

Chapter 13

Why Do Students in STEM Higher Education Programmes Drop/Opt Out? – Explanations Offered from Research

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Introduction

According to statistics from the Organisation for Economic Co-operation and Development (OECD), almost one-third of all higher education students drop out of their studies before they complete their first degree (averaged across all OECD countries and all subjects) (OECD 2010). The term ‘drop out’ is commonly used to describe those students leaving their course before they pass the final examination. The loss of students from science, technology, engineering and mathematics (STEM) studies to other careers presents a particular reason for concern since: ‘in many countries, S&T are among the disciplines where the dropout rates are the highest’, with science suffering more than technology (OECD 2008, p. 74). This loss of students has been described as a ‘leaky pipeline’ in the science education literature (Seymour 2002). However, as pointed out by Hovdhaugen (2009), different designations are used within distinct research settings: ‘In the USA, the phenomenon is described as ‘dropout’ or ‘student departure’ while British researchers usually use the concept ‘non-completion’ or ‘non-continuing students’” (Hovdhaugen 2009, p. 2). These different expressions reflect whether we interpret students leaving an educational programme as a push or a pull effect and for whom it is a problem.

In this chapter we provide an overview of how research has tried to explain and understand the issues related to students leaving higher education programmes with a specific focus on STEM courses. We illustrate three significant trends within the

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literature; the results from Seymour and Hewitt, Tinto's model and studies combining drop-out and theories of identities. We explore whether research on retention and non-completion has produced findings that can identify a direction forward for HE institutions and courses to take measures to reduce the number of students leaving. We show that most of the research focuses on overcoming deficits in students' prior knowledge, but that a more specific focus on identities as an analytical framework for understanding young people leaving STEM higher education programmes is also emerging. A detailed description of method used in the study can be found in Ulriksen et al. (2010).

Leaving STEM Higher Education: Seymour and Hewitt's Research

Switching is not defined as a problem when it is believed to be caused, on the one hand, by wrong choices, under preparation, lack of sufficient interest, ability or hard work, or on the other, by the discovery of a passion for another discipline. (Seymour and Hewitt 1997, pp. 391–392)

As Seymour and Hewitt state, it is necessary to establish that a problem exists in order to address it. This is also true for the issue of students leaving STEM courses. As discussed in Seymour (2002), the early days of research within this field were dominated by the view that it was the students who were the problem. However, in their analysis of 335 STEM students at seven different types of institutions in a 4-year ethnographic study in the US, Seymour and Hewitt (1997) found that there was no evidence for those beliefs. On the contrary, their study showed that the most common reasons for students to switch degree courses arose in response to a set of common problems experienced by both switchers and non-switchers. They did not, as Seymour puts it in a later article, 'find switchers and non-switchers to be two different kinds of people: they did not differ by performance, motivation or study-related behaviour to any degree that was sufficient to explain why one group left, and the other group stayed' (2002, p. 82). On the whole, Seymour and Hewitt found more similarities than differences between the switchers and the non-switchers. There is a high level of agreement across the whole student sample about the issues that led to defection by switchers and to dissatisfaction among non-switchers, and there are strong similarities in the importance members of each group ascribe to each set of concerns. Based on their findings, Seymour and Hewitt (1997) stated that the problems which arose from the structure of the educational experience and the culture of the discipline (as reflected in the attitudes and practices of STEM faculty) made a much greater contribution to STEM attrition than the individual inadequacies of students or the appeal of other majors.

There seems to be an agreement between Seymour and Hewitt's study of STEM students and the more general research on retention and non-completion of students in higher education (see the reviews of Pascarella and Terenzini (2005) and Harvey et al. (2006)) in focusing less on the students' prior knowledge or preparedness, and

more on the teaching and learning experiences the students are presented with once they have entered the programmes.

This point, as well as the fact that switchers and non-switchers, to a large extent, experience the same kinds of problem, result in Seymour and Hewitt using the metaphor of an 'iceberg' to illustrate their conclusion: 'Those who switch represent only the tip of a much larger problem' (Seymour and Hewitt 1997, p. 31).

In general STEM programmes lose students who possess interest and abilities within the field because the pedagogical approach and the study environment are unattractive. To be clear, the learning experiences of the students lead them to lose interest in science. These poor learning experiences are related to the traditions, teaching priorities and ethos of the disciplines, as is the case with the principle of 'weeding out' low performing student, but also the generally low priority that students experience is given to teaching by science faculty (Seymour and Hewitt 1997).

There have been a large number of studies within the field of drop out/opt out since Seymour and Hewitt's (1997) study. However, many of the studies still focus on retention as a matter of increasing students' skills before or during the first year of study and they aim at identifying factors associated with students' academic success (Ariadurai and Manohanthan 2008; Burnett 2001; Dyer et al. 2002; Mills et al. 2009; Yan 2002). Only a few studies have focused on changing university cultures, including teaching practices (for a full review see Ulriksen et al. 2010).

Leaving Higher Education – Tinto's Model

The work of Vincent Tinto has achieved an almost paradigmatic stature (Braxton et al. 2000) for trying to understand retention within higher education in general. Tinto's model (1975, 1988, 1993, 1998) emphasises that student departure from university should be regarded as a process. Students enter with a set of pre-entry attributes (cf. Chap. 14), and these attributes produce a set of goals and commitments that the students bring with them as they start their course and engage in the social and academic environment at the institution.

Tinto criticises psychological approaches to understanding students leaving college: 'such models invariably see student departure as reflecting some short-coming and/or weakness in the individual', and thus the result of personal failure (1993, p. 85). Instead, Tinto emphasises a more sociological approach, focusing on the institution. Though previous sociological approaches to the study of retention provide relevant insights, Tinto claims that they tend to leave the actual interaction between students and institutions almost untouched (Tinto 1993, p. 86ff). It is precisely this level – the students' interaction with the institution and how this influences student persistence – that is his primary interest. The student's involvement leads to some degree of social and academic integration that again produces a set of goals and commitments that lead to a decision to depart from or stay at the university. The academic integration primarily refers to those parts of university life that are related to the formal education and to the student learning during the

course. This interaction mainly takes place in classrooms, lecture halls and study groups. The social integration refers to the student's interaction in informal parts of university life such as unions, cultural gatherings and informal contact with teachers outside of the classroom (Tinto 1993).

Comparing the 1975 version of the model with the one from 1993, the student's interaction with staff/faculty has moved from the social system to the academic system, acknowledging that academic integration is not simply about performing well, but is also a matter of interacting with teachers. However, the academic and the social system of the institution are regarded as two distinct, but 'invariably interwoven' systems (1993, p. 109). Further, in the 1993 version of the model, the process at university is 'nested in an external environment comprised of external communities with their own set of values and behavioural requirements' (Tinto 1993, p. 115). Thus the university is a social system that works within a set of other social systems, and the students are simultaneously engaged in several systems.

Importantly, Tinto also makes the point that the university consists of more than one culture – that there are subcultures, and that students may become integrated into one of these, but not in to the dominant culture (1993, p. 105). These two points, namely, firstly, that the social and the academic systems are interwoven, and therefore influence each other, and secondly, that universities consist of more than one culture leads Tinto to emphasise that educational communities in the classrooms are an important arena for the integration of students at university. This is certainly important for non-residential students, who live outside campus, and commute every day. For these students in particular the social integration usually has to occur during class or in relation to class activities (1993, p. 206, and Tinto 1997, 1998). In his concluding remarks he states that an institution's capacity to retain students:

... hinges on the establishment of a healthy, caring educational environment which enables all individuals, not just some, to find a niche in one or more of the many social and intellectual communities of the institution. This view of the effect of institutions upon student leaving highlights the intricate web of reciprocal relationships which binds students to the communal life of the institution. Rather than single out any one action or set of actions as being the primary cause of student departure, it argues that student leaving is affected by most institutional actions regardless of their immediate referent. (Tinto 1993, p. 204f).

Tinto's model has several virtues. One is that it regards student leaving as a longitudinal process that involves more than one factor. Another is that it includes both the social and the academic aspect of students' integration.

Evidently, holding an almost paradigmatic position does not mean that Tinto's model of student departure is uncontested or uncriticised. At one level, questions have been asked as to whether Tinto's claims can be substantiated by empirical findings, and on another, it has been argued that his study lacks sensitivity towards ethnic minority students' situation in higher education.

In their review, Pascarella and Terenzini state that they can find 'moderate' support for the 15 claims they identify in Tinto's model (Pascarella and Terenzini 2005, p. 425f and 443f). However, as noted by Pascarella and Terenzini, a review by Braxton et al. (1997) reports only 'partial' support for some, and 'frail' support

for the other claims. Based on this finding, the authors do not recommend abandoning the model but suggest revising it instead (Braxton et al. 1997, p. 156). Still, the importance of being integrated into the university community is echoed in other findings in the US review. In particular, Pascarella and Terenzini report that different programmatic interventions such as supplemental instruction and first-year seminars have an impact on student persistence (Pascarella and Terenzini 2005, p. 398ff). However, they point out that the dynamics beneath this success are unclear, for instance as to whether the impact is direct (that is, that the skills developed, etc. increase student persistence) or indirect (for instance, earlier socialisation into the university culture and increased interaction with faculty, staff and peers) (Pascarella and Terenzini 2005, p. 403). Likewise, they find that different experiential and inquiry-based learning approaches increase rates of persistence, not least due to the student-faculty contact and active learning involved (Pascarella and Terenzini 2005, p. 406). Similar findings are reported by Braxton et al. (2000), who found that student-active learning activities have a positive influence on student persistence, and *inter alia* on social integration, and they make the point that 'faculty classroom behaviours play a role in the student departure process' (p. 581).

On a theoretical level, Tinto has been criticised for making general claims from a model that may only fit some groups of students (Pascarella and Terenzini 2005, p. 56). Hurtado and Carter (1997), studying experiences of Latino students' sense of belonging at university, state that Tinto's model does not take account of the importance of racially tense environments at universities. According to Tierney (1999), Tinto's model implies that minority students, or students who in other ways differ from the dominant majority culture, undergo a process of assimilation. It would follow that, as a consequence, minority students must discard aspects of their cultural background in order to succeed at university. Tierney (1999) argues that this philosophy contradicts experiences from his own research with students of colour, which conversely indicates that precisely the inclusion of the family and the neighbourhood of the minority students has led to an increase in students' sense of belonging at university, and, in that sense, to their social and academic integration.

Hurtado and Carter (1997) similarly found that for Latino students at predominantly white universities deliberate inclusion strategies had a positive impact in terms of them their feeling at home at the university through maintaining interactions both inside and outside campus (1997, p. 338), as did participation in some culturally-related activities such as association with social-community organisations and religious organisations (p. 335). For these students, it is not simply a question of being integrated or not, but rather to preserve a relation to multiple peer-groups and cultural environments.

Undoubtedly, there is a risk that social and academic integration could be interpreted simply as assimilation and that measures taken by the institutions to prevent non-continuation could overemphasise that students should conform to the dominant culture. The research reported by Tierney and by Hurtado and Carter indicates that this approach could be detrimental to the persistence of ethnic minority students. But also other groups of students with a particular gender

(cf. Chap. 19) or social background (Chap. 14) can be in danger of leaving due to their minority position. Therefore, it is critically important to be aware of whether support activities and structures at universities acknowledge these differences or not.

However, does Tinto's model imply that social and academic integration should be interpreted simply as assimilation? In our view, the answer partly depends on whether the model is read as a normative or an analytical statement. In the 1993 version of the model, Tinto identifies some limitations in using the analogies of the initiation rites and of egotistical suicide on entering university (1993, p. 104ff). Likewise, he emphasises that 'the great majority of colleges are made up of several, if not many, communities or "subcultures," each with its own characteristic set of values and norms' (p. 105) and that for some students 'events external to the college play an important role in community membership' (p. 105). More importantly, what permeates the model is the notion that attending university is a process of socialisation, and as such it is to be regarded as an interactional process between what the students bring with them and the culture they meet. Furthermore, this socialisation does not limit itself to academic features, but affects the tastes and practices of students in a broader context (Huber 1991). Similar observations are made by Becher (1989, cf. Becher and Trowler 2001) who – even though his study concerned research communities and not specifically student communities – points to the different cultures (or tribes as he calls them) that exists within academia, to which students need to gain access (cf. Gerholm 1990). For students at bachelor's level, Hasse (2002), in her study of first-year physics students at a research-intensive university, highlighted that becoming a physics student is more than merely learning the content knowledge; it is a matter of acquiring the right *poise*, or '*sprezzatura*' as she calls it with reference to Italian courts. Conceiving studying as a process of socialisation also partly explains the importance of interaction with faculty members outside the classroom. Such an interaction has an impact due to the process of socialising the students to values and attitudes in the academy.

The idea that facilitating subcultures at university could provide a sense of belonging for students who do not feel related to the dominant social and academic culture at the institution, or whose academic aspirations do not necessarily concur with the dominant academic orientations and paths, sounds convincing. In that sense, not conforming with the dominant culture is apparently a viable way for non-traditional students to survive at university. However, even if the institutions engage in facilitating religious or cultural organisations and institutions at campus, the stance of the institution would still be ambiguous. In his study of the academic field, Bourdieu (1990) remarks that the *habitus* of those holding the dominant positions in the field serves to select those who are to be included and exclude others:

What may appear as a sort of collective defence organized by the professorial body is nothing more than the aggregated result of thousands of independent but orchestrated strategies of reproduction, thousands of acts which contribute effectively to the preservation of that body because they are the product of the sort of social conservation instinct that is the *habitus* of the members of a dominant group (Bourdieu 1990, p. 150)

The socialisation of new students at bachelor's or PhD level, therefore, is not simply to ensure the academic qualification of the newcomers, but rather to make sure that the new members comply with the existing dominant culture. Therefore, when Tierney states that 'educational organizations must also accommodate for and honour students' cultural differences' (1999, p. 83), this may be true if those organisations have an interest in increasing student completion; but from the perspective of the organisations' struggle for position in the academic field, this is not necessarily the case. The interests of the universities are in these cases – from a Bourdieuan perspective (Bourdieu 1984, 1986) – at least ambiguous.

This point also has significance for some of the measures taken by universities to ease the way for minority students. As indicated by both Tierney (1999) and Hurtado and Carter (1997), studies of minority students suggest that for those groups of students to succeed, it may be a more viable path to establish subcultures that value the social and cultural capital of the minority. However, following the analysis of Bourdieu, this approach may well increase the probability of their completing their studies, but it is likely that it will also have the consequence that they are never fully integrated and accepted into the core of the academic community. This should not be an argument for giving up strategies such as the ones suggested in Tierney's study, or for calling for a total assimilation in the white, dominant culture. On the other hand, it seriously questions the impact of targeted sub-cultural services and offers on students' chances of obtaining equal possibilities within the academy.

In our view, Tinto's model provides an approach to examine the student experience that focuses on student departure as a process involving them coming to terms with both academic and social aspects of university life. Consequently, integration becomes a pivotal concept. Furthermore, both Tinto's remarks on the multiple communities and subcultures at university, the critical comments from, amongst others, Tierney (1999) and Hurtado and Carter (1997), and Tinto's further reflections on, inter alia, this critique (Tinto 2006–2007) emphasise that the process of integration is a complex one in which the differences in students' background, the composition of capital, the universities' level of inclusiveness, and the students possible positions in the academic field all influence the students' expectations of success and educational outcomes.

A Focus on Identity to Understand Retention

Based on the above discussions of Tinto's model, it would appear meaningful to apply an approach to the understanding of drop out/opt out among young people from STEM higher education courses that is informed by a narrative psychological conception of identity. If entering a study programme is regarded as a process of socialisation, then identity is a core concept for understanding how students relate to the experience and to the culture and environment they encounter. Since the integration into the culture of the discipline is, inter alia, brought about through

the teaching and learning activities and the feedback from the teachers (Hasse 2002), then the relation between these elements in the courses and the identities of the students is of interest. This position is in line with the emphasis that both Seymour and Hewitt (1997) and Harvey et al. (2006) put on the students' study experiences – not least during the first year.

Identity is a concept which, though originally from the field of psychology, has spread to a range of other disciplines, for example, anthropology, history, sociology, linguistics and feminist theories (Holland et al. 1998; Wetherell 2009). Research focusing on identities has been relatively rare in the field of science education, but in recent years it has become a subfield in the study of young people's participation in STEM education (e.g. Hazari et al. 2010; Schreiner 2006; Archer et al. 2010; Hsu and Roth 2009). Identity has been conceptualised from a number of different theoretical perspectives. These positions constitute a continuum from the idea of the individual as stable and coherent to the notion of identity as being multiple, flexible and continually re-negotiated (see Chaps. 3 and 4).

The research focusing on identity draws upon a range of perspectives most of which share an emphasis on the importance of the interaction between the individual student and the culture of the discipline. Secondly, it highlights the importance of being recognised as a legitimate member of the group of science students or 'science people'; and thirdly, it draws attention to the point that some positions are available to some students rather than to others. Overall, there is an emphasis on the socio-cultural aspects of studying, and the analysis of the underrepresentation of particular groups of students.

Research on identity and student persistence in STEM has to a large extent applied quantitative methods (see for instance White et al. 2006; Schreuders et al. 2009; Wasburn and Miller 2004–2005; Xu 2008). In a review of studies on women in computer-related majors, Singh et al. (2007) found that the quantitative studies are primarily based on descriptive analyses, individualized measures, and implicit theoretical frameworks. The qualitative methods used in the research to understand identity issues vary from life history interviews with a small sample of students (Wood 2002), focusing on already ongoing initiatives (Davis 2001) to methods involving a range of qualitative methods (Carlone and Johnson 2007). This research is primarily set in a US context and is mainly related to minority representation problems, in particular the lack of women or non-white students (or both) in STEM programmes (for a full review of this literature see Ulriksen et al. 2010).

In one of the examples of European research addressing identity within STEM education, Stentoft and Valero (2009) state that:

The notion of identity represents a way to move beyond the existing debate on whether mathematics learning is in essence individual or social. It can be seen as a notion which may assist researchers providing the missing link for grasping the dialectic relationship between the individual and the social dimensions of learning (Sfard and Prusak 2005 p. 15); and therefore it has been taken as a fruitful concept for providing more sophisticated interpretations of processes of mathematics education practices (Stentoft and Valero 2009, p. 56)

Following Stentoft and Valero, applying a socio-cultural post-structural perspective on identities is a way of building a bridge between looking at students leaving university as being either an individual or an institutional problem. It is a way to move away from a dichotomised perception of the problem to a more dynamic understanding in which identity is considered a fragile and ongoing process embedded in the institutional discourses and practices, closely related to the students' actions and participation. In this post-structuralist perspective, identity is perceived to be a process rather than a stable entity, where the individual produces culture at the same time as being produced by culture. This understanding of identity is not widespread in research in science education, but there are some examples of literature that take it into account.

Based on a study of women of colour working on constructing a science identity, Carlone and Johnson (2007) discuss identity as something closely connected to recognition, using a socio-cultural framework:

Identity is not just something an individual feels; it is not even what an individual does, although both feelings and actions are components of identity. A science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person (Carlone and Johnson 2007, p. 1192).

This position strongly connects identity to cultural settings and to other individuals, meaning that the students are not free to construct an identity on their own. They are dependent on recognition from others, and to obtain it they have to make themselves recognisable as legitimate 'science people'. This recognition has to be obtained in a context that is derived from socio-historical discourses of science and what science is, and from historical meanings and societal images of being a woman in science.

In their study, Tate and Linn (2005) use a multiple identities framework that is grounded in situated cognition theory and pay particular attention to the social relations and communities the students engage in. Rather than talking about 'student identity', Tate and Linn distinguish between three identities: social identity (the view of self in society or through society's eyes), academic identity (activities and success) and intellectual identity (desire to be an engineer and insight in the engineering field). They conclude that:

The multiple identities framework also reveals the intersections of the identities. Students' social identity may affect their academic identity. For example, a student who feels uncomfortable in an engineering environment may experience difficulty in forming study groups helpful to their academic performance (Tate and Linn 2005, p. 491).

The work of Tate and Linn draws attention to the diverse contexts and communities that students engage in, and consequently, studies of students' experiences at university that only address one of these identities may provide a misleading image of the students' situation. Furthermore, their work emphasises how these multiple identities influence each other.

Other research that takes up a more pronounced post-structuralist perspective emphasises that identities is so closely woven into the social and the cultural that they are inseparable. Hughes (2001), in a study of a group of students consisting of

both males and females and of students of different ethnicity in a UK city school and post-16 city college, focuses on how identity is connected to recognition and to which positions are available in the construction of a science identity. She points out that different curricula and teaching methods make different potential identities available to students with gender or ethnicity different from that of the majority of students in STEM. Consequently, she cautions against simply linking particular genders to particular sciences. Instead, she concludes how ‘socially relevant and more constructivist science can generate a wide range of scientist subjectivities, increase the possibilities for scientist identities and thus open the way towards a more inclusive science curriculum’ (Hughes 2001, p. 288). The way science is presented to students set the scene for their participation in science and produce a wide range of subjectivities the students can relate themselves to in their identity-work.

As it is, applying identity as a theoretical perspective in understanding students’ experiences and student persistence is primarily found in studies focusing on minority students, which in an STEM context includes both ethnic minority students and women. However, if attending university, as we argued earlier, is a process of socialisation (cf. Tinto 1998; Becher 1989; Becher and Trowler 2001), then it seems relevant to address the identity issue for majority students as well in trying to comprehend the question of persistence or opting out. This point seems even more relevant considering the finding of Seymour and Hewitt (1997), mentioned earlier, that the most common reasons causing students to switch programmes were rooted in experiences shared by both switchers and non-switchers. However, the fact that these experiences were shared does not mean that they were identical. This underlines the importance, not of research into individual traits or characteristics, but research into the intersection of different characteristics and how they are recognised, interpreted and acted upon by both the individual and by others in the academic culture and community.

Conclusion and Implications for Further Research

In this chapter we have reviewed research on students dropping or opting out of higher education with a special focus on STEM studies (for a full analysis see Ulriksen et al. 2010). The research on retention and non-continuation of students across different disciplines shows that there is no one factor determining student success. Instead, whether students persist or not are influenced by a number of factors, and these different factors interact.

The student’s social and economic background and the reasons and processes behind their choice of study have an impact, as does the induction into the study programme. Students’ preparation for their studies influence persistence, but their academic level and abilities cannot explain why some persist and others opt out. Conversely, the teaching and learning environment and the teaching methods applied prove to be highly important. The teaching and learning activities students are engaged in, the design of the curriculum and the interaction with faculty and peers are also important.

In a substantial part of the research included in this review, the problem of retention is being framed as located in either the student or located in the institution, respectively. However, another research approach to retention highlights the issue of identity construction and of being recognised as a legitimate member of the group of 'science people'. The inclusivity of the study environment and the disciplinary culture provides possible positions for the students to take, and make some identities more legitimate and recognisable than others. Apparently, the STEM culture is still to a large extent distinguished as being competitive, detached, white and male-dominated. Students who for one reason or another (for instance gender, ethnic origin or the part of the discipline the student takes interest in) differ from what is considered normal within the field will often have more difficulties in being socially and academically integrated, and in developing an identity as one belonging to the discipline.

Suggestions of how to increase retention tend to focus on adjusting the students and leaving the institutional or disciplinary side stable and untouched. A few papers move in the direction of organisational change, where the courses and the teaching and learning activities are adjusted according to students' background and experiences. One example is Wistedt (2001) who found how Swedish university technology programmes which with success attracts and keeps female students, were characterized by cooperation based, problem oriented methods, rich interactions with students and staff. She argues how institution must focus on radical changing the study programmes rather than paying attention to recruitment campaigns to retain and attract female students. But these kinds of suggestions risk being rejected because they are considered to be detrimental to the quality of the course, as described in Seymour (2002). This perception of the disciplines as stable and also objective entities with a fixed curriculum (Angell et al. 2004; Hughes 2001) leads any suggestion of changing the curriculum to be regarded as a setback for the science discipline and student achievement. If the discipline is not regarded as an object of negotiation, the point of departure for reducing drop out must be the students. This perspective makes it very difficult to introduce any measures that challenge the identity issue.

From this chapter we draw three important results. Firstly, this perception of STEM within the STEM provides an explanation as to why so few studies have followed the research ideas set out by Seymour and Hewitt (1997). In their work, they rejected the idea that the problem should be located in the student and instead framed it in relation to the match between the institutions and the students. We find that this is one of the prime reasons why it is so difficult to really address the problem of retention in STEM. STEM educators often demand a retention check list that can be imposed without changing the existing framework for teaching and the faculties' relation to the students. Evidently, these are factors that, according to research focusing on identity and the relation between students and institutions, need to be addressed. Further, it is likely that this is the reason why some research addresses this highly complex problem of retention by focusing on the straightforward variables of students' behaviour and capabilities.

Secondly, it makes it even more urgent to further develop research into the culture(s) of STEM disciplines and courses, in the formation of identity during the study, and to expand the scope of this research to all groups of students – not just the minority groups, but also the dominant white male culture. This approach further suggests that the problem of retention should be rephrased from focusing on how to adjust the students so that they can meet the requirements of the existing science programme to a broader perspective on students' experiences with studying science, where not least the question of how STEM programmes can become part of students' identity formation. Will it be possible for STEM programmes to convince future and present students that being integrated in a STEM discipline is an attractive perspective for a young individual trying to find out who she or he is, and what direction her or his life should take?

Thirdly, there is a need to combine research addressing identity issues with pedagogical research approaches that address, for instance, the purpose and objectives of science studies, what content is included and what is excluded in science programmes and the teaching and assessment approaches. Future research as well as future initiatives in higher education addressing the opting out or dropping out of students therefore needs to adopt a broad perspective in terms of both the teaching and learning activities, and on the possible identities made available to students. However, what from our perspective stands out as perhaps the most important finding in this review is that a substantial part of the findings of what could increase student retention within STEM, are at odds with the self-conception, culture and tradition of STEM disciplines and environments. Consequently, if STEM programmes and institutions genuinely wish to increase the number of students completing the STEM degree they enter, their courses need to turn their focus from the students alone on to themselves and the culture and values that are revered there, and consider whether they are perhaps a part of the problem. In our view, this is indeed most likely the case.

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