism is made, care is taken to ensure that no single subject or department is publicly humiliated. For instance, to highlight the science department's misalignment of instructional goals and activities with assessments, general examples will be given so that the department staff would not become too defensive, which would then make productive dialogues almost impossible.

Following the presentation, opportunities are provided for school personnel to seek clarification. Staff of the different departments would then be invited to the department-/subject-specific meetings with the evaluator(s) of the subject area. The evaluation findings are discussed and interpreted at an individual level—according to subject or according to the individual teacher who developed the curriculum. This meeting not only provides school staff the opportunity to explain why they do what they have done (as reflected in the curriculum documents) but also serves as a platform for the evaluator to offer his/her perspective and the basis for the judgement rendered. It is in many senses of the word a dialogue, not a monologue by the evaluator. Teachers, the primary users of the evaluation findings, are actively involved in interpreting the findings and generating recommendations on next steps to bring the curriculum forward and to the next level.

What Are the Intended Outcomes? How Do Schools Make Use of the Outcomes of Evaluation?

As can be seen, one of the intended outcomes of the evaluation is to generate constructive conversations among stakeholders (school personnel, curriculum developers, headquarters/central office supervisors, etc.) responsible for the curriculum to facilitate learning (Preskill, 2008). The evaluation and the sharing of the findings are deliberately designed to remove the tension between evaluator and those being evaluated—they share meanings, understand complex issues and uncover assumptions (Preskill & Torres, 1999) so that they can engage in collaborative exploration on ways to improve the curriculum to achieve what it is designed to achieve.

The types and range of documents requested by the evaluation team and the rubric used also help schools to pay attention to the critical aspects of their curriculum. Are their goals clear? Is there coherence among the different aspects of the curriculum within each subject and across subjects? The evaluation rubric also enables the school to think about problems beyond their range of experience. In fact, once the school sees the usefulness of the evaluation exercise, it would even use the rubric to monitor its own curriculum development and judge its own products. This self-evaluation is then submitted together with the curriculum documents of the next round of external evaluation, with clear description of steps to ratify the problem areas identified in the previous evaluation and areas that need further work or are being worked on. Besides self-evaluation, it is also hoped that evaluation findings will spur the school to embark on research to verify the evaluation findings and/or find answers to questions raised by the evaluation.

The reality is that use of the findings does not happen immediately or naturally. If the purpose of the evaluation is to help improve the curriculum, then the evaluators must engage in follow-up action to facilitate using the findings to guide curriculum improvement. If recommendations are not acted on, it does not mean the evaluation has been futile. Evaluators need to understand that inaction could be because the school, in response to the findings, has decided not to act until it has greater clarity of its goals, better assessment of its staff capacity, better calibrated its resource capabilities, etc.

Evaluation findings can also serve as an indicator of professional development needs. Even a well-designed curriculum grounded on sound principles, with exemplary features, can be poorly executed, and this will come through when student products are examined. The evaluation team, together with the school personnel, can then try to investigate the reasons for the nature and quality of student products and, through frank dialogue, eventually identify teachers' areas of need. Sometimes, curricula weakness can be attributed to factors beyond the school staff's control. For instance, parents who protest against, say, concept-based curriculum and complain to the ministry or central office about the school's failure to prepare their children for high-stakes tests could result in the school developing curriculum that focuses on content coverage, and to cover content, teachers inevitably adopt teacher-centred pedagogy like lectures. The nature of the professional development could well extend beyond teaching strategies to 'how to engage parents'.

Follow-up workshops to address the shortcomings surfaced in the evaluation would of course enhance the chances of achieving the evaluation outcome—to improve curriculum (and teaching and learning, etc.)

To be sure, another outcome, unintended of course, is that the evaluation findings can be ignored and forgotten. This will happen if the school is not willing to learn from shortcomings and goes through the process only because it is due for evaluation. This is a very real outcome because there are many challenges associated with evaluating concept-based curriculum.

Issue in Evaluating Concept-Based Curriculum: Conceptual Teaching and High-Stakes Test

Why would a school that has undergone an evaluation choose to ignore the findings, even if they agree with them? Dan Ariely (2010) put it this way: 'Human beings adjust behaviour based on the metrics they're held against. Anything you measure will impel a person to optimise his score on that metric'. High-stakes standardised tests are used to assess children, and children's performance on these is in turn used to evaluate teachers. Do high-stakes tests test conceptual understanding? No. Will teachers who are judged on the results of high-stakes tests teach conceptually or teach to prepare students to take the tests? The answer is obvious. Hence, one of the biggest challenges is to overcome teachers' resistance to curriculum revision. There is no alignment between what is espoused to be valuable—using concept-based curriculum to teach for higher-level thinking and deeper understanding—and the metric used to judge teachers: student performance on tests that test memorisation and regurgitation. While concept-based curriculum stresses an idea-centred approach, to teach less and learn more, the test-directed curriculum focuses on coverage (of topics) on the tests.

Introducing a 'new' curriculum takes time, especially if the 'new' (concept-based) curriculum requires the use of alternative pedagogy to replace that which teachers have honed to an art to prepare students for high-stakes tests. To deliver concept-based curriculum effectively, teachers would also need professional development and space for trial and error; they will need opportunities to have conversations about the 'new' curriculum, to learn from others' experiences and to receive affirmation about their experimentation. Delivering concept-based curriculum requires making many decisions that teachers used to implementing the (exam-based) syllabus may not be familiar with. Questions like how to choose concepts; how to write enduring understandings; how to align concepts, enduring understandings with instructional activities and assessments; how to choose resources that are of appropriate pitch; when to provide scaffolding for students to access complex materials; how to ensure exposure to concept-based curriculum while at the same time adequately preparing students for high-stakes exams (e.g. ensuring that extensions in breadth and depth are built on 'core' content). To guard against premature abandonment of concept-based curriculum by teachers, key personnel must be prepared for and acknowledge that there could be initial dips in performance, what Fullan calls an 'implementation dip' (2003).

The criticality of professional development for teachers and the time for teachers to become confident and adept at it cannot be underestimated. Time should also be considered while making sure that there is adequate capacity for the successful implantation of the curriculum. Teachers may have a very clear vision of what concept-based curriculum can do for learners. Teachers may even have very good knowledge of the what and the how of designing concept-based curriculum. But the translation of something general to subject- and topic-specific concepts and enduring understandings is a different thing altogether. It is not uncommon to see schools developing macro curriculum documents with eloquently written statements of philosophy and sophisticated enduring understandings that they would like students to have as a result of the carefully designed concept-based curriculum. Under pressure to design concept-based curriculum, teachers use designated overarching concepts or macro curriculum frameworks like understanding by design or teaching for understanding and devote much attention to developing enduring understandings (generalisations) and essential questions at the macro level. However, because of difficulty in translating these into discipline-specific, topic-relevant enduring understandings and critical content, the subject-specific documents either make no reference to the macroconcepts and/or identified enduring understandings or they will 'copy' the macro ideas into their subject scope and sequence, with enduring understandings replaced by specific instructional objectives aligned to topics that will be tested. School leaders need to ensure that the macro document will be implemented with fidelity and put in place processes to support the teachers. At the same time, the leadership also needs to understand that apart from equipping teachers with technical know-how, effort has to be put into changing teachers' mindset and attitude. It is only natural for teachers to cling to the old way of teaching if they feel they will be incompetent in teaching the new curriculum (Black & Gregerson, 2002).

Yet another challenge the evaluator could face is that of striking a balance between objectivity and desire to encourage the curriculum development and implementation effort. On the one hand, it is almost impossible to be absolutely objective since evaluation will be influenced one way or another by the personal values of the evaluators. On the other hand, sensitive to the needs of the school being evaluated and eager to offer context-specific advice to inform the curriculum innovation, the evaluator seeks to understand the thought processes of the curriculum designers and their thinking behind setting the goals and objectives and becomes too empathetic—allowing empathy for the school to sometimes lead to less than helpful evaluations that fail to objectively point out the lacklustre quality of the output (designed curriculum submitted for evaluation) but overcommends the dedication and diligence of the school in its effort to design and implement the new curriculum.

In any curriculum evaluation, there will be many different groups of stakeholders involved, and the evaluation findings will be interpreted differently by different stakeholders. Therefore, the evaluation team must have a keen appreciation for the audience of the report, take the necessary steps to situate discussions in the relevant context and acknowledge the transitions the school is making. If the evaluation is to be conducted on a regular basis, say, once in 2 or 3 years, be prepared that there will be differences in the follow-up actions of different groups of teachers.

Finally, it is important to remember why the evaluation was done in the first place—to provide the school with information to improve its curriculum. Therefore the conversations about the evaluation findings must be sustained to bring about changes, and to support the hunger for learning, the school and the evaluation team could explore how intermittent feedback could be given about incremental changes that are made.

References

Applebee, A. N. (1996). *Curriculum as conversation: Transforming traditions of teaching and learning*. London: University of Chicago Press.

Ariely, D. (2010). You are what you measure. *Harvard Business Review, June,* 38.

Black, J., & Gregerson, H. (2002). *Leading strategic change*. Upper Saddle River, NJ: Prentice Hall.

Bobbitt, J.F. (1918). *The curriculum*: Boston/New York: Houghton Mifflin.

Bracken, B. A. (2004). *The psychoeducational assessment of preschool children* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience and school*. Washington, DC: National Academy Press.

Bybee, R. W., Buchwald, C. E., Crissman, S., Heil, D. R., Kuerbis, P. J., Matsumoto, C., et al. (1990). *Science and technology education for the middle years: Frameworks for curriculum and instruction*. Washington, DC: National Center for Improving Science Education.

Campbell, D. T. (1969). Reforms as experiments. *American Psychologist, 24*(April), 409–429.

Cronbach, L. J. (1963). Course improvement through evaluation. In A. A. Bellack & H. M. Kilebard (Eds.), *Curriculum and evaluation* (pp. 319–333). Berkeley, CA: McCutchan.

Cronbach, L. J. (1982). *Designing evaluations of educational and social programs*. San Francisco: Jossey-Bass.

Eisner, E. W. (1969). Instructional and expressive educational objectives: their formulation and use in the curriculum. In L. Stenhouse (Ed.), *An introduction to curriculum research and development*. London: Heinemann Educational Books.

Eisner, E. W. (1985). *The art of educational evaluation: A personal view*. Philadelphia, PA: Falmer Press.

Erickson, H. L. (2007). *Concept-based curriculum and instruction for the thinking classroom*. Thousand Oaks, CA: Corwin Press.

Fullan, M. (2003). *Change forces with a vengeance*. London: Routledge Falmer.

Grundy, S. (1987). *Curriculum: Product or praxis?* London/New York : Falmer Press.

Joint Committee on Standards for Educational Evaluation. (1994). *The program evaluation standards: How to assess evaluations of educational programs* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Kelly, A. V. (1999). *The curriculum: Theory and practice* (4th ed.). London, UK: Paul Chapman Publishing Ltd.

Kelly, A. V. (2009). *The curriculum: Theory and practice* (6th ed.). London, UK: SAGE.

Kerr, J. F. (1968). *The problems of curriculum reform: Changing the curriculum*. London: University of London Press Ltd.

Marsh, C. J., & Willis, G. (2003). *Curriculum: Alternative approaches, ongoing issues* (3rd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Ministry of Education, Singapore. (1997). *Shaping our future: Thinking schools, learning nation*.

Ministry of Education, Singapore. (2004). *Teach less, learn more*.

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Patton, M. Q. (2008). *Utilization-focused evaluation* (4th ed.). Thousand Oaks, CA: Sage.

Paul, R. W. (1992). Critical thinking: What, why, and how? *New Directions for Community Colleges, 1992*(77), 3–24.

Paul, R. W., & Elder, L. (2001). *The miniature guide to critical thinking: Concepts and tools*. Dillon Beach, CA: The Foundation for Critical Thinking.

Preskill, H. (2008). Evaluation's second act: Spotlight on learning. *American Journal of Evaluation, 29*(2), 127–138.

Preskill, H., & Torres, R. (1999). Building capacity for organizational learning through evaluative inquiry. *Evaluation, 5*(1), 42–60.

Purcell, J. H., Burns, D. E., Tomlinson, C., Imbeau, M. B., & Martin, J. L. (2002). Bridging the gap: A tool and technique to analyze and evaluate gifted education curricular units. *Gifted Child Quarterly, 46*, 306–321.

Reis, S., & Renzulli, J. S. (1992). Using curriculum compacting to challenge the above-average. *Exceptionality, 10*, 113–125.

Rossi, P., Freeman, H. E., & Lipsey, M. W. (Eds.). (2006). *Evaluation: A systematic approach*. Thousand Oaks, CA: Sage.

Scriven, M. (1994). Evaluation as a discipline. *Studies in Educational Evaluation, 20*(1), 147.

Stake, R. (2003). Responsive evaluation. In T. Kellaghan & D. L. Stufflebeam (Eds.), *International handbook of educational evaluation* (pp. 63–68). Dordrecht, The Netherlands: Springer.

Stenhouse, L. (1975). *An introduction to curriculum research and development*. London: Heineman.

Stufflebeam, D. L. (1983). The CIPP model for program evaluation. In G. F. Madaus, M. S. Scriven, & D. L. Stufflebeam (Eds.), *Evaluation models* (pp. 117–142). Hingham, MA: Kluwer Nijhoff Publishing.

Tomlinson, C. A. (1999). Leadership for differentiated classrooms. *The School Administrator, 9*(56), 6–11.

Van Tassel-Baska, J. (2003). What matters in curriculum for gifted learners: Reflections on theory, research and practice. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 174–183). Boston: Allyn & Bacon.

Van Tassel-Baska, J., & Little, C. A. (2003). *Content-based curriculum*. Waco, TX: Prufrock Press.

VanTassel-Baska, J., & Stambaugh, T. (2006). Project Athena: A pathway to advanced literacy development for children of poverty. *Gifted Child Today, 29*(2), 58–63.

Weiss, C. H. (1998). Have we learned anything new about the use of evaluation? *American Journal of Evaluation, 19*(1), 21.

Wenglinsky, H. (2000). *How teaching matters: Bringing the classroom back into discussions of teacher quality*. Princeton, NJ: Educational Testing Service.

Lessons Learned from Developing and Implementing the Concept-Based Curriculum

Liang See Tan and Letchmi Devi Ponnusamy

In this final chapter, we discuss lessons learnt from the complexities of crafting and practising concept-based curriculum within schools and how these practices are related to curriculum perspectives and teacher capacity in terms of knowledge, skills and dispositions. We attempt to synthesise issues and ideas that have emerged across the different accounts put forth and raise the deeper question of *how researchers and practitioners can work together in conceptualising, implementing and assessing concept-based curriculum so that it is suited to the high ability learner.* Thus, in this concluding chapter, we delve deeper into the tenets of the larger political and social processes of curriculum making within the school as well as the key functions of a teacher in driving the curriculum change. As shown in accounts presented by the different authors in their chapters, there is evidence of an increasing interest and effort among educators to introduce and use concept-based curriculum in order to facilitate greater depth of learning for high ability learners. In view of the demands of equipping learners with twenty-first century dispositions and literacies, policymakers and educators in Singapore have put in concerted efforts in reframing the purpose, process and outcomes of learning in the education system.

According to Goodlad and Richter (1966), curriculum making is an intellectual and educational endeavour dwelling in complex political and social processes. They articulate three levels of curriculum decision-making, namely: the instructional, the institutional and the societal. They suggest that having a clear designation and communication of who the curriculum decision-making agents are at these levels will facilitate curriculum making. This can be illustrated by using Singapore as an example. In Singapore, there are structures and narratives at the instructional, the institutional and the societal level. Parallel to Goodlad and Richter's three levels of mechanisms, we see the presence of the micro-, meso- and macro-levels of the education system as suggested by Bronfenbrenner's (1979) ecological system

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theory. There have been efforts to achieve broader student outcomes through: (1) in instruction, which is at the micro-level (e.g. white space for professional learning team), (2) institutions, which is at the meso-level (e.g. the establishment of the Academy for Singapore Teachers), and (3) the society, which is at the macro-level (e.g. Thinking Schools Learning Nation; Teach Less, Learn More; twenty-first-century competencies framework; etc.). This means that the purpose, process and outcomes associated with school-based curriculum innovation such as that of the concept-based curriculum are intertwined with the larger societal, institutional and classroom goals.

Curriculum Perspectives and Teacher Knowledge

The conceptualisation and implementation of concept-based curriculum requires committed teachers who are flexible, adaptive and innovative in curricular works. Although research has shown that working in a supportive context helps (Tan & Ponnusamy, 2014a), a facilitative infrastructure that empowers teachers to make curriculum decisions is insufficient to sustain teacher competency and efficacy in developing concept-based curriculum. Any classroom change expected in education hinges on the level of readiness and effectiveness of teachers (Garet, Porter, Desimone, Birman, & Yoon, 2001; Mourshed, Chijioke, & Barber, 2010). Developing such infrastructure is crucial in education systems that have traditionally relied on centrally controlled curriculum and instructional decision processes, which are hoping to ensure greater customisation of education to meet future needs.

Planning and implementing curriculum change also requires schools, teachers and learners to break away from many years of accustomed practices. However, any attempt to bring in concept-based curriculum into the classroom has to factor in the reality of what teaching and learning looks like in the current classroom. Today, there seems to be widespread acceptance that teaching and learning activities are largely focused on fact memorising rather than on a deeper understanding of subject knowledge (Cohen, McLaughlin, & Talbert, 1993; Darling-Hammond & McLaughlin, 2011; Porter & Brophy, 1988). A large proportion of teacher-learning opportunities today are still transmission-based, so that when teachers attend out-of-school workshops, the professional learning is not always contextually situated and networked (Kelly, 2006). Therefore, although planning and implementing concept-based curriculum has the potential to promote quality thinking and depth of disciplinary understanding, there is a list of teacher and school factors that can impede curriculum change efforts.

In society, a school can be seen as a social agent that is interwoven into the social fabric and influenced by the need for economic development. Therefore, it is not surprising that there are multitudes of voices that call for schools to ensure that their content and aims of curriculum can cater to varying goals. Content and aims of curriculum are often seriously contested and debated.

At the societal level, depending on the social, political and economic priorities, a diverse curriculum perspective is described by Eisner (1985): (1) development of cognitive process, (2) academic rationalism, (3) personal relevance, (4) social adaptation and social reconstruction, and (5) curriculum as technology. The pressure in prioritising societal needs often results in snapshots of multiple curriculum perspectives in the centralised national curriculum. For example, in Singapore, a variety of factors has led to a range of curriculum perspectives. The performative pedagogy (Hogan et al., 2013) that persists in Singapore leads to educators holding the perspective of curriculum as technology; educational initiatives such as Thinking Schools Learning Nation, which mirror the nation's desire to develop and expand on the cognitive processes in learning, have focused on the cognitive development perspective. On the other hand, the Teach Less, Learn More initiative aims to drive teachers to focus on a plethora of good practices and system level support to promote personal relevance.

To support better learning and teaching, it is critical for teachers to be cognizant of the underpinning curriculum perspectives. These perspectives help them to more effectively accomplish their own curriculum goals and better work with others (Schiro, 2013). When teachers lack an understanding of the theoretical basis of the strategies and activities that they use, the outcome is that the use of these strategies will be less effective (Black & Wiliam, 2012; Shulman, 1987; Turner-Bisset, 1999). Thus, it is essential for teachers to embrace the relevant curriculum perspectives in order to effectively practise concept-based curriculum.

Hattie's (2003) meta-analysis, which found teachers contributing to 30 % of the variance in student learning outcomes, has spurred policymakers in some countries to resource and refocus the way teachers learn about their practice through learning communities (e.g. the Academy for Singapore Teachers—a national teacher-learning institution). Additionally, in the spirit of engaging learners, more autonomy to make curriculum decisions has been delegated to schools and teachers in recent times. Given such policy-level expectations, the teacher's instructional role is being extended from curriculum deliverer to curriculum planner and designer. Hence, teachers need to prevail over both instructional and curriculum decisions in order to maximise the intellectual and social space available for learners.

Studies by the OECD (2009) show that teachers' beliefs, practices and attitudes are closely associated with teachers' strategies to shape learners' learning, school improvement and effectiveness, as well as teachers' professional development. Specifically, teachers' beliefs about curriculum guide their pedagogical practices in the classrooms. Questions remain about whether teachers are cognizant of the need for expertise in curriculum design and development, whether they have the resources they need and whether school leaders are able to activate teacher agency in teaching for conceptual understandings. If these are lacking, then providing teachers with opportunities to deliberate and develop curriculum will enable them to become better agents of curriculum change.

Complexities in Deliberating Curriculum and Situated Learning

Schwab (1973/1978) highlights four common places for curriculum deliberative processes: student, teacher, subject matter and the milieu. Unlike Tyler's approach (i.e. four steps that relate to the sequence of setting up learning objectives, the selection of the learning process, the organisation of them into programmes and the assessment), Schwab's deliberative process is less linear and more flexible and dialectical. In the same vein, Grundy (1987) suggests teachers are constantly involved with praxis, in the way that teachers' actions shape and change the curriculum and pedagogies. There is a continual interplay between thoughts and actions as well as between ends and means. This process involves interpretation, understanding and application in "one unified process" (Gadamer, 1979, p. 275). Having the experience to design and craft curriculum permits teachers to identify problems/issues in teaching and learning and attempt to figure out how the issues can be resolved. Thus, valuing curriculum making as praxis is advantageous for teacher learning.

The shift of teachers' role, from curriculum deliverers to curriculum designers, creates tension in their work. In examining the preschool education reform in Singapore, Lim-Ratnam (2013) highlighted three threads of tensions in the curriculum-making process: (1) tensions between the philosophy of child development and expectations of school readiness by the public; (2) tensions in changing teachers' mindsets, beliefs and practice; and (3) tensions concerning issues of quality and affordability. Koh and Luke's (2009) study of Singaporean teachers' assessment practices also highlights similar issues.

These tensions have also been observed in the context of an Integrated Programme school. In a case study analysis, Koh, Ponnusamy, Tan, Lee and Ramos (2014) reported that curriculum making is a demanding endeavour for teachers as they are accustomed to following a prescribed national curriculum and preparing learners to race for the prized academic achievement. In the case study, teachers shared that they were overwhelmed when the responsibility of making curricular and instructional decisions was devolved to them and they were tasked to reframe the curriculum. Although the school leader advocated for curriculum and pedagogies that strived for conceptual understandings, teachers constantly struggled to reconcile the demands of high-stakes examination requirements and the need to reframe the curriculum for conceptual understandings. Such tensions can affect the success of curriculum change.

Designing and implementing concept-based curriculum is different from designing a typical curriculum. Even with the availability of structural and administrative support in school and opportunities for professional development, teachers might feel uncomfortable crafting curriculum as it is a greater professional demand placed on them. In this endeavour, teachers cannot simply cover the syllabus; instead, they have to be active agents who are confident about their knowledge about students and content in order to make professional judgements on curriculum. Hence, they have to engage in continuous recontextualisation of knowledge and their professional practice (Guile, 2014; Shulman, 1987; Turner-Bisset, 1999) in order to make better professional judgements (Shalem, 2014).

Lessons Learned from Developing and Using Concept-Based Curriculum

The key lesson learned from the chapters in this book is that the curriculum change process can be a complex enterprise that requires collective efficacy from key stakeholders in the context. However, synthesising the accounts of developing concept-based curriculum in America, Australia, South Korea and Singapore, it becomes clear that there are multiple leverages at the levels of school, teacher and classroom, and there are suggestions on how the quality of learning and teaching can be shaped by leveraging on teacher learning and professionalism within a system even as the concept-based curriculum is being designed and rolled out. We point to some key syntheses at the level of the school, the teacher and the classroom.

School Level: Strategic Direction for Curriculum Innovation and Changed Practice

The observation emerging from the chapters from different countries and contexts is that concept-based curriculum is adopted as curriculum improvement, or innovation is seen as a part of school improvement. Furthermore, in this case, the curriculum innovation does not take place only when the school is failing. Rather, developing concept-based curriculum for the high ability learner is construed as a legitimate means of sustaining quality learning and teaching experiences. In the literature, we know that curriculum change in school takes many forms and change may happen at any scale within a school (Hung, Lim, & Lee, 2014; Tan & Ponnusamy, 2014a). A way to trigger change that is impactful is to take the whole-school approach. Chapters 8 and 9 illuminate the value in taking such an approach in conceptualising and implementing concept-based curriculum. As mentioned in Chaps. 8 and 9 as well as Tan and Ponnusamy (2014a), it appears that the whole school approach in curriculum innovation and improvement has greater potential in propelling a seamless culture for learning at the school and teacher level.

To better understand and explain how schools are able to be agentic actors in driving curriculum change, we shall use Bernstein's pedagogic device to illustrate.

Bernstein (1990, 2000, 2001) underscores the pedagogic devices[1] that regulate the conversion of an official discourse into pedagogic communication. The rules of the pedagogic device guide the production, transmission and acquisition of the school curriculum. In the context of curriculum innovation, the distributive rules mediate the order in learning and teaching within the school by virtue of the learners' needs. As such, a different form of teacher knowledge and consciousness has to take place in order to reframe the curriculum. In a way, the curriculum that needs to be innovated is contesting the existing practices. Contrary to Bernstein's view of the discourse in recontextualising rules that take place from the original site of production (i.e. the official recontextualising field (ORF)) to the pedagogic recontextualising field (i.e. the non-official pedagogic discourse (PRF)), curriculum innovation in Singapore does not relocate or shift from the official discourse to a non-official discourse to form the pedagogic text. Instead, the official and non-official discourse of recontextualising the curriculum to facilitate learners' needs happens within the school. Both the ORF and PRF are operating simultaneously, hoping to shift the existing practice towards a reconfigured curriculum. As such, the tensions and confrontations are high especially when the stakes (i.e. the IP) are high. Nevertheless, taking a whole school approach in reconfiguring the curriculum and pedagogies, the tensions and confrontations might be diffused among teachers as the professional dialogue shapes the innovation and practice. For example, school leaders could strategically direct the curriculum change process by focusing on curriculum vision (Tan & Ponnusamy, 2014a). This vision should be focused and yet give room for teachers to reframe and reinterpret the curriculum to be innovated. As such, school leaders would clearly leverage on the social practice to engender the culture for learning. Finally, evaluation rules construct pedagogic practice by providing the criteria to be transmitted and acquired (Bernstein, 2000). This is an important nexus of designing and implementing the curriculum for high ability learners (as illustrated in Chap. 14). Evaluative rules specify the transmission of suitable curricular contents in proper time and context and perform the significant function of monitoring the adequate realisation of the pedagogic discourse. Hence, it is important for schools to develop capacity among staff to assess the quality of the modified curriculum as part of the long-term plan for curriculum innovation.

Teacher Level: Activating Teacher Agency and Leveraging on Collective Teacher Efficacy

The second major theme arising from Chap. 3 as well as Chaps. 7, 8 and 9 in this book is having leaders consider positioning teachers as one of the key levers for change. The teacher factor in the process of curriculum change can be understood at

[1] The pedagogic device is described by Bernstein as the ensemble of rules or procedures via which knowledge is converted into classroom talk, curricula and online communication (Singh, 2002). The three hierarchically related rules are the distributive rules, recontextualising rules and evaluative rules.

both the individual and collective levels. At the individual teacher level, a way to galvanise change is to embrace and activate teacher agency. The endorsement of teacher autonomy by the school leaders does not necessarily empower teachers to take charge of designing and implementing curriculum unless there is an opportunity for teachers to interpret and see the rationale and meaning in changing the curriculum and pedagogies. For example, catering to learners' needs might drive the teacher to contextualise the curriculum and modify their pedagogies (refer to Chaps. 7, 8, 9). There is also a need, as pointed out in Chap. 3, to redirect the teacher towards recognising their own inputs into the redesign of lessons that are concept-focused, i.e. where they actively reexamine and reframe concepts within the context of the discipline, the learner and the lesson activities.

This is what Sachs (2011) refers to when she points out that teacher learning should not be based on a deficit-based view; rather, teacher learning should capitalise on teacher agency and personal responsibility. Sachs maintains that of the four common professional development models present today, namely, retooling, remodelling, revitalising and reimagining, the latter two are about personal transformation and change. She argues that these two models provide the "third space" (Elliot, 2011) for teachers to pose questions and identify issues that are important to them and their students; these models also seek to develop teachers who are creative developers of curriculum and innovative pedagogues (Mockler, 2005). This "third space" is facilitative of teacher dialogue and the pondering of generating creative solutions for the issues encountered in their daily teaching lives. This is a form of practitioner inquiry. In this respect, the refocusing of teaching and learning around a concept-based curriculum will take place in the third space.

Nevertheless, personal agency alone is not enough; teachers need the relational agency as well. This is because teachers do not function at the individual level; their work is largely connected with many colleagues within a subject or department in a school. Chapters 8 and 9 also provide us with the lesson that the success of developing curriculum for high ability learners is to build a community of practice (CoP) with the guidance of curriculum vision set forth by the school leaders (Tan & Ponnusamy, 2014a). A CoP provides teachers with the opportunities to learn and improve classroom practice as well as student learning (Lave & Wenger, 1991; Tan & Ponnusamy, 2014b). For example, Chaps. 5, 6 and 7 illustrate how teachers contextualise curriculum in their own respective subjects with teams of teachers, and Chap. 9 shows how the curriculum models were contextualised to suit the learner profile within the school. Such participation will enable adoption of and acceptance into a range of formal and informal practices which form a collective identity that is contingent upon the development of norms and cultural practices. This in turn contributes to a sense of ownership among members and induces more open and critical discourse that strives for collective efficacy.

Classroom Level: Reconfiguration and Meaning-Making in Learning and Teaching

The third theme generated from Chaps. 5, 6 and 7 as well as 10, 11, 12 and 13 shares the nuances and insights from the teachers' points of view in their respective subjects. In many instances described in the above-mentioned chapters, teachers allude to the potential of concept-based curriculum in providing intellectual challenge to the high ability learner. Alexander highlights three pivots in generating classroom dialogue, namely: organisation, dialogue and meaning. The aim of developing and implementing a concept-based curriculum for high ability learners is to reorganise the curriculum to suit learner profile and provide opportunities to generate classroom dialogue that brings meaning to learning (Alexander, 2008). In the classroom, the concept-based curriculum can be a purposive cultural intervention as it provides an embryonic experience in nurturing the dispositions to explore and experiment with ideas by generating questions for thinking rather than answers to put learning at rest. In teaching for conceptual understanding, learners are given the opportunities to make meaning of the information at hand and manipulate the concepts by connecting them in a meaningful way. Hence, designing and implementing a concept-based curriculum is a cultural and pedagogical intervention (Alexander, 2005) in the development and learning of high ability learners.

Conclusion

In conclusion, the chapters contributed by both international scholars and practitioners from Singapore illustrate how concept-based curriculum can be conceptualised, designed and implemented. A large part of the concept-based learning and teaching currently focuses on retooling and remodelling of teacher professional development (Sachs, 2011). The scholars and practitioners who contributed to this book have enriched the field of curriculum innovation by sharing their insights as they experience and work on concept-based curriculum. All these real-life teacher-learning experiences speak to the need to acknowledge the discursive nature of teacher learning. More importantly, the chapters also exhibit how teachers' personal understanding of the nature and role of concepts as units of meaning-making in a discipline is intertwined with the process of curriculum development and implementations for high ability learners' deeper learning. Hence, having schools and teachers work as a collaborative community in concept-based curriculum development and implementation generates the critical mass in engendering broader learning experiences for the high ability learner.

References

Alexander, R. (2005). *Culture, dialogue and learning: Notes on an emerging pedagogy*. Paper presented at the International Association for Cognitive Education and Psychology (IACEP) 10th International Conference, University of Durham, UK.

Alexander, R. (2008). *Essays on pedagogy*. Abingdon, UK: Routledge.

Bernstein, B. B. (1990). *Class, codes, and control: Vol. 4: The structuring of pedagogic discourse*. London: Routledge.

Bernstein, B. B. (2000). *Pedagogy, symbolic control, and identity: Theory, research, critique, revised education*. Lanham, MD: Rowman & Littlefield.

Bernstein, B. B. (2001). From pedagogies to knowledges. In A. Morais, I. Neves, B. Davies, & H. Daniels (Eds.), *Towards a sociology of pedagogies: The contribution of Basil Bernstein to research* (pp. 363–368). New York: Peter Lang.

Black, P., & Wiliam, D. (2012). Developing a theory of formative assessment. In J. Gardner (Ed.), *Assessment and learning* (pp. 206–229). London: Sage Publishing.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Cohen, D. K., McLaughlin, M. W., & Talbert, E. (1993). *Teaching for understanding: Challenges for policy and practice*. San Francisco: Jossey-Bass.

Darling-Hammond, L., & McLaughlin, M. W. (2011). Policies that support professional development in an era of reform; Policies must keep pace with new ideas about what, when, and how teachers learn and must focus on developing schools' and teachers' capacities to be responsible for student learning. *Phi Delta Kappan, 92*(6), 81–92.

Elliot, G. (2011). Creating spaces for practitioner research: Strategic leadership to create a third space for practitioner enquiry in an authentic professional learning community. In N. Mockler & J. Sachs (Eds.), *Rethinking educational practice through reflexive inquiry*. Dordrecht, Netherlands: Springer.

Eisner, E. W. (1985). Five basic orientations to the curriculum. In *The educational imagination: On the design and evaluation of school programmes* (pp. 61–86). New York: Macmillian Publishing.

Gadamer, H. G. (1979). *Truth and method*. London: Sheed and Ward.

Garet, M., Porter, A., Desimone, L., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

Goodlad, J. I., & Richter, M. N. J. (1966). *The development of a conceptual system for dealing with problems of curriculum and instruction*. Washington, DC: The Cooperative Research Programme of the Office of Education.

Grundy, S. (1987). *Curriculum: Product or praxis*. Lewes, UK: Falmer Press.

Guile, D. (2014). Professional knowledge and professional practice as continuous recontextualisation: A social practice perspective. In M. Young & J. Muller (Eds.), *Knowledge, expertise and the professions* (pp. 78–92). Abingdon, UK: Routledge.

Hattie, J. (2003). *Teachers make a difference: What is the research evidence?* Paper presented at the Australian Council for Educational Research, University of Auckland.

Hogan, D., Chan, M., Rahim, R., Kwek, D., Khin, M. A., Loo, S. C., et al. (2013). Assessment and the logic of instructional practice in Secondary 3 English and mathematics classrooms in Singapore. *Review of Educational Research, 1*(1), 57–106.

Hung, D., Lim, K. Y. T., & Lee, S. S. (2014). *Adaptivity as a transformative disposition for learning in the 21st century*. Dordrecht, The Netherlands: Springer.

Kelly, P. (2006). What is teacher learning? A socio-cultural perspective. *Oxford Review of Education, 32*(4), 505–519.

Koh, E., Ponnusamy, L. D., Tan, L. S., Lee, S. S., & Ramos, M. E. (2014). A Singapore case study of curriculum innovation in the twenty-first century: Demand, tensions and deliberations. *The Asia-Pacific Education Researcher, 23*(4), 851–860. doi: 10.1007/s40299-014-0216-z

Koh, K., & Luke, A. (2009). Authentic and conventional assessment in Singapore schools: An empirical study of teacher assignments and student work. *Assessment in Education: Principles, Policy & Practice, 16*(3), 291–318.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.

Lim-Ratnam, C. (2013). Tensions in defining quality pre-school education: The Singapore context. *Educational Review, 65*(4), 416–431. doi:dx.doi.org/10.1080/00131911.2012.707641

Mockler, N. (2005). Transforming teachers: New professional learning and transformative teacher professionalism. *Journal of In-Service Education, 31*(4), 733–746.

Mourshed, M., Chijioke, C., & Barber, M. (2010). *How the world's most improved school systems keep getting better*. London: McKinsey & Company.

OECD. (2009). Teaching practices, teachers' belief and attitudes. In *Creating effective teaching and learning environments: First results from Teaching and Learning International Survey (TALIS)* (pp. 87–135). Paris: OECD Publishing, Retrieved from http://www.oecd.org/education/school/43023606.pdf

Porter, A. C., & Brophy, J. (1988). Synthesis of research on good teaching: Insights from the work of the institute for research on teaching. *Educational Leadership, 45*(8), 74–85.

Sachs, J. (2011). Skilling or emancipating: Metaphors for continuing teacher professional development. In N. Mockler & J. Sachs (Eds.), *Rethinking educational practice through reflexive inquiry*. Dordrecht, The Netherlands: Springer.

Schiro, M. S. (2013). *Curriculum theory: Conflicting visions and enduring concerns* (2nd ed.). Los Angeles: Sage Publishing.

Schwab, J. J. (1973/1978). The practical: Translation into curriculum. In I. Westbury & N. J. Wilkof (Eds.), *Science, curriculum, and liberal education: Selected essays* (pp. 365–388). Chicago: University of Chicago Press.

Shalem, Y. (2014). What binds professional judgment?: The case of teaching. In M. Young & J. Muller (Eds.), *Knowledge, expertise and the professions* (pp. 93–105). Abingdon, UK: Routledge.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Singh, P. (2002). Pedagogising knowledge: Bernstein's theory of the pedagogic device. *British Journal of Sociology of Education, 23*(4), 571–582. doi:10.1080/0142569022000038422.

Tan, L. S., & Ponnusamy, L. D. (2014a). Adaptivity and creativity in the arts: The nexus and affordances. In D. Hung, K. Y. T. Lim, & S. S. Lee (Eds.), *Adaptivity as a transformative disposition for learning in the 21st century* (pp. 177–208). Dordrecht, The Netherlands: Springer.

Tan, L. S., & Ponnusamy, L. D. (2014b). Weaving and anchoring the arts into curriculum: The evolving curriculum processes. In C. H. Lum (Ed.), *Contextualised practices on arts education: An international dialogue on Singapore arts education* (pp. 219–258). Dordrecht, The Netherlands: Springer.

Turner-Bisset, R. (1999). The knowledge bases of the expert teacher. *British Educational Research Journal, 25*(1), 39–55.

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