Chapter 21
Understanding Student Participation and Choice in Science and Technology Education: The Contribution of IRIS

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Introduction

This chapter considers the contribution of the studies in this book to our understanding of students' educational choices. This is done across five themes: theoretical perspectives; choice as a continuous process; the role of identity and social structure; gender; and methodological insights. The chapter ends with suggestions for a future research programme exploring student choice and participation.

Theoretical Perspectives

Part I of this book presents the theoretical perspectives drawn upon in the Interests and Recruitment in Science (IRIS) project. Chapter 2 focuses on the Eccles et al. expectancy-value model of achievement-related choices, which posits that educational choices can be explained by young people's beliefs about how well they will do in, for example, a study programme, and by the value they attach to the programme in question. This subjective value represents how interesting the student expects the programme to be, how easily it is negotiated into the student's identity

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construction, how useful it will be for reaching other goals, and how much it will cost in terms of time and effort. According to the expectancy-value model, individuals' values and beliefs are shaped by a range of social and psychological factors, such as cultural surroundings, personal goals and self-perceptions. Chapter 2 also describes sociological theories on late-modernity, adding an understanding of how young people's expectations and values may be influenced by a late-modern zeitgeist. Such theories argue that rich, developed societies emphasise late-modern values such as self-realisation and personal well-being for the individual. This should be understood as a way of coping with changes in society leaving the individual as apparently less bound by tradition and to a large extent free to construct their own identity through life choices. This, firstly, leaves the individual with an obligation to handle these options and to be able to release his/her potential in a way that appears authentic and fitting to the individual's sense of self. Secondly, this constitutes a sense of ambivalence between being free and being at risk. Furthermore, since social class, gender, and other social categories are still affecting what is possible, the student also needs to handle the contradiction between what appears to be a condition of liberty but also involves significant limitations.

In IRIS, these perspectives have influenced instrument development and methodological choices and have aided interpretation of results. For instance, the strong focus on personal interest in the accounts IRIS respondents give of their choice (Chaps. 9, 18 and others) may be interpreted in the light of the importance of individual self expression and the influence of late-modern perspectives on youth.

Chapter 3 presents narrative theories, in particular narrative psychology, as a framework for understanding how students negotiate their educational options as part of their identity construction. This approach studies how young people construct narratives in ways that are recognised as compatible with how they see themselves and how they are perceived by others. Importantly, identity construction is viewed as an on-going and constantly changing process that, at the same time, tries to maintain a stable sense of self embedded in the surrounding culture. Elsewhere, Tinto's perspectives on social and academic integration are used in Chaps. 13 and 15 to add to our understanding of how students negotiate their choice narratives and their identity when they have started a new study programme. Perspectives on gender, presented in Chap. 4, are discussed in a later section of this chapter.

The theoretical perspectives presented in Chaps. 2 and 3 have been employed in various ways throughout the book. For example, the expectancy-value model is used as a theoretical and/or analytical framework in Chaps. 9, 11, 16 and 18. The use of narrative theories in this book varies in form, as elaborated in Chap. 3. Chapters 7 and 15 (and empirical parts of Chap. 3) use narrative psychology both as the underlying conceptual framework for understanding the notion of identity, and as a guide for the construction and analysis of interview data. Chapter 13 employs a narrative psychology conception of identity in its review of research on drop out from higher education, and Chap. 9 uses these perspectives in an analysis of short statements from students about how they came to choose their study programme.

The contribution of the present book is not so much to add to, or challenge, the above theories but to bring them together and in some cases to apply them to new contexts and settings. Theories of narrative psychology have rarely been used to inform research on STEM participation. The expectancy-value model has been used to examine choices of science and mathematics courses, but was developed as a more general model for achievement-related choices and performance. Late-modern perspectives and narrative theories are relatively undeveloped in a science education research context. Schreiner (2006) drew on broader sociological theories of late-modernity in her study of young people's orientations to science, thereby suggesting that the perspectives could be relevant also for understanding participation in STEM. The IRIS project has attempted to take these multiple theoretical perspectives and consider the extent to which, taken together, they provide fruitful insights into our understanding of STEM-related educational choices in particular.

The work of late-modernity theorists such as Giddens, Beck and Bauman has been criticized for implying that social structures such as class have lost their relevance to studies of young people's choices and behaviour (Atkinson 2008; Furlong 2009). The IRIS project has found late-modernity perspectives useful for understanding how young people regard an educational choice as their own individual project, with both a personal freedom and a personal responsibility to choose. However, as is stated in Chap. 2, the IRIS project distinguishes between young people's idea of having a free choice and the actual limitations to their freedom that are imposed by social structures such as gender and class (Archer et al. 2012).

We have found it fruitful to bring together aspects of the Eccles et al. model and narrative perspectives in understanding student choice. The arrows in the figure of the Eccles et al. model given in Chap. 2 might be interpreted to mean that choices happen at an instant in time, and are the outcome of a series of influences (working from left to right in the model). However, the empirical evidence in Chap. 3, for example, using the narrative approach, demonstrates how such an interpretation of the choice process is rather limited. Narrative theory emphasises how the influence of culture, family and peers interact constantly with the choice process. In the Eccles et al. model, the iterative nature of the influence of the parts of the model is indicated by a dotted arrow going from the choice and back to the rest of the model. However, underestimating this dotted arrow and interpreting the model in a strict left-to-right sense will restrict the possibilities to look at the on-going dynamics of a choice process. Though valuable information is provided by studies measuring either the predictive power of expectations of success and subjective values for STEM choices (Eccles 2007; Eccles et al. 2004) or students' own retrospective reports of the influence of expectations and values (Bøe 2012; and Chaps. 9 and 18 of the present volume) more and different information is needed to fully understand young people's STEM choices. Eccles and colleagues have themselves included interview components alongside questionnaire data in longitudinal studies of how expectations and values develop (see for example Fredricks and Eccles 2002; Jacobs et al. 2005). By specifically using narrative theories in qualitative investigations, IRIS demonstrates an effective way of studying how the process of making meaning of a STEM choice takes place over time – before, at, and after specific decision points.

Choice as a Continuous Process

As discussed above, one of the starting points for the work of the IRIS project was the view of student choice as a continuous process of activity and reflection by the student rather than a decision made at a specific point in time. Thus, we have made a distinction between 'decision points' and the 'choice process'. One example of a decision point would be enrolling on a specific university course (e.g., chemical engineering) following the end of upper secondary schooling. Such a decision point might be preceded by periods of reflection on future courses by the student over several years, and perhaps also (intermittently) activities around this choice such as talking to careers specialists, parents, friends and conducting internet searches about courses and careers. Furthermore, work within IRIS has also highlighted the ongoing nature of the choice process beyond key decision points. Thus, a student's formal educational experiences are characterised by a continuous choice process, punctuated by key decision points. Here we elaborate on the extent to which this perspective is supported by the research reported in this book.

The examination of school science students' retrospective reflections on the decision point of choosing post-compulsory courses in two schools in England (Chap. 7) demonstrated both the extent of the pre-decision choice process and its varying nature. Students' reflections included reference to experiences from primary schooling onwards that were seen as influencing their final decision. Furthermore, these reflections could be characterised in varying ways, for example: early commitment to specific courses followed through to the decision point; ongoing uncertainty up to the decision point; periods of commitment to specific courses interspersed with periods of uncertainty leading to new course commitments. These varying choice processes support findings from the earlier work of Anna Cleaves, who used longitudinal interview data, and challenge the often stated assumption that commitment to science courses tends to be cemented in the early years of schooling (Cleaves 2005). This perspective also challenges the common metaphor of interest and participation in STEM subjects as a 'leaky pipeline' (Blickenstaff 2005). A more nuanced metaphor is one of 'shifting pathways' with bidirectional flows; out of, but also in some cases into, the STEM 'pipeline'. For example, these bidirectional flows are shown clearly in the 'Sankey diagram' generated by Sadler et al. (2012) to represent changes in students' career interest from the beginning of high school to the end.

Perhaps a less obvious feature of the choice process is its extension beyond key decision points. This point has been highlighted in interviews conducted with students concerning their choice of university course. For example, an analysis of interviews with 20 first year students following STEM programmes in Denmark identified the 'expectancy-experience gap' as a key feature of post-decision choice processes (Chap. 15). In choosing to enrol on a specific university programme, students show their expectations of the course. This analysis suggests, for many students, that their experiences of the programme are very different from their expectations. This disjuncture can lead to further choices and decision points (hence a choice process) for example to change course, or leave Higher Education

altogether. For example, the Danish student, Emily, enrolled on an engineering degree. She experienced a large expectancy-experience gap that involved an ongoing process of reflection on her decision to follow this course, and ultimately resulted in a decision to leave the programme. Similar findings result from the analysis of Norwegian university students' written reflections on their choice of university course, as exemplified by the computer science student, Tina, who wrote 'I am still very uncertain. Am I really the right girl for this?' (Chap. 17).

A striking feature of the choice process, and one with significant methodological implications (as discussed later in this chapter), is the developing nature of students' accounts of the process of choice. This development is shown particularly in Chap. 3, which explores the significance of narrative approaches to studies of the choice process. The chapter provides an example, Christine, who originally stated that she did not want to follow a course leading to teaching, but then (following the decision to enrol on such a course) reconstructed her narrative to state that she had always wanted to become a teacher. This process is interpreted through the lens of narrative psychology as an attempt by the student to maintain a sense of stability in her understanding of herself, as her experiences develop. This chapter suggests a metaphor for reflections on choice in terms of the view from a car winding through the countryside with changing views of the countryside through both the front and rear car windows. The choice narrative may include perspectives on the future (looking through the front window) and retrospective accounts of how experiences in the past led up to the present situation (looking through the rear window). An important point here is that when the perspective through the front window changes (that is, the decision of which path to follow and therefore which choice to make) it also changes what is seen in the rear window. In other words, the interpretation and narrative concerning what happened in the past changes as the forward perspective changes. Therefore, an individual's conception and interpretation of both these views – her narrative of the choice – is constantly tried out and negotiated in the students' ongoing social relations.

The Role of Identity and Social Structure

Another starting point for the IRIS project was the key role that identity plays in students' choice of STEM higher education. The importance of the identity component has been corroborated by several of the studies within IRIS. Identity perspectives have clear links to narrative theory and late-modernity perspectives referred to above, for example Giddens (1991) who described identity as the process of keeping "a particular narrative going" (p. 54). Shanahan (2009) has highlighted the significance of interactions involving individual personality and broader social structures in the development of identities. This point relates to the classic discussion of structure and agency, concerning 'the degree to which the behaviour of individuals and groups can be attributed to social, political and economic forces or wilful, purposeful intentionality' (Shanahan 2009, p. 45). Identity is developed and acted within a social structure that provides opportunities and

limitations for the identities that individuals can develop. Thus, when studies report that students' choices are based on 'personal interests' we need to recognise that these interests are embedded in, and interact with, a social context. Ryan (2012, p. 170) contests the suggestion that choices or preferences are freely made, asserting that "social structural constraints operate and further, that 'traces' of constraint can be discerned in accounts of 'choices'". The present volume provides examples of the importance of the structural level in understanding the way identity is constructed and how it affects recruitment and retention in STEM higher education. In this section, we explore how the studies in this book contribute to our understanding of these interactions.

Institutional Structures

One general structural level that affects students' choices is the educational system and the provision of programmes within it. Clearly, students' choices are limited by the courses offered by universities. Thus changes in the patterns of students' choices not only reflect changes in the attitudes and preferences of young people, but also changes in the provision of programmes. As explored in an Australian context, when new and different programmes are offered, students may move to different subject areas (Chap. 10). Hence, the structural level of the educational system is important in developing an understanding of the importance of identity in two ways. Firstly, there is a danger of interpreting shifts in student choices as representing changes in student identities without recognising that such shifts may have more to do with changes in the availability (or entry requirements) of specific courses. Secondly, the structure of the programme, and the choices it makes possible also present the students with particular elements that they can integrate into their identity construction. Changes in the provision of programmes can, therefore allow, or even call for, particular shifts in identities developed by STEM students.

Frequently, STEM programmes can be related to a single discipline (for instance a 'physics' degree programme is clearly identified with the discipline of 'physics'). In such cases students need to be able to recognise desirable identities related to this specific discipline. For some fields of study this is problematic because the identities that can be developed within the particular discipline are limited and perhaps unattractive to individuals (cf. Holmegaard et al. 2014). However, experiences in the UK suggest that programmes that include disciplinary components from both STEM and other fields (for instance, forensics) can attract more students, not least women. Similar tendencies can be found in Danish programmes combining engineering with other disciplines such as medicine, biotechnology, design, or architecture. However, it should be noted that these 'mixed' programmes frequently include aspects from biology and medicine, fields that otherwise also attract more women. Nevertheless, it is likely that programmes combining elements from different fields of STEM may allow for the construction of a broader variety of identities and therefore attract a more diverse group of students, including more women.

Another important aspect of the structural level is found in the results from the Slovenian study of students' choice to embark on a PhD (Chap. 11). The study shows that national funding programmes targeted at particular challenges facing female PhD students had an important impact in making a PhD within STEM more attractive to these students. This finding indicates how structural and economic factors affect student choice patterns.

The Significance of Curriculum

Another structural element affecting students' identity work is the curriculum. Here 'curriculum' refers to the content of teaching and the kinds of teaching and learning activities within educational programmes. The design of the curriculum offers particular opportunities for students in terms of what identities they are able to construct when they are on a particular programme, the way they can act as students, and the kind of participation that is possible. Therefore, a conflict may arise between the possible identities and practices made possible in STEM programmes and the identities that are recognisable and attractive to the students. In an analysis of the Danish upper-secondary school physics curriculum, Krogh (2006) used the concept of cultural border crossing (Aikenhead 1996) to compare the identity-related values of late-modern students and values in physics teaching, what he called 'the ethos of science teaching' (Krogh 2006). Krogh found a fundamental clash between values of young people and the ethos of physics teaching that impede students' identifying with doing science. The two students, Claire and Anya (Chap. 7), provide examples of how the same curricular element (socio-scientific issues) was valued differently by individual students. Whereas Claire preferred science content linked to 'facts' that were new to her, Anya appreciated more the possibility of linking science content to her everyday life. Thus, including socio-scientific issues in the curriculum may cater for the interest of some students whilst being at odds with the self-image of other students.

For students who have already entered a higher education STEM programme, the process of academic and social integration involves balancing, on the one hand, the possible interests and practices necessary to become involved in the curriculum and the social life within the programme, and, on the other, their personal interests and self-images. For the biochemistry student, Frida (Chap. 15), this balancing act involved a focus on the parts of the programme curriculum that allowed her to get a sense of 'turning into a professional' (e.g., putting on a lab coat) and prioritising social integration.

In summary, the construction of identity, and a viable narrative about who the students are and who they are to become, is closely related to the structural level of curriculum design. Programme content and teaching/learning activities need to provide room for the development of student identity. The different reactions of the students described above (e.g. Anya and Claire, Chap. 7) suggest that any degree curriculum should seek to open up multiple ways for students to engage with the subject.

Available Discourses

A pivotal element in the students' construction of identities is the set of available discourses through which social structure acts. Several chapters in this volume show that students' choices are related to existing discourses. For example Chap. 6 highlights a prevalent discourse that science disciplines are for 'the clever' and that learning science is particularly demanding and difficult. This finding suggests that students need to see themselves as 'clever' in order to pursue science disciplines, an identity that many students (including high attaining students) find difficult. Furthermore, engagement with science subjects also means that students may be considered "brainiacs" who "don't want to do anything else in their life", as the student, Celina, remarks in Chap. 6. A discourse that science is for clever and 'good' students means that the students who wish to engage in science also need to adopt a 'good student' identity. Thus, 'science as difficult and for the clever' is a discourse that restricts participation in science for students of both genders, and for students from particular social and ethnic backgrounds (Chap. 6).

Chapter 9 describes how personal interest is central in the discourses that young people engage in concerning educational choice. When prompted to describe their educational choice, young people choose to present a narrative focused on individual interest, downplaying other influence factors (parental influence, career prospects) and priorities that are arguably at play. A discourse and a disciplinary culture demanding strong personal interest and dedication (as also seen in Chap. 18) may turn some students away, notably those that have broader educational and career priorities than pursuing passionate interest alone (Bøe and Henriksen 2013; Hazari et al. 2010).

As noted in Chap. 15, many study programmes and disciplines can be said to have an 'implied student' (Ulriksen 2009). That is to say that the curriculum and the culture within the programme hold particular expectations and presuppositions concerning the interests, attitudes, and practices of the students involved. Even though there may be more than one implied student associated with a particular programme, it nevertheless means that the students need to relate to, and to some extent adapt to, the student implied by the programme. For some students, there is a conflict with their notions of who they believe they are or who they wish to become. At the same time, it is difficult for the students (or the teachers) to challenge these presuppositions because they are implicit rather than explicit.

As the statement by Celina quoted above suggests, students' choices are also affected by discourses outside their degree programme. Students balance the discourse of, for instance, what a 'proper' scientist or engineer is, with discourses from their social life within, and outside of, their educational institution. Consequently, when students make their choice of study, they are positioning themselves in relation to different discourses many of which originate outside their educational context. Hence, the issue of identity cannot be limited to a relation between the individual student and the subject; it reaches beyond the subject and beyond the educational world.

As argued earlier, choice is a continuous process over time. Consequently, when young people are deciding which programme to enter, they become entangled in a web of different discourses concerning higher education and other realms of life rooted in the personal history of the student. Clearly students' narratives about themselves can change, alongside the discourses that are culturally and socially available to them. However, there is an inevitable inertia associated with these changes. Thus, it is reasonable to assume that efforts to change the choice patterns of young people have to involve more than an isolated event. If the experiences of young people in different recruitment and outreach initiatives are to impact on the choice of young people, in spite of dominant and persistent contrary discourses, it is more likely to happen if the students are involved in the activity over a sustained period of time (Chap. 12). Furthermore, as the choice process continues after the students have entered their higher education programmes, these different discourses continue to act as the student is coping with the university experience and deciding whether to persist or not (Chaps. 13 and 15).

In summary, research in IRIS has demonstrated that the importance of identity and discourses for educational choice cannot be limited to the relation between the discipline and the individual, but involves discourses related to a number of fields. Moreover, identity and discourses continue to affect the experiences and decisions of students even after they have entered the science path. IRIS research demonstrates the importance of addressing issues of identity on several levels: institutional, social and cultural.

The Role of Gender Within Students' Experiences of Choice

The studies in this book corroborate previous research in showing clear differences, at the group level, between male and female student participation in many STEM subjects in higher education. In some subjects (e.g., physics and engineering) women are typically under-represented, whilst in other STEM subjects, gender participation disparities are much less pronounced. Indeed in some STEM programmes women may be over-represented (e.g., the molecular biomedicine programme examined in Chap. 19). One purpose of the IRIS study was to explore the experiences of students that underpin these different gendered participation patterns. In doing so we have emphasised the importance of not treating female (or male) experiences of choice in an undifferentiated manner. The monolithic (or 'essential') character of the concepts of male and female has to be abandoned in favour of an understanding that is sensitive to the differences within each group. Firstly, male or female is not something someone is. Rather, it is something that is performed. Secondly, each gender can be performed in numerous ways. Within-gender cases may differ more from each other than many between-gender cases (Butler 1990; Søndergaard 1996; Sinnes and Løken 2012). Thus, we have not sought to identify a 'female approach to choice' that can then be used to account for the gendered participation patterns. To do so would run the significant risk

(as elaborated in Chap. 17) of reinforcing gender stereotypes, and thereby sustaining existing gendered participation patterns. Rather, our research has explored the different ways in which, for example, women experience the processes of subject choice. However, at the same time, we have avoided a 'gender neutral' perspective on subject choice. By this we mean an approach that, in an attempt to avoid stereotypes, refrains from addressing issues in terms of gender. Such an approach would contribute little to developing ways of reducing the male/female disparities in participation patterns within specific subjects.

In Chap. 4, it is argued that even if the overall discourse of science presents 'science' and 'doing science' as neutral and objective, the subject is often associated with being male due to a long-standing historical association of male gender with rationality, versus the 'emotional' female gender. This gendering is amplified by an ongoing discourse of science as being 'a boy's thing'. In Chap. 18 it is demonstrated how Italian male STEM students tend to rely on pre-established roles (which in the case of science and technology are easily available in the culture) when making their educational choice. The ASPIRES study (Chap. 6) provides an example of one girl who stated that she had stopped attending a school science club because it was mainly boys who attended. Girls who turn towards science, therefore, need to develop strategies that can balance interest in and intentions to enter science with this popular discourse.

Among female science students, the discourse of science as masculine leads to an ambiguous sense of being different and standing out because they belong to a minority, while simultaneously opposing being labelled in a particular way due to their gender (Chap. 17). These students therefore both identify themselves as 'like any other girl', as the female student, Stella, expressed it, and as someone who is always visible because of being a minority, as expressed by Maria in the same chapter. Many female students, therefore, have both to cope with a discourse questioning whether doing science is compatible with being a girl, and with the situation of being visible and standing out. Similarly, Danielsson (2009) claimed that taking on a physics identity for a female student requires distancing oneself from what is "traditionally" female. However, an important point here is that the pressure of becoming a particular kind of student that requires women to neutralise their gender expression may also be a challenge to particular ways of being a male student, a point also made by Walker (2001) in a study involving engineering students.

In some STEM programmes male students have the experience of being a minority group, e.g., male students in the female-dominated molecular biomedicine programme (Chap. 19). Even so, while men and women share some experiences when being a minority, Chap. 19 also reports that the conditions for coping with these experiences differ for men and women. Many of the female students adopted a strategy of 'being as'; becoming like one of the boys, thereby 'neutralising' their gender. However, the strategy of many of the male students was that of 'fitting in'; adjusting to the dominant culture and ways of behaviour, but doing so while remaining different, retaining their male gender. Furthermore, it was also found that the conditions for women being a minority varied across the two study

programmes. Women in computer science programmes appeared to have more room for 'being a girl' in different ways, as compared to the culture within the physics and nanotechnology programme. This finding illustrates the nuanced outcomes of an analysis that looks for differences between science subjects, and which goes beyond an essentialist or monolithic perspective on women's experiences of choice, and yet is not gender neutral.

The results of the IRIS project corroborate previous studies that suggest that there are indeed group-level differences in male and female STEM participation as well as in the conditions and opportunities of men and women. Some of these differences are related to social discourses about men and women and to social structures that are detrimental to women choosing a STEM path. The studies in this volume also call for attention to be paid to how these gender differences are addressed in both future research and policy. The challenge for future research is to continue the exploration of social structures, discourses, curricular components, etc. that impede the participation of women in fields of science where until now they have only had a small representation. At the same time, this should be done in a way that does not imply an understanding of gender as having a monolithic or 'essential' character, and that is sensitive to the individual variations within gender groups.

Methodological Insights

We have conceptualised educational choice as a process over time, punctuated by multiple decision points. Furthermore, an individual is continually constructing (and re-constructing) accounts, or narratives, of these processes and decisions. This perspective has significant methodological implications. For example, 'snapshot' accounts of educational choice (collected at a single point in time), whilst providing important insights, are limited in capturing the 'process' character of educational choice. Rather, longitudinal studies, of the kind reported in Chap. 3 and by Cleaves (2005), are more suited to investigations of the processes of educational choice. Relatedly, retrospective accounts of choice may not reflect the narratives that students constructed which were influential at the time of an educational decision. Many of the research studies reported in this volume have used both retrospective and snapshot accounts. Such studies are also dominant in the wider research literature. For example, Sadler et al. (2012) is a recent example of a study into changes in career interest using a retrospective cohort study. While such studies do provide useful insights into educational choice processes (e.g. enabling the collection of data from larger groups of students to probe group-level differences over time) they need to be supplemented with longitudinal studies that are open to the potential for re-constructed narratives of student choice.

The IRIS research collaboration involved a cross-country questionnaire (with both closed and open response questions) and in-country case studies typically using more extended, qualitative methodologies. This use of multiple methods to

explore educational choice has several advantages. We have been able to identify diverse influences on educational choice: the detail of extended personal accounts; indications of broader socio-cultural influences; and, more systemic influences resulting from institutional, regional and national educational policies. Furthermore, we have provided an overview of student choices, e.g., at a national level, whilst also probing more deeply into the experiences of individual students. However, we recognise that more could be made of the potential for mixed methods, i.e., studies that utilise insights from one approach to inform the design and analysis of another approach. One recent example of such a study used quantitative analysis of a large-scale national dataset to construct a sampling frame for the selection of case study schools (Bennett et al. 2011; Hampden-Thompson et al. 2011).

Several of the contributions in this book demonstrate the use of national datasets to identify trends in student participation over time. Chapter 14 reports on changing patterns in student choices in Denmark. This official, annual and ongoing dataset links students' educational choices to characteristics such as gender, academic attainment and parental educational background. Analysis results in fine-grained identification of educational trends linked to socio-economic and other factors, that extend beyond the more usual blanket identification of 'a shortage of science students'. England has a similar national pupil dataset that has been used in educational research studies (Homer et al. 2013). Gill and Bell (2013), for example, use multilevel modelling techniques to identify the effects of school type (e.g., mixed or single sex schools) on student participation in post-compulsory physics, whilst controlling for the effect of other variables (e.g., science attainment, socio-economic status). Given the significance of educational outcomes for individuals, societies, governments and economies, it is surprising that such datasets, and their use to inform educational policy, are not more widespread.

The Australian study reported in Chap. 10 demonstrates a different approach to identifying national trends. Here the authors have repeated the use of a carefully designed and trialled questionnaire, first used in the 1970s, to challenge a common assumption of declining student enjoyment of science. This analysis led the researchers to consider alternative influences on educational choice, resulting in the identification of the likely significance of systemic policy structural changes beyond science education in the Australian national context. Again, such use of well-designed instruments, repeated over time, could be more widespread.

Few studies, either in this volume or in the research literature more broadly, involve the research-informed design and evaluation of interventions that aim to change educational participation. Such intervention studies provide the opportunity to test, and refine, hypotheses on how educational participation can be changed. The ongoing ASPIRES project (Chap. 6) promises to be an exception. Again, such studies would be of great value to both researchers and policymakers. This volume does include examples of research into the impact of pre-existing educational interventions (e.g., the inclusion of teaching about socio-scientific issues in Chap. 7; ENT3R and 'the girls' day' in Chap. 12). Whilst these studies do provide insights, the strength of findings would be much greater were researchers able to design the intervention from the outset to test specific hypotheses.

Future Research Directions

A central theme of the studies reported in this book, and one that surfaces in several places in the overview above, is that of choice as a process that develops over time. We have drawn a distinction between this ongoing choice process, and specific decision points that punctuate students' lives (e.g., completing and submitting a university course application form by the required deadline, deciding not to return to enrol on the second year of a university chemistry degree programme). Our use of theoretical perspectives from narrative psychology has also emphasised the shifting nature of students' retrospective accounts of subject choice, up to and beyond specific decision points. These research insights highlight some of the limitations of 'snapshot' accounts of educational choice (collected at a specific point in time) and analyses of retrospective accounts of choice experiences provided by students. To further develop our understanding of choice processes, and the impact of specific intervention strategies, would require the use of longitudinal research designs that examine student experiences up to, and beyond, key decision points.

Whilst recognising their limitations, our research does recognise the important contribution of 'snapshot' accounts of educational choice. For example, there is the feasibility of collecting data from large (and perhaps representative) groups of students. An important part of the background for IRIS is the under-representation of females in many STEM disciplines – in itself a group-level phenomenon. To look for explanations and remedies to this situation, looking at group-level differences in for instance expectancies and values does give insight into which factors (for instance in the school-science curriculum) may on average attract more girls to STEM – and thus over time contribute to changing the persistent group-level difference in STEM participation. Furthermore, it is difficult for large-scale recruitment interventions to be tailored to individuals. It is important then to be aware of group-level differences, for instance between genders or other subpopulation groups, in order to appeal to the majority of their target group. "Snapshot" accounts of the interests, expectancies and priorities of large groups therefore have value in such a context.

Longitudinal, qualitative research studies need to recognise the range of factors influencing student choice. We have emphasised the role of student identity construction and the interaction of this process with social structures (e.g., the responses of peers and parents) and institutional structures (e.g., the availability of specific programmes and gender balance within subjects) and associated discourses. An important way forward is to not only address this variety of factors, but to scrutinise the way they intersect and interact. Taking a holistic account of this range of factors is likely to require qualitative approaches. That said, the IRIS study has pointed to the potential value of mixed research methods, for example using large-scale national/regional quantitative datasets (e.g., recording student characteristics, the outcomes of specific decision points) to identify targeted cases for longitudinal, qualitative data methodologies.

The nature of choice is also likely to be changing. In terms of institutional and disciplinary structures, many of the boundaries of STEM subjects within higher

education are shifting. 'New' subjects such as forensic science, biophysics and nanotechnology are becoming prominent. Such subjects provide the potential for new subject discourses, e.g., around 'cleverness', difficulty and gender. Furthermore, youth itself is a developing theme, as portrayed by developments in sociological theories of late-modernity. Research studies are needed that identify, and explore, choice experiences around these 'new' subject disciplines, examining how identity and gender are being played out in distinctive ways.

We have also emphasised the need to break down the monolith of gender, to consider within-gender differences, whilst at the same time avoiding a gender neutral perspective on choice processes. Within IRIS, this approach has been most successful within case studies using qualitative methodologies. By contrast, despite their value in providing important group level insights, large-scale survey analyses run the danger of reproducing gender monolith accounts of choice. Again, we would emphasise the potential value of the use of large-scale quantitative data analysis mixed with more nuanced qualitative data analysis.

Several chapters in the present volume have highlighted the influence of out-of school experiences, media and popular culture, and popular science in students' educational choice. The use of electronic and social media has accelerated even during the short time since the studies reported on here were designed, and future research could explore how social media as well as web sites such as for instance YouTube (which several higher education institutions now use to advertise their programmes) enter into students' choice processes. Another direction which might be further pursued in future studies is how the structural level – higher education policy, funding mechanisms, application and acceptance procedures – impact on educational choice processes.

Given the wealth of research studies conducted to date, it could be argued that we already know all we need to know about how young people make educational choices. From this perspective, the main challenge now is to develop research-informed educational interventions and associated practices that impact on how young people see STEM in relation to their educational and career aspirations and on gender equity in terms of opportunity and participation across STEM subjects. Our perspective is that research activity is still needed, but that more effort needs to be placed on the design and long-term evaluation of educational interventions aiming to impact on subject choice. Chapter 22 presents some insights, based on theoretical perspectives and empirical findings from IRIS, that we believe designers of such interventions need to consider.

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