

# Tackling transition in STEM disciplines



Supporting the Science, Technology, Engineering and Mathematics (STEM) student journey into higher education in England and Wales

Julie A. Hulme and Janet De Wilde



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Jim Butler (Operations Manager, STEM)  
Dr Gill Cooke (Discipline Lead for Engineering and Materials)  
Marina Crowe (Academic Development Officer, STEM)  
Karen Fraser (Academic Development Officer, STEM)  
Dr Julie Hulme (Tackling transition project manager and Discipline Lead for Psychology)  
Dr Mary McAlinden (Discipline Lead for Mathematics, Statistics and Operational Research)  
Dr Nathan Pike (Discipline Lead for Biosciences)  
Dr Mark Ratcliffe (Discipline Lead for Computing)  
John Stockwell (Academic Development Officer, STEM)  
Dr Anne Wheeler (Discipline Lead for Geography, Earth and Environmental Sciences)  
Dr Janet De Wilde (Assistant Director and Head of STEM)  
Aled Williams (Discipline Lead for Built Environment)  
Dr Paul Yates (Discipline Lead for Physical Sciences)

### Academic Associates:

Helene Ansell	Professor Paul Roche
Deb Gajic	John Turner
Nicola Hawley	Dr Helen Walkington
Jane Kettle	Dr Catherine White
Dr Vanessa Kind	Dr Lynda Yorke
Gill Miller	

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## Executive summary

The *Tackling transition in STEM disciplines* project engaged 381 delegates, including academics, teachers, students and other stakeholder group representatives, across eight STEM disciplines, in strategic discussions about the issues faced by students making the transition from pre-tertiary education into studying STEM within higher education. A large corpus of qualitative data was generated through correspondence, report and evaluation of these events, which was analysed thematically. Five overarching themes were identified:

1. Strategic importance of student transition into higher education.
2. The STEM student journey.
3. Student preparedness for transition from pre-tertiary education to higher education.
4. Awareness, communication and transition from pre-tertiary to higher education curricula.
5. Change and collaborative initiatives to ease transition.

Within these themes, there was considerable consensus between delegates regarding key issues faced by students and educators, and important priorities that need to be addressed. Transition was recognised as one of the most important issues facing STEM educators at the current time, and it was noted that transitions occur throughout the student journey, including from primary to secondary school, from school to sixth-form, and from undergraduate to postgraduate study or employment. Learning from other transitions could be an important feature of supporting students through the transitional experience. Delegates were also in broad agreement that students could be better prepared to make the transition from pre-tertiary to higher education, particularly with regard to important academic skills (note-taking, time management, writing, information literacy, practical skills, independent learning, critical thinking and numeracy were all identified as important across the range of disciplines). There were also frequent comments suggesting that students needed to be prepared in terms of the learning and teaching approaches employed within higher education, and with regard to their expectations and understanding of the nature of their academic discipline of choice. Similarly, some delegates identified psycho-social factors that impacted upon the student transition experience and could be further developed to facilitate the transition process. Across all disciplines, it was reported that there was relatively little understanding of either curricula or of teaching, learning and assessment practice within each sector from members of the other sector, and that this urgently needed to be addressed if student transitions into higher education were to be facilitated. Finally, delegates were committed to engaging with a process of change and collaboration to support transiting students, and student engagement with this process was seen as crucial.

While the delegates across disciplines were largely in agreement about the main issues, there were some important disciplinary differences. For example, entrance requirements to undergraduate Psychology were considered to be highly influential on the Psychology student experience, whereas this was less problematic for other STEM disciplines. Widening participation is on the agenda throughout higher education, but its issues vary within different disciplinary contexts. For example, in many of the traditional STEM disciplines (e.g. Engineering, Physics, Mathematics), and in Built Environment and Computing, the majority of students are male, and there is a strong drive to increase female participation. However, in Psychology, the balance is dramatically the other way, with a strong majority of female students. Most of the academic delegates at the event were under pressure to recruit more students, but the emphasis here was also discipline-sensitive; in Built Environment, this was strongly driven by an urgent need within the labour market, whereas in other disciplines it tended to be led by the higher education providers themselves.

Solutions to the problem of transition were also generally proposed to have a disciplinary context. Delegates were especially enthusiastic about sharing discipline knowledge across the sectors, arranging collaborative visits of both staff and students to provide mutual insight into the student experience within the discipline, to share academic and physical resources, and to provide both face-to-face and virtual support within disciplines across the pre-tertiary and higher education communities.

The report considers each of these themes in the light of the pedagogic literature and theory, and proceeds to make nine recommendations relating to policy and practice within the higher education sector. It is expected that stakeholders with an interest in student transitions in STEM subjects from other sectors will also find the report informative and useful. It is also hoped that the report will provide a springboard for further research and for the gathering of additional evidence-based practice to help educators and students to 'tackle transition'.

# I. Introduction

The first year of undergraduate study, while often eagerly anticipated by students and perceived as an exciting time, is generally accepted to be the most challenging for students in terms of retention (staying in higher education) and success (achieving satisfactory outcomes on course assessment measures). Considerable work has been conducted in recent years through the Paul Hamlyn *What works? Student retention and success?* project to identify good practice across the sector that supports students once they enter higher education (Thomas, 2012), and to a large extent providers are successful in supporting students through the first year. This is evidenced from the fact that while approximately 8% of students in the UK withdraw from their higher education programmes during their first year, between 33% and 42% of first-year students actually consider withdrawing (Thomas, 2012). There is, however, considerable variance in retention and success rates across different discipline areas within institutions.

Much of the work undertaken on student transitions into the first year of undergraduate study has been generic. For example, Yorke and Longden (2008) conducted a survey-based study (quantitative and qualitative) of first-year students' experiences of university. Students were contacted during the early/mid-semester two period, and non-continuing students were contacted again the following year to investigate their reasons for leaving. The study included students from 25 institutions, across nine broad discipline areas. The report on this work, however, does not examine disciplinary issues within the data, with the exception of noting that an important reason for withdrawal by some students was 'wrong choice of field of study'. This reason for withdrawal was particularly influential for younger, more traditional students in pre-1992 universities who had no prior experience of higher education. However, the report does not explore whether the specific discipline choice had any impact upon the probability of retention. Additional key challenges identified for successful transition in this work related to poor quality learning experience, not coping with academic demand, unhappy with location and environment, dissatisfied with institutional resourcing, problems with finance and employment, and problems with social integration. It seems likely that at least some of these may be influenced by the disciplinary context of study, particularly the quality of learning experience, academic demand, and institutional resourcing. STEM subjects may perhaps be perceived by some students as difficult to learn, or less engaging, and often require high levels of resourcing to support practical learning. Considering transition into STEM disciplines and the factors that influence this aspect of the STEM student experience therefore seems crucial.

Within the wider context of STEM education, the successful transition of students into STEM degrees, and their ultimate retention and success, is a matter of national concern. The House of Lords Science and Technology Committee (2012) completed an inquiry into STEM in higher education, identifying a need for increased numbers of employable, skilled STEM graduates as a matter of urgency for the economic health of the UK. However, it is important to realise that the STEM disciplines are heterogeneous in terms of entrance requirements, student diversity issues, teaching and learning approaches and the student experience. For example, students pursuing a degree in Mathematics are usually required to study Mathematics (and often Further Mathematics) at level three (e.g. A-level, Advanced Highers, Access, and International Baccalaureate qualifications), whereas in Engineering, it would be unusual for a student to acquire a level three qualification in Engineering (although other entrance requirements will apply).

In addition to the national policy agenda relating to STEM education, the National Student Survey 2014 data suggest that students in STEM disciplines tend to be more satisfied with their overall learning experiences than those in other discipline areas (Grove, 2014), although previous research and detailed analysis of the 2011 data suggests that this may vary across disciplines and discipline groupings on individual items of the survey. Again, this implies that there are important differences between STEM subjects within UK higher education, and that it is important to consider transition in STEM in a discipline-specific, rather than generic, way.

Some differences across student experiences of learning STEM disciplines may result in differences in student preparedness and expectations of their chosen subjects, and thus it cannot be assumed that all transitional issues within one STEM discipline are equivalent to those in another. For example, in Psychology, where

approximately 58% of undergraduate students obtain a level three qualification in the subject prior to entering university (UCAS, 2012), Winstone and Bretton (2013) identified an 'expectation-reality gap' that students face during their first year of undergraduate study. Students in this qualitative study were found to have unrealistic expectations with regard to the nature of and extent to which they would need to engage in autonomous learning, the teaching methods they would encounter within higher education, and levels of achievement (at A-level, for example, 70% might be considered a low mark by high achieving students, but represents a first-class mark within most higher education institutions). Unrealistic expectations can in turn challenge students' ability to make a successful transition and result in academic disengagement (Rowley, Hartley and Larkin, 2008). While students' expectations are likely to influence their student experience in all disciplines (Lowe and Cooke, 2003), the subtle differences between STEM subjects have not been explored in the literature, and further investigation is desirable.

The emphasis of research and sharing of practice to date has largely focused upon what universities and other higher education providers can do to support students once they arrive; the question of how to better prepare students prior to their arrival, or the extent to which this might be possible, has not been addressed. Previous work from the HEA (Hulme, unpublished) suggested that relatively little was known by academics about pre-tertiary Psychology curricula or teaching methods, while teachers in schools and colleges were often unaware of the nature of courses in modern universities, both in terms of curriculum and teaching methods. A recent literature review relating to transition (Kitching and Hulme, 2013) recommends dialogue and collaborative working across the sectors as key to supporting students entering higher education programmes.

In order to address these knowledge gaps, to identify ways of supporting students through transition to HE, and to better inform teachers and lecturers about curriculum and practice in both the pre-tertiary and HE sectors within specific STEM disciplines, the HEA STEM team extended the previous project (Hulme, unpublished) across eight STEM discipline areas: Biosciences; Built Environment; Computing; Engineering and Materials; Geography, Earth and Environmental Sciences (GEES); Mathematics, Statistics and Operational Research (MSOR), Physical Sciences; and Psychology. These disciplines formed the basis of the current project, *Tackling transition in STEM disciplines*, which involved a series of events, held in different regions and nations of the UK, to which academic staff, postgraduate students, undergraduate students, pre-tertiary students, school teachers, college teachers, representatives of examination boards and representatives of professional bodies and subject associates were invited. The events were designed to achieve several aims:

1. To facilitate knowledge sharing and discussion across the sectors.
2. To provide a platform whereby new collaborative work, across the sectors, could be initiated to ease student transition.
3. To identify key issues relating to transition in each of the STEM disciplines.
4. To inform the HEA's work on transition in the STEM disciplines by providing evidence of current issues related to student transition.

This report will outline the nature of the events and the findings from the participating STEM discipline areas, identifying key themes within and across STEM disciplines, and providing an overview of issues and recommendations for future practice relating to tackling transition in STEM education.

## 2. Tackling transition events

Events were held in each STEM discipline area, across different parts of England and Wales, with regional attendance. Between one and three events were held per discipline area, with most disciplines hosting two events. Scotland and Northern Ireland were not covered within this project because of different educational policy contexts in those nations. Changes to the Scottish pre-tertiary curriculum, in the form of Curriculum for Excellence, required a different approach to be taken, and thus a separate project was run independently in Scotland.

Events in each discipline area were promoted via diverse mechanisms to ensure maximum awareness across both the higher education and pre-tertiary sectors. Typically, these included use of HEA discipline newsletters, the HEA website, promotion through relevant professional and subject-related bodies, use of social media, JISC-lists and direct contact with both higher education and pre-tertiary institutions in geographical proximity to each event. Academic staff, pastoral staff, school/college liaison staff, admissions tutors and students were encouraged to attend from the higher education sector. Teachers from schools and colleges, and their students, were encouraged to attend from the pre-tertiary sector. Invitations were also sent to representatives from relevant subject bodies and examination boards.

Each event lasted for between two and three hours, during the evening, on a weekday. Scheduling after the close of a typical working day was preferred to facilitate attendance by school and college teachers, who are often unable to leave their normal place of work during working hours. Refreshments were provided, and an informal atmosphere was encouraged. A focus on finding solutions, rather than on identifying problems or allocating blame, was emphasised throughout. This format had previously been found to be successful in terms of facilitating attendance from diverse stakeholders and enabling open discussion through previous tackling transition events held in Psychology.

The programmes for the events varied slightly, to accommodate disciplinary preferences and cultural differences. However, the basic template for the evening followed a similar pattern in all disciplines. Each event started with an introduction from HEA staff and invited speakers, sometimes with input from professional and subject-related bodies. This was followed by guided discussion in small groups of delegates, whereby each group contained a mixture of stakeholder types, focusing on their experiences of working or studying within the discipline area, particularly with regards to factors affecting transition to higher education. Aspects of good practice were shared, and delegates were facilitated to share ideas and network, with encouragement being given to build relationships across the sector divides. Finally, delegates were asked to record at least one action that they would take as a result of attending the event, to ease the transition experience for their students. These pledges were captured by the event organisers, and where possible, delegates were contacted several months later to find out about the progress they had made, and any impact that the event had had on their practice in the longer term.

A summary of the events held in each STEM discipline area can be seen in table 1.

## 3. Ethics

BERA ethical guidelines have been observed in the production of this report. Qualitative data were collected from delegates and others involved with the tackling transition in STEM events and project, as part of the day-to-day running, evaluation and dissemination of the events. Individuals were informed that their communications at and about the events would be used to inform the HEA's work on student transitions. All responses have been anonymised. Original data have only been viewed by relevant HEA staff, and were stored on a password-protected secure server.

Table 1: Summary of tackling transition in STEM events held in the academic year 2013-14

<b>Discipline</b>	<b>Sub-discipline (where applicable)</b>	<b>Event location</b>	<b>Number of delegates</b>
<b>Biosciences</b>		Cardiff	48
<b>Biosciences</b>		London	18
<b>Built Environment</b>		Manchester	44
<b>Built Environment</b>		Leeds	37
<b>Computing</b>		Birmingham	13
<b>Computing</b>		Oxford	12
<b>Engineering and Materials</b>	Engineering	Nottingham	16
<b>GEES</b>	Geography	Newcastle-upon-Tyne	19
<b>GEES</b>	Geography	Chester	22
<b>GEES</b>	Geography	Bangor	12
<b>MSOR</b>		Swansea	25
<b>MSOR</b>		London	29
<b>Physical Sciences</b>	Astronomy	Cardiff	15
<b>Physical Sciences</b>	Chemistry	Durham	11
<b>Psychology</b>		Oxford	30
<b>Psychology</b>		Manchester	30

## 4. Findings and themes

Delegates' views and ideas were captured via several mechanisms, including recorded pledges made at the events, notes taken in discussion groups, notes taken by event organisers or academic associates, verbal feedback from group work, correspondence pertaining to the event, post-event reports (usually written by event organisers and made available to delegates) and qualitative comments provided as part of the event evaluation process. A semantic thematic analysis (Braun and Clarke, 2006) of this data corpus, using an inductive approach, was used to code the data, and allowed the identification of several themes, which will be explored in turn.

Quotations are presented here to illustrate these themes. They are presented as written by delegates, except that any potentially identifying information has been removed. Not all relevant quotations are presented here, due to the large amount of available data. Quotes have been selected because they exemplify ideas particularly well, and to illustrate the diversity of stakeholders articulating particular ideas. In some cases, partial quotes have been presented, with "... " used to represent missing words from the original. Where [square brackets] have been incorporated into quotations, this signifies that an identifying word, such as a name or organisational name, has been removed and anonymised. This has been done for consistency, even where the data are already in the public domain (such as some post-event reports and blog posts).

Note that where a delegate is identified as a 'teacher', this indicates that they are employed within the pre-tertiary sector (school or college), whereas the term 'academic' has been used to indicate an individual working within the higher education sector (university or college-based higher education). Likewise, the terms 'pre-tertiary', 'undergraduate' and 'postgraduate' have been used to distinguish between school and college students and higher education students at different stages in their academic journey. In some cases, this information about the individual providing the quote is not known, and they have therefore simply been identified as a 'delegate'.

The key themes identified in the data corpus were as follows:

1. Strategic importance of student transition into higher education.
2. The STEM student journey.
3. Student preparedness for transition from pre-tertiary education to higher education.
4. Awareness, communication and transition from pre-tertiary to higher education curricula.
5. Change and collaborative initiatives to ease transition.

### 4.1 Strategic importance of student transition into higher education in STEM

Across all of the STEM disciplines involved in this project, there was an acknowledgement of the importance of understanding and tackling transition from pre-tertiary education into higher education. Delegates from all stakeholder groups expressed interest in the topic:

*"Transition to uni is one of the most significant challenges students face, and has been under-rated and affects all students. Wanted to hear more about this including from teachers"* (Geography academic).

*"Interest in transition issues due to being involved in A-level Mathematics curriculum development"* (MSOR academic).

*"I am interested in transition having been a student then a teacher then a student then a teacher again"* (Psychology delegate).

*"...this is clearly an area which is an issue for students"* (Engineering academic).

*"Due to the current work being carried out by myself and other awarding bodies on changes to the GCE specification in England (linked with HE demands), I felt that it was an opportunity to gain some insight into the concerns of both sides"* (Psychology examination board representative).

*“I work on Psychology books in the HE department at [a publisher], and so was interested to see how educators are trying to bridge the gap between school and university, and if there is anything publishers can do to help with this” (Psychology publisher).*

Some delegates were interested in tackling transition because they felt that it was relevant to their roles, because transition impacted upon their teaching and pastoral support of students, or because their role had specific elements that related to student transitions. This indicates that there is existing practice to try to support students through entry to higher education:

*“I am the schools liaison person for the department” (Psychology academic).*

*“My role in university, as senior academic tutor, means that I am currently actively involved in ensuring the best transition from school to university as possible” (Biosciences academic).*

*“I work with [organisation] as an employer advisor and wanted to improve my knowledge regarding working within the construction sector” (Built Environment delegate).*

*“It is relevant to my work at university, on producing level-four teaching and learning, and also my role as [professional/subject-related body] vice president” (MSOR delegate).*

*“My areas of interest and responsibility correlate exactly with the topics covered” (Astronomy delegate).*

Transition was viewed as a strategically important issue for higher education providers to address across all disciplines included in this project, with large numbers of delegates referring to a need within the higher education sector to recognise and take action to support the student transitional experience, whilst remaining mindful of a need to maintain academic standards:

*“I am interested in the transition between FE and HE, and what more we in the HE sector, particularly as a lecturer, can do to facilitate this transition without lowering standards” (Biosciences academic).*

*“...awareness of student preparation in FE and how to handle this via guidance tutorial support during first year at university” (Geography academic).*

*“My job involves supporting the transition of students into HE from A-level and other non-traditional routes. We don’t have any Maths support within our programme at the moment, but looking at ways of incorporating it” (MSOR academic).*

*“...general agreement that it was necessary for universities to be proactive in reaching out to schools and in the process work out good strategies to help transition” (MSOR academic).*

*“As course leader for undergraduate Psychology programmes, I am very keen to look at the issues around transition; it is a problem I struggle with every year with every new intake” (Psychology academic).*

Likewise, pre-tertiary providers articulate a responsibility to prepare their students to progress into higher education, and see this as an important part of their roles. This was true across all disciplines, including those where the pre-tertiary to higher education progression within a discipline was not always straightforward (for example, for Maths and Science teachers thinking about progression into Engineering, or Built Environment). Whilst pre-tertiary teachers may not know what route many of their students will take after completing their courses and even if they will continue to higher education, they are keen to ensure that the students are well prepared:

*“Transition is a huge issue, I want to ensure my students are well equipped to succeed in whatever they go on to do” (Geography teacher).*

*“Relevant to supporting progression strategies we are developing in my FE institution to support progression of learners from my department” (Biosciences teacher).*

*“It is an area that few of our students currently opt for and we were interested in finding out more about the opportunities in the sector and the different progression routes” (Built Environment delegate).*

*“Consideration of how to prepare my students for university” (Geography teacher).*

*“Felt that it would be useful to have the opportunity to discuss with university lecturers the problems that they feel the students have and what we as teachers of 16-18 age group could do to overcome these problems. I also wanted to find out what is currently being done for the transition of pupils to university” (MSOR teacher).*

*“I am interested in the challenge of producing successful A-level candidates – v- successful candidates that can be successful undergrads, i.e. how to dare to leave spoon-feeding to promote independent learning, also how it is affecting university teaching” (Chemistry teacher).*

*“I was hoping to find out how to make my lessons a better preparation for those looking to study psychology at university” (Psychology teacher).*

Commitment from both educational sectors was also evident from a frequently expressed enthusiasm for talking about issues relating to transition, and a real desire to share good practice. Delegates were keen to hear ideas from others, but also to share their own experiences in an open and honest way, both their success stories (as a way to support others) and areas in which they were experiencing challenges (to gain guidance from others). Students also remarked on their eagerness to contribute ideas, based on their experiences of transition, and welcomed the opportunities to be heard provided by the tackling transition events. There was also an element of delegates looking for validation of their existing practice. The desire for discussion and sharing was particularly evident amongst MSOR delegates, but was commonly expressed across the range of STEM disciplines:

*“I was enthused and engaged by the discussions and the open mindedness of those attending. There was a palpable willingness to consider new ideas” (Biosciences delegate).*

*“I wanted to share ideas on transition from college to university” (MSOR delegate).*

*“I was keen to learn more about the issue, share my experience and meet like-minded people who have the initiative to do something about this problem” (MSOR delegate).*

*“It was interesting to listen to the various initiatives that are being pursued at other institutions in order to engage students with Mathematics and their courses. It is always useful to get new ideas” (MSOR academic).*

*“To present my opinion on an ongoing issue and to hear the views of individuals from both ends of the spectrum” (MSOR delegate).*

*“Encouraged me in what I’m already doing” (MSOR delegate).*

*“To put forward issues that are relevant and discuss possible solutions” (Psychology delegate).*

*“...outlined the ideas presently being used by [a university] to alleviate some of the pressure experienced by first year students in their transition from A-level to university level work” (Engineering post-event report).*

*“I thought I could be some use” (Astronomy academic).*

*“...having discussions which reinforced I am teaching the right skills” (Psychology teacher).*

*“...give my input on the matter!” (Psychology undergraduate student).*

Collectively, these quotes from delegates and others involved in the events indicate a general concern and interest in the transitional experience of students from pre-tertiary to higher education in STEM disciplines, and an eagerness to engage with the issue and to improve practice to support students through their transitions. This commitment and prioritisation of awareness and support for transitional experiences is evident across all STEM disciplines, and in all stakeholder groups, including higher education and pre-tertiary representatives, students, publishers, professional and subject-related bodies, and examination boards. It is apparent that transition into higher education is of major interest to STEM educators in the UK, and that opportunities to share practice and ideas are highly valued.

## 4.2 The STEM student journey

Both higher education providers and pre-tertiary educators are under pressure to recruit students onto their courses. In higher education particularly, there is a desire to attract more undergraduates than there are places to allow selection of the best qualified candidates. It is perhaps not surprising, then, that delegates at the tackling transition events articulated issues around promoting their disciplines and attracting students into their particular subject areas at higher education. There was a desire to promote the discipline, and to communicate its value and interest to potential students. This was most evident within Geography, although implicit within other disciplines too:

*“...provides activities connected to geophotography, pollution, crime and sustainable cities to show year nine and sixth form students from a variety of schools that Geography is ‘fun’. The aim of this day has always been to encourage students to take Geography at GCSE, A-level and beyond”* (Geography post-event report).

*“The discussion that was generated focused on how they felt that this was going to pose problems for recruiting students to Geography A-level...”* (Geography post-event report).

In Built Environment disciplines, recruitment was identified as a pressing concern, with a majority of delegates referring to it. In most other STEM disciplines, the focus was on a fairly straightforward progression, either from a pre-tertiary qualification in a discipline into the same discipline area in higher education (for example, Mathematics and Further Mathematics at A-level into a Mathematics degree, or Geography A-level into a Geography degree), or into a related discipline area in higher education (for example, Mathematics and Physics at A-level into an Astronomy or Engineering degree). In Built Environment, however, there was a slightly different emphasis from delegates seeking to promote progression into these disciplines as a route to a professional career, often via vocational courses in a higher education context:

*“The first speaker....talked about the range of exciting and challenging careers that the sector offers, and explored the reasons why it doesn’t carry the same level of attractiveness as other professional areas. He acknowledged the importance of construction and built environment to the national economy...”* (Built Environment post-event report).

*“The current image of the sector is that of a dirty old-fashioned one dominated by manual trades. The reality is however that the sector offers a wide ranging of rewarding, challenging and exciting careers to people of all backgrounds and levels of ability”* (Built Environment post-event report).

*“Applications to university for CBE courses are 2% down on 2013 (when all applications are up 4%). The construction industry is gaining confidence with activity increasing and the demand for construction professionals is set to increase significantly over the next few years but the supply of graduates leaving courses will decline unless we can work together to encourage applicants”* (Built Environment post-event report).

Alongside a general desire to promote their discipline areas and to recruit students into higher education, delegates across the disciplines were committed to widening participation and an inclusive approach to recruitment and engagement in their subjects. Delegates were equally concerned about ensuring that their teaching was inclusive, and felt that an understanding of transition was central to this. There was considerable enthusiasm for discipline-specific outreach activities to encourage widening participation:

*“I’d like to know more about how to make my teaching more inclusive for these new students – appreciating the issues underlying school-HE transition will help this”* (Biosciences academic).

*“I’m speaking to colleagues about setting up a widening participation event for students from local colleges”* (Psychology academic).

*“...degree courses to be designed with diversity and pre-tertiary experience in mind”* (Geography post-event report).

*“Get in touch with [person] about outreach events and widening participation and help A-level students whenever I get the opportunity”* (Psychology undergraduate).

*“Help with widening participation within the university for school children and college students with a relevant part of the university. Also help connect WP in the uni with schools for Maths days”* (Psychology academic).

*“Outreach project for year 13 students”* (Engineering academic).

In Built Environment, delegates expressed specific concerns about widening participation related to recruiting females, recruiting non-traditional students and to recruiting more able students:

*“I am keen to get more of the girls I work with into construction”* (Built Environment delegate).

*“CBE subjects have been described as inappropriate for more academically able students. However most CBE courses at higher education level have to meet the high standards demanded by professional bodies”* (Built Environment post-event report).

*“The ambassadors raise the delegates’ awareness of the different routes to higher education, the variety of qualifications available at this level and the varied careers that this can lead to in CBE”* (Built Environment post-event report).

*“More positive and varied role models from industry should be encouraged to break down the stereotypes of our industry and raise awareness of the diverse range of routes in the industry and the careers the industry can offer”* (Built Environment post-event report).

*“Careers information material should be targeted to parents and carers and University open days should also pay particular attention to this group”* (Built Environment post-event report).

Delegates recognised that the transition from pre-tertiary education into higher education was just one of a series of transitions undertaken by students throughout their lives. Educational experiences and influences were recognised from parenting and primary school through to post-compulsory education of all types, including vocational routes. There was a sense that educators could learn from transitions in other contexts, and that learning from the pre-tertiary to higher education transitional experience might be transferable to other contexts. The need for communication with much younger children about STEM education and careers also became apparent in this context:

*“Transitions occur at many stages, not just between A-level/FE and HE”* (Geography delegate).

*“PGCE providers may need to investigate the transition from undergraduate courses to postgraduate in more detail”* (Geography post-event report).

*“Some schools use a form of portfolio for the KS2 to KS3 transition, allowing students to demonstrate a ‘passport of skills’ that they were bringing to the new school. This could be developed at the KS5 to undergrad level, with students being able to demonstrate what practical competencies and experience they have gathered, and allowing university staff to see where potential gaps and weaknesses existed”* (Astronomy post-event report).

*“Raise awareness in primary schools and secondary schools and colleges as part of a wider national campaign using social media”* (Built Environment post-event report).

*“Construction qualifications, e.g. BTEC level 2, are offered to some school students but many schools either do not offer this as an option, only offer it to their less academic students or those schools who are offering construction are reconsidering it due to the changes in the league tables. If this is the case, how do we raise awareness of CBE as a career/study option?”* (Built Environment post-event report).

Support for students making career choices alongside educational transitions was also advocated by many delegates. Again, this was particularly prevalent in Built Environment, with its inclusion of vocational training in higher education, but was also mentioned in MSOR and Psychology. Educating teachers and parents about career choices, as well as careers advisers, was seen to be desirable, and employer engagement was strongly recommended by many delegates:

*“The lack of awareness of the industry and the qualifications needed to enter higher education could be overcome by the use of ambassadors who could come into schools and colleges and engage with staff as well as students” (Built Environment post-event report).*

*“...explained routes into CBE roles and the support that is available to employers, schools and colleges, and careers advisors to help facilitate potential students make appropriate choices” (Built Environment post-event report).*

*“More engagement between employer role models in schools, particularly female employer role models and aligned to this stronger links between employers and colleges” (Built Environment post-event report).*

*“Careers advice in schools appears to be channelled to pupils subject to their academic skills, as schools are pushing to improve their scores in league tables rather than providing what the student wants” (Built Environment academic).*

*“Use some of the pooled resources on careers in Maths education” (MSOR delegate).*

*“Make links - ...careers talks” (Psychology teacher).*

It is clear that most delegates were aware of issues around progression and serial transitions into, through and out of the education system, across most STEM disciplines. However, from these data, it can also be seen that the emphasis on this type of learning journey is qualitatively different across the different discipline areas. Delegates at Built Environment events wrote far more frequently and extensively about these issues, and were much more focused on employer engagement and vocational training, than their colleagues in other disciplines. Nevertheless, even in more traditionally academic disciplines, such as Physical Sciences, Geography, MSOR and Psychology, there is a clear acknowledgement of a need for progression opportunities within the disciplines to be clearly signposted to students at an early age, and in a way that promotes inclusive recruitment and engagement in higher education and within industry.

### **4.3 Student preparedness for transition from pre-tertiary education to higher education in STEM**

Issues relating to student preparedness were mentioned by delegates from all of the STEM disciplines involved in this study (although to a much lesser extent within Built Environment than any of the others), with the main issues being around student skills, and the question of whether pre-tertiary study, and particularly A-level, provided students with sufficient opportunities to develop skills required for learning in higher education. These ideas were considered by academics, pre-tertiary teachers, and students themselves, and were also mentioned by other stakeholder groups occasionally. There was a mixture of concern about whether students were adequately equipped with appropriate skills for entry to higher education, and also a desire to support students in developing these skills, with the latter being particularly evident amongst pre-tertiary educators:

*“Very useful for discussing key skills and attributes the HEIs want learners who are progressing to have – we can embed this further into our curriculum and teaching practices (reinforces our current aims and objectives within the department)” (Biosciences teacher).*

*“The need for HE learners to develop critical thinking skills. The importance of essay writing for those learners entering science degrees” (Biosciences delegate).*

*“The importance of reading around a subject and doing extra research to help my studies and not just relying on my teachers and textbooks for the important information” (Geography student).*

*“Read more! Question more and be open to ideas. Quality of written communication is something we all need to work on in preparation for university” (Geography student).*

*“Importance of study skills and independent learning” (Chemistry delegate).*

*“That I really need to improve how I teach evaluation skills” (Psychology teacher).*

*“Thinking more broadly about independent study and what that actually means” (Psychology delegate).*

*“...students have no experience of extended writing which is required at university” (post-event email regarding Astronomy transitions).*

*“Gap between A-levels and universities in terms of essay writing, research skills and independent learning” (Geography delegate).*

*“There is felt to be a poorer standard of problem-solving skills, and an inability to write ‘scientifically’ – new students seem to struggle to appreciate their audience when writing, and have significant problems converting a physical problem into mathematical terms” (Astronomy post-event report).*

*“Weakness in IT, resilience as learners, practical skills” (Chemistry delegate).*

There was general agreement across STEM disciplines, with a particularly strong emphasis in Geography, that perceived skills gaps observed by academics were largely the result of differences in the teaching styles and methods used at pre-tertiary level in comparison to universities. In addition, there was a view from delegates that pre-tertiary teaching is much more constrained and restricted than university teaching, with a strong drive towards students learning for assessment. This is reinforced by a requirement of pre-tertiary teachers to deliver high achievement rates to contribute to their institution’s league table position, and strong pressure around this from their managers, from students and from parents (both of whom are motivated by a need for the student to succeed in order to progress, for example into the ‘best’ universities). This is perceived to encourage students to maintain an assessment focus on entering university, whereas university lecturers would like to encourage a stronger emphasis on learning.

*“It was reassuring to learn that other Mathematics lecturers are experiencing the same problems that I have experienced regarding students being ill-equipped for study at university, and being exclusively focused on assessment rather than their education” (MSOR academic).*

*“I have a better understanding of the student mentality towards past papers and example problems. I know what they are expecting now and I hope to better address this in my teaching” (MSOR academic).*

*“The need to continue to challenge ‘teaching to the test’ at A-level” (MSOR academic).*

*“A clearer understanding of the tensions between teaching at A-level and undergraduate” (Geography delegate).*

*“A greater understanding of the contrasting styles of teaching and learning in schools and universities” (Geography delegate).*

*“I don’t think school teaching staff will ever fully understand how university life and teaching is different until they meet with and engage in dialogue with lecturers” (Geography academic).*

*“The differences between school and uni approaches to teaching and the potential impacts that these may have for our new students” (Geography academic).*

*“I did learn a lot about the differences in studying Maths at A-level and UG level” (MSOR delegate).*

*“It’s not just the Maths that is different, the way you learn it is too” (MSOR academic).*

However, some pre-tertiary teachers do not see supporting students in passing their exams as being mutually exclusive to developing the sorts of skills the students will need in preparation for higher education:

*“Looking at ways to encourage my sixth form college colleagues to better prepare students for HE (and in the process prepare them well for exams)” (MSOR teacher).*

*“I am looking at ways to marry together the demands of exam success and readiness for undergrad study” (Psychology teacher).*

As can be seen from these quotes, similar skills were raised across the different STEM disciplines: writing skills (mentioned in Biosciences, Geography, Psychology and Physical Sciences, but not in MSOR, Built Environment, Computing, or Engineering), mathematical skills, critical thinking, time management, and independent learning were frequently mentioned. A sub-theme was also noticed in which delegates questioned whether pre-tertiary education might actually inhibit the development of important skills for higher education transition. Comments were also made regarding new undergraduate students’ lack of skills in relation to referencing and academic integrity, with plagiarism and collusion being mentioned relatively frequently as problem behaviours seen in newly-entering undergraduates:

*“The fact that secondary teaching discourages note-taking whilst HE wants this ability from a student. Teaching methods are very different and set up problems for students transferring to HE” (Geography academic).*

*“It was noted that it is not the practice for schools to allow note taking in lessons as this is criticised by Ofsted inspectors” (Geography delegate).*

*“Sixth forms should include didactic teaching in their delivery, to prepare students for HE” (Psychology academic).*

*“New students are found to have little or no experience of referencing research articles etc., and generally have quite weak research skills (being heavily reliant on Google searches). There does not seem to be any ‘standard’ referencing system taught in schools...It was unanimously agreed that new students struggled with plagiarism and collusion when they arrived at university, and that this was also seen at school level” (Astronomy post-event report).*

*“Students learning in a certain way at school which then has to be unlearned” (Chemistry delegate).*

Some pre-tertiary teachers felt that better understanding of the ways in which their subject was taught at university would help them to incorporate similar methods into the pre-tertiary classroom, to familiarise students, equip them with some of the necessary skills and prepare them for transition:

*“It would be nice to see how universities teach computing so that A-level teachers can adapt their teaching so the students are used to the style of teaching and therefore won’t be a big jump when they go to university” (Computing teacher).*

Language skills, of course, do not just comprise writing skills, but include reading, comprehension and use of technical terminology. There was some suggestion that this was an important consideration for supporting student transition. In Wales, concern was expressed on behalf of students who received pre-tertiary education in the medium of Welsh, and the extent to which these students were prepared for English-medium learning at university:

*“I am currently working on a transition project to aid our Welsh-speaking students in their transition from Welsh medium education to the English medium medical degree” (Biosciences teacher).*

Perhaps unsurprisingly given the nature of STEM subjects, practical skills were a matter of frequent comment by many delegates across the STEM disciplines. In particular, the absence of (or removal of) practical coursework from some A-level specifications was bemoaned, particularly by some academics, and especially in Physical Sciences and Psychology:

*“Little lab work and no formal lab report writing” (Astronomy academic).*

*Confidence including that related to laboratory skills” (post-event email from Chemistry organiser).*

*“The need for order of magnitude thinking and real practical investigative skills” (Astronomy delegate).*

*“The disappearance of coursework (no more learning by doing) might mean that we get students with an even narrower set of skills and a very superficial and abstract knowledge of the discipline” (Psychology academic).*

*“A better understanding of the (lack of) practical work as a part of A-level Psychology” (Psychology academic).*

Although this viewpoint was expressed most by academics, teachers also recognised that pre-tertiary coursework and practical work provided their students with opportunities to develop useful skills for transition to higher education:

*“That the threat to practical science work for school students is being taken seriously by teachers and HE lecturers alike” (Astronomy delegate).*

*“The idea that practical work within A-level psychology is important to aid the transition to university” (Psychology teacher).*

*“With the planned decrease of practical work components at A-level in future, this problem is likely to become worse. Both teachers and university staff are concerned by the apparent loss of practical work and the associated skills sets that are developed in school. This is already apparent at university level, with students struggling to successfully complete practical work at undergraduate level” (Astronomy post-event report).*

However, it was recognised that incorporation of practical work into the pre-tertiary classroom takes time, which is sometimes not available to teachers, and also requires adequate laboratory resourcing, which is also problematic:

*“Time constraints on experimentation in schools” (Geography teacher).*

*“A lack of equipment in schools means that students have often only seen demonstrations of experiments, rather than actually participating in them...Practical work is clearly becoming a significant issue – it is unclear how this can be addressed, given significant infrastructure problems in many schools” (Astronomy post-event report).*

Some delegates were keen to point out that their particular discipline areas provide useful ways of developing practical learning opportunities in schools:

*“Construction and built environment provides a really good vehicle for carrying out experiential learning in schools” (Built Environment post-event report).*

The perceived lack of practical and active learning opportunities for students during pre-tertiary education was also considered detrimental for later independent, student-led learning, with some students adopting passive learning styles that persisted well into their higher education experience:

*“It is difficult to get students out of the mind-set that learning is only a case of turning up to class and listening, something that persists up to the final year for some degree students” (Geography post-event report).*

Mathematical and statistical skills were also subject to frequent comments from delegates across the STEM disciplines. In particular, students who may be mathematically competent were seen to struggle to apply these skills in the context of their undergraduate study, and some students were also thought to be lacking in skills and confidence when working mathematically:

*“Many have not studied Maths since I 6, and quite a few suffer from a lack of basic skills, confidence, and even very real anxiety. [Professional body] requirements mean that most students will study at least four or five modules with a statistical focus, and students have to pass each of these in order to progress in their course – so this is a big part of the retention/success issue for Psychology” (post-event email from Psychology event organiser).*

*“This inability to break a problem down into manageable, mathematical terminology is reflected in a lack of ‘thinking like a scientist’, with students often unable to undertake ‘order of magnitude’ estimates, or to assess uncertainties or sources of error” (Astronomy post-event report).*

*“Ideas about Maths education in Astronomy degrees, and school curriculum” (Astronomy delegate).*

*“While astronomy students are required to have A-levels in Maths and Physics, it was felt that the conceptual links between the subjects were often absent, and that differences in terminology between Maths in school and Physics in university were particularly difficult...It was felt that students were unprepared for the amount of Maths required of them at university level in Physics and Astronomy courses” (Astronomy post-event report).*

*“University departments should make the volume and level of Maths clearer to applicants, and consider more ‘catch-up’ Maths courses in the first term” (Astronomy post-event report).*

In MSOR disciplines, Further Maths qualifications were considered important and relevant to transition:

*“I am now more enthusiastic to become involved in the Further Maths programme and will look into how this may help the transition process” (MSOR delegate).*

*“I work with Further Maths Support Programme Wales and am interested in the issues of transition as Further Maths qualifications contribute a lot to smooth transition from school to university levels” (MSOR delegate).*

*“More promotion of Further Maths to aid transition...and promote the benefits of Further Maths to helping the transition to degree” (MSOR delegate).*

Despite the almost universal acknowledgement of different emphases in pre-tertiary and higher education, however, an alternative perspective was presented, relating to the possible cause of the skills gap, and the possible solution. It is proposed that students may acquire relevant skills at school, but then forget them prior to entering university; this is a different explanation than that given above, where students are perceived not to have acquired them in the first place. In contrast, however, the concept of students needing to ‘unlearn’ school education is also mentioned, but in this case the solution is seen as needing to come from the higher education sector, in terms of supporting student progression to bridge the gap, rather than through a change on the part of schools:

*“So is there a mismatch between what universities want and what schools provide? Interestingly not. Schools provide the basics, lay the foundations as it were, however, we come back to the perennial problem of student skills retention and often the default position students assume of relying on A-level knowledge instead of ‘unlearning’ and moving forwards to the next level. This is a problem universities need to address in the first semester of study” (Geography post-event report).*

Likewise, there was a recognition from some delegates that pre-tertiary education was not intended solely as a progression route into higher education, particularly within a single discipline, and that a student taking, for example, a particular subject at A-level, may not need to be prepared to study that subject within higher education. The diversity of exit opportunities from pre-tertiary education makes it difficult and maybe even inappropriate to tailor pre-tertiary education precisely to the needs of higher education. In this context, the assessment focus of pre-tertiary education is seen as pragmatic, rather than problematic:

*“...a university education was not the only outcome of A-levels, so the curriculum could not be adjusted solely on this basis” (Astronomy post-event report).*

*“Interesting to hear that the ‘secondary schools’ are not preparing the students, surely the secondary schools are measured on exam results and not preparation for university and the students are being taught to just to pass exams” (Biosciences delegate).*

It is noticeable that the majority of delegates who mentioned skills-related issues referred to them in terms of a skills deficit or gap within students entering university. However, a less popular view, that some skills had in fact improved, was expressed too:

*“The flip-side of this is that it is felt that many ‘non-practical’ skills (i.e. IT, programming, presentational skills) were much better now than in the past” (Astronomy post-event report).*

In fact, being skilled and competent in itself was perceived as sometimes challenging students making the transition to higher education, as able students may not be sufficiently prepared for the ‘stretch’ that they will experience at undergraduate level:

*“It was generally agreed that ‘more able’ students were not used to having to work hard, having not been stretched at A-level previously. As with students who struggled with the Maths content, it was felt that some form of transitional support period might help ease students into the university system, rather than the sudden step-change that they currently experience” (Astronomy post-event report).*

To some extent, the development of skills throughout the student learning journey, from pre-tertiary education into higher education and out into employment, was associated with the development of a sort of professional identity, and learning to “think like” a professional in that particular discipline area:

*“The need to think like an astronomer at university”* (post-event email from Astronomy organiser).

Delegates also recognised that students did not only learn skills in a linear way, within a subject, a pre-tertiary level, but that they brought with them skills and knowledge from earlier school experiences and from interdisciplinary learning which could be transferred into undergraduate level study. However, it was also recognised that students sometimes struggled to transfer their learning from different elements of their pre-tertiary education into higher education, and to see how and where these were relevant, partly because interdisciplinary learning was rarely linked for them:

*“It was noted by all groups that students struggled to break free of the compartmentalisation that develops at A-level, and thus struggled to integrate their Physics and Maths when dealing with problem-solving at university level. There was felt to be a lack of co-ordination within schools, between Physics and Maths in particular, with differences in the terminology, symbols, etc used, and no attempt to cover similar topics ‘in synch’ with each other. Students were thus unable to identify the tools that they had available to deal with various problems, and it was generally felt that they needed to develop a more synoptic approach”* (Astronomy post-event report).

In addition to being prepared in terms of skills for their transition to university, some delegates discussed ideas relating to students’ emotional and personal preparation for transition. An aspect of transition that emerged strongly from the Chemistry events, but was less evident in other disciplines (although it was mentioned in Engineering, MSOR and Psychology) was a need for student resilience, the development of confidence, and discussion of the emotional and personal impact of transition on the student experience. In Engineering, this has been so well recognised at one university that they have developed a psychologically supportive approach to teaching new students:

*“Better understanding of range of student feelings on arrival at university”* (MSOR academic).

*“Will keep promoting methods to promote more resilient, independent students but am faced with quite a broad spread of ability in my A-level sets, differentiation more important than normal A-level Chem)”* (Chemistry teacher).

*“There’s a significant gap in the understanding among sixth formers of university life and its social, intellectual and emotional demands”* (Psychology academic).

*“...outlined the ideas presently being used at the [University] Chemical Engineering department to alleviate some of the pressure experienced by first year students in their transition from A-level to university level work. The work operates through an understanding of the experience of the students prior to their arrival and uses psychological aids to help generate a positive learning environment in a shorter time frame whilst additionally boosting students’ confidence in new material through association with material studied.”* (Engineering post-event report).

Student difficulties in adjusting psychologically to the transition to higher education were also thought to be exacerbated by differences between the teaching environments across the two sectors. Class sizes in Engineering, MSOR and Computing were commented upon in this context, although it was also noted that at least one university is dealing with this by taking steps to offer more small group teaching in first year:

*“Coping with large groups and small class sizes, and basically, how do you learn?”* (Engineering delegate).

*“...divide the cohort into groups of 30 (they run each class three, four, five times a week depending on the size of the cohort)”* (post-event email sent by Engineering organiser).

*“I was not aware that most unis have no small group tutorials but that 20 was perhaps the lowest class size, and many are much higher than this”* (MSOR teacher).

*“...this does not solve the problem that many students feel completely out of their depth and isolated in huge classes”* (post-event email from organiser who attended both Computing and Engineering events).

#### 4.4 Awareness, communication and transition from pre-tertiary to higher education curricula in STEM

Many delegates from different STEM disciplines drew attention in their responses to ways in which pre-tertiary curricula, beyond just learning and teaching styles, impacted upon students' transition experiences. Academic delegates seemed to be largely unaware of the content of pre-tertiary curricula in their discipline in the UK. It is perhaps worth noting that academics frequently talked about “the” pre-tertiary curriculum, demonstrating a lack of awareness of the diversity of pre-tertiary curricula offered even within the UK:

*“Despite working with schools a great deal, I learnt some very interesting things about what A-level Physics students do and don't do as part of their courses these days... We need to talk to A-level science/Maths teachers far more, and to the incoming students, to find out what they (should) know – not make assumptions based on what we think is the case”* (Astronomy academic).

*“An insight into the issues schools and FE colleges face, and a greater understanding of what is taught to students at that level”* (Psychology academic).

*“Few, if any of them, had looked at the A-level curriculum”* (post-event email from organiser who attended the Computing and Engineering events).

*“The majority of academics are unfamiliar with what is being taught in schools in general and with the A-level syllabi in particular and many teachers are unfamiliar with what is being taught at degree level”* (Geography post-event report).

*“There is the fact that different exam boards require different skills and areas of knowledge which results in sixth form students going to universities with backgrounds of different learning experiences”* (Geography post-event report).

*“To see just how much of a ‘them and us’ situation exists between teachers of pre-tertiary and university lecturers. I was struck by how naïve some of the HE teachers were about the reality of teaching at A-level, resources, specifications, etc”* (Psychology teacher).

This lack of awareness was widespread, despite realisation that A-level curricula are easily accessible online.

Discipline-specific issues were also evident, with delegates appreciating the opportunity to learn about student transitions in the context of their own subject area, with people who were familiar with the same curricular issues:

*“Now have a better understanding of the issues relating to transition into HE study specific to Maths”* (MSOR delegate).

At the majority of events, the mix of different stakeholder groups worked well, with a balance between academic staff, pre-tertiary teachers, and students, as well as a few representatives of other groups. In the few cases where pre-tertiary, and particularly school teachers, were under-represented, academics expressed disappointment about this, despite finding the events useful overall, showing the strength of their desire to find out more from the teachers about life in the pre-tertiary sector. There was a keenness from academics at the events to find ways to engage more with pre-tertiary teachers:

*“Would have liked to have seen more representatives from schools and FE colleges as it is crucial to appreciate the other point of view. An evening well spent”* (Biosciences academic).

*“Equally, as academics, it was also noted that it was difficult for universities to build links with local schools/colleges and teachers”* (Geography post-event report).

*“If time allows, I’d like to look for an opportunity to share teaching experiences with secondary teachers (eg exchange visits) to understand better where first year students are coming from” (Biosciences academic).*

*“We need to have better communication with the school teacher to help the students manage the transition” (Engineering academic).*

*“There were many excellent ideas (...). However, possibly the most valuable aspect was the opportunity to meet a range of practitioners (and get their contact details!). It does help to know which HE staff are interested in transition” (Psychology teacher).*

Academics were not alone in their lack of awareness of the pre-tertiary curricula, however; teachers were also uncertain about the nature of the curricula in relevant disciplines within higher education, and felt that they were to some extent cut off from what happens in higher education.

*“Details about what my students will encounter when starting a Maths degree when they leave us” (MSOR teacher).*

*“Find out how different HEIs organise first year undergraduate teaching and what support is available for students. Also to discuss what could help the transition and what schools could do to help” (MSOR delegate).*

*“Discussion at my table between teachers and lecturers – we had a number of small epiphanies as a result of sharing perspectives” (MSOR delegate).*

*“The detailed discussion and meeting with university staff to consider the different approaches to education” (MSOR delegate).*

*“Understanding gained from university perspective” (MSOR teacher).*

*“Teachers are unaware of what happens once their students leave for university, so better communication is definitely needed” (Astronomy delegate).*

*“There is a pressing call from the teachers to find out what universities want from our school students” (Geography teacher).*

Similarly to the academics (above) who said that they did not know how to make contact with schools and colleges, teachers expressed a view that it could be difficult to establish links with universities. Sharing information across the sectors, as well as within them, to raise awareness was a very welcome aspect of the tackling transition events, particularly for the MSOR, Geography and Psychology communities, so that the events were seen as both a networking and mutual learning opportunity for all the different stakeholder groups. There was enthusiasm among delegates for continued dialogue across the sectors:

*“It was very useful for school teachers to talk to university staff and vice-versa” (MSOR delegate).*

*The discussion began with the teachers (present) saying that they were unclear as to whom in HE they could approach and how they could go about it” (Geography post-event report).*

*“Contacts with the university so I can get training on what university students study and what the demands of a degree are today” (Geography teacher).*

*“Having made contact with university staff, I am going to maintain this contact” (MSOR delegate).*

*“It has encouraged me to be more proactive in establishing links with universities” (Psychology teacher).*

*“Those teaching psychology across the different education systems need to get better at talking to one another” (post-event blog by Psychology academic).*

An exam board representative was also interested to find out more about curricula in higher education:

*“Something more about HE and the fact that they work with assessment objectives right through to level six” (Psychology exam board representative).*

In addition to valuing what they had learned at the tackling transition events through interacting with people across the different sectors, delegates also felt that there was a need for cross-sector interaction and

communication to include other stakeholder groups outside of education, and in Built Environment, many delegates indicated that employers should be involved in the ongoing dialogue:

*“Promote further liaison with interested parties”* (Biosciences delegate).

*“Details of contacts such as industry ambassadors and local course providers”* (Built Environment delegate).

*“Generate a database of schools and colleges teaching A-level Geography in the greater North Wales area... which will provide the basis for developing links between university and schools in the area”* (Geography post-event report).

*“Although I have already begun to make links with one university, I have been encouraged to further this link and to ensure that it is a meaningful relationship rather than a one-off event”* (Psychology teacher).

*“This needs more formal networking in the establishment of longer term partnerships between schools and employers”* (Built Environment post-event report).

It was deemed important that students contributed to this dialogic process, to ensure that their perspectives and experiences were understood, and that interventions were suitably designed with these in mind. Students themselves were strong advocates of this view, although teachers and academics were also in agreement, especially in Psychology and Geography, where there was considerable student engagement in the events. Undergraduate and postgraduate students also felt that they had a role to play in talking to pre-tertiary students prior to their arrival at university, and pre-tertiary students could see this becoming worthwhile after making the transition into higher education:

*“Examining the student experience during the first term and identify the issues that the students encounter from their perspectives”* (Biosciences delegate).

*“Get student opinion, what would they feel would improve their prospects with following computing and ask former students about their experience and their transition, gives extra perspective”* (Computing student).

*“I wanted to help out with the event as when I applied for university there was not much information about the transition into HE and what to expect so I wanted to help others who are in the same situation as I was to improve their transition and make the most of their resources available”* (Geography undergraduate).

*“Insights from current students as to the differences between school and university”* (Chemistry delegate).

*“I enjoyed talking to the sixth former on our table who gave me a good idea of what our students think/want”* (Psychology academic).

*“Act on the suggestions made by my ex-students on how to better prepare them for studying psychology at university”* (Psychology teacher).

*“Feedback to [teacher] about what would have been useful in preparation for uni”* (Psychology pre-tertiary student).

*“Look for past pupils to speak to prospective Mathematics students”* (MSOR teacher).

A number of delegates were keen to ensure that dialogue also took place within their own institutions, to raise awareness within their own teams and amongst their colleagues of transitional issues. Some planned to do this formally, while for others a more informal dissemination method was intended. Teacher trainers (such as PGCE providers within universities) hoped to ensure that the trainee teachers on their courses were informed about transitional issues:

*“I’m going to do a presentation to staff in the department”* (Engineering delegate).

*“The intention is that delegates will then be able to use this information to improve their own practice and cascade relevant details on to their own clients, for example work colleagues, young people, students or adults who may be considering construction as a career”* (Built Environment post-event report).

*“All information will be shared with my HE teams”* (Built Environment academic).

*“I also thought it would be useful to pass on any information to my students who will become future A-level Mathematics teachers” (MSOR teacher trainer).*

*“I am working with engagement staff in the University to look at effective ways of addressing this. I am sharing best practice...to address transition” (Biosciences academic).*

In addition, whilst lack of cross-sector awareness was generally agreed by delegates to be problematic, one delegate suggested that the challenges were particularly difficult for international staff working within the UK, where their understanding of the UK education system was understandably limited, thus making it even more difficult to gain insight into the student transitional experience:

*“As an international staff, I got a better idea about UK school education and high education system” (Engineering delegate).*

The HEA was perceived to have a role in supporting the dissemination and sharing of information and practice across the different sectors, and HEA resources and this report were said to be required urgently by Biosciences delegates:

*“This was felt to be an area where HEA...could really help, fostering more interaction between A-level and university first year studies” (Astronomy post-event report).*

*“It would be useful to receive more guidance from the HEA” (Biosciences academic).*

*“I appreciate that a report is going to be forthcoming from these sessions, but it would have been useful to have (at the end) a copy of any existing HEA publications regarding engagement with schools/HE transition” (Biosciences delegate).*

For those delegates who were, or became, aware of the nature of pre-tertiary curricula, there were some common matters of concern about ‘fitness for purpose’ as preparation for transition to HE. These concerns included particular comments about the Welsh Baccalaureate, as well as the more traditional A-level entry routes:

*“Sharing concerns about the Welsh Bacc” (MSOR teacher).*

*“That some HE staff feel that the current A-levels in Mathematics are not fit for purpose” (MSOR teacher).*

*“There were frank discussions on the causes of the transitional gap and many mixed conclusions were drawn, a large part was levelled at the ‘fit for purpose’ aspects of modern A-levels, another was the ‘market’ examination system encouraged by A-level examinations” (Engineering post-event report).*

However, whilst the majority of delegates talked about A-levels, and the vast majority of academics expressed concerns about pre-tertiary curricula, a single comment was made suggesting that International Baccalaureate provided a better preparation for students entering higher education with regard to time management skills, at least, and one delegate talked of a need to review the skills focus provided by Access courses. Extended Project Qualifications were also suggested to benefit students in terms of skills development in readiness for higher education:

*“Teachers find that students following the International Baccalaureate qualification often develop much stronger time management skills (probably as a result of a more open timetable, required development of such skills earlier than is typical with AS/A2). The current AS/A2 courses means that the teachers are more often responsible for time management aspects” (Astronomy post-event report).*

*“Review study skills units on Access courses and emphasise the need for critical thinking and analysis by Access students” (Biosciences teacher).*

*“...the usefulness of the Extended Project skill-based learning pre-University” (Astronomy delegate).*

Likewise, there may have been a somewhat nostalgic recall of earlier pre-tertiary curricula, and an implication that previous pre-tertiary courses provided better preparation for transition to higher education, as exemplified here:

*“Several people commented on the loss of the old Nuffield Physics course, which emphasised practical work and even included science comprehension activities which developed students science reading/writing skills” (Astronomy post-event report).*

Teachers were keen to help to address the perceived gaps in the pre-tertiary curriculum, especially where skills are considered, but they were also cautious about their ability to do so in a content-packed curriculum and in the context of examination board assessments that currently exist. In this sub-theme, there was some overlap with the discourse about student skills (presented in section 3.3), suggesting that issues of curriculum and skills may be inextricably linked. Academics, even when sympathetically recognising that teachers do not have the freedom to alter the pre-tertiary curriculum, are insistent that changes are needed, and some talk about a need for students to ‘unlearn’ their pre-tertiary education. Some delegates expressed this in terms of a need for different bodies to demonstrate joined-up thinking with regard to education throughout the whole student learning journey, to create better progressive development.

Running throughout delegates’ remarks about this sub-theme were strong indications that they perceived schools and colleges as being constrained, working to a prescriptive curriculum imposed by external bodies, whereas universities were perceived as having freedom and flexibility around what and how they teach and assess students. This was acknowledged by both teachers and academics, most strongly but not exclusively within Psychology and Geography. Teachers, in turn, called for those working in the higher education sector to communicate more clearly with them about what they wanted to see in their students when entering higher education:

*“Schools are constrained whereas universities are more flexible in teaching style” (Engineering delegate).*

*“...how can school and college teachers prepare students for undergraduate psychology when universities have greater freedom over what to teach and how to assess students? How can they prepare students for the kinds of learning activities they will experience at university...when there is seemingly less and less opportunity to deviate from an overloaded curriculum?” (Psychology blog written by an academic delegate after the event).*

*“As a sixth form teacher, I feel constrained by the pressures of value added and the demand for exam skills being taught at the expense of subject knowledge and critical thinking” (Psychology teacher).*

*“It was very useful to hear the constraints that school teachers are under in comparison to the relative flexibility in HE” (Psychology academic).*

*“They have seen schools as fostering ‘teacher-led’ teaching styles, using a single source of information in the form of a text book, rather than approaching the subject from different perspectives. In reply, teachers have argued that they are severely constrained by the National Curriculum, GCSE and A-level requirements. It is suggested that examination boards do not reward critical thinking but are looking for prescribed answers, and similarly the lack of emphasis on skills and processes is determined by the examinations. The amount of material required by examinations does not foster a ‘student led approach’. The National Curriculum is imposed on teachers and they are constrained by the availability of text books” (Geography post-event report).*

Some delegates framed this as an issue at the level of local educational authorities (for schools and colleges – although note that local educational authorities are now responsible for fewer schools than was previously the case) and government policy (for the UK education system as a whole), expressing frustration with the management of and political agenda for education:

*“That teachers of A-level Psychology, the HEA and the exam boards are aware of how different the teaching and learning is from what happens at university but feel the government’s agenda only widens the gap” (Psychology academic).*

*“Maybe universities should be working more with schools/students/teachers/Gov policy makers etc to advise on issues of transition/and align the educational pathway from primary, secondary to HE and Uni” (Biosciences delegate).*

*“Local authority? There needs to be a high-level body to tell headmasters that computing teachers need time and space for CPD” (Computing post-event report).*

Indeed, one delegate intended to raise the transitional issue directly with government:

*“I am hoping to reinforce some of the ideas when in the House of Commons on [date]” (Astronomy delegate).*

Running alongside the sub-theme relating to policy was a more specific view that the current consultations on A-level syllabi were crucial to support a smoother transitional experience for students, but also that consultation needed to be as wide as possible and to take into account skills delivery. These comments were especially prevalent in Geography, where one event included a presentation on the current A-level curriculum reforms:

*“The debate focused on the fact that there was...no focus on skills development that would make the transition to university, preparing and equipping students...It was agreed that there was a lack of a joined up process when it came to reviewing and revising Geography provision, and the agreement was that reviews need to not only look backwards to Key Stage Three and Four, but forwards to university-level Geography, but should also look sideways at subjects like Science where some core ‘geography’ concepts now appear to be taught” (Geography post-event report).*

*“Due to the current work being carried out by myself and other awarding bodies on changes to the GCE specification in England and Wales (linked with HE demands) I felt that it was an opportunity to gain some insight into the concerns of both sides” (Psychology exam board representative).*

In Geography, comments relating to A-level reform were closely associated with similar discourse around the QAA subject benchmark review for Geography in higher education, although this was felt to have been more appropriately focused on skills for transition, in contrast to the A-level review which delegates implied was overly focused on content:

*“Interestingly, the QAA Benchmark committee, who have different objectives to the A-level reform group, have seen to redefine the core areas of Geography...and their focus reflects skills” (Geography post-event report).*

*“Everyone agreed that the skills focus identified by the QAA Benchmark statements for university level study was equally important at A-level stage. At this point in the process of reform, it was agreed it was difficult to second guess what would eventually happen with the syllabus content. Teachers were keen to focus on the skills aspect to help with transition” (Geography post-event report).*

There was also consensus that professional bodies needed to be involved in curriculum reforms at all levels, but again this needed to be through wide consultation, rather than imposed upon the educational communities:

*“Managing the expectations of...professional bodies who wish to influence our syllabi” (Engineering academic).*

*“This was felt to be an area where...e.g. [professional body] and [professional body] could really help, fostering more interaction between A-level and university first year studies” (Astronomy post-event report)*

The transition from pre-tertiary curricula to those in higher education is also influenced by student expectations around their subject of study at university. Successful transition requires students to adapt their understanding of the nature of their chosen academic discipline; there appears to be a mismatch in terms of the way that STEM subjects are presented during the pre-tertiary phase compared to within higher education as a whole. This is related to the academic content, rather than being simply a matter of skills, as discussed above, although there is some degree of overlap. Thus a number of comments from delegates related to the understanding of students of the subject of study, and their expectations about what it would be like at

university. It was suggested that students' expectations were changing, and that there needed to be better communication to students during both pre-tertiary education and upon entry into higher education. This theme was particularly prevalent in MSOR, Engineering and Psychology, but was also mentioned in Biosciences:

*"...teacher colleagues to prepare their students academically in that we can do more to explain what uni Maths really is"* (MSOR delegate).

*"Try to be more proactive in discussing with sixth form students about what Maths at university will be like"* (MSOR teacher).

*"Communicate with students more effectively as to our expectations of them when they arrive at university and develop and encourage their skills in independent learning"* (Engineering academic).

*"Managing student expectations, tell them what we expect of them... What do students actually understand on entry to university?"* (Engineering delegate).

*"Involved in teaching students and realised that this is becoming more of a problem as more students attend university with different expectations"* (Biosciences academic).

*"Making the 'science' aspect clearer when 'selling' the subject"* (Psychology teacher).

*"Students can often not understand what the subject will involve at university, especially the statistics aspect"* (Psychology publisher).

For some delegates, particularly pre-tertiary teachers, the university entrance processes (including through UCAS) were relevant to the discussion of curricular transitions. Teachers wanted to understand better the ways in which universities applied admissions criteria, to support their students to gain access to higher education, especially in Chemistry:

*"More specific guidance for A-level students on what will help them receive an offer"* (Chemistry teacher).

*"How universities look at student applications to decide who may receive an offer"* (Chemistry teacher).

*"UCAS applications, personal statements and what should be disclosed"* (Chemistry teacher).

More significantly, however, there were quite extensive comments around the issue of appropriate subjects of study prior to commencing an undergraduate degree in a particular discipline area. This was particularly apparent amongst STEM disciplines where there is not a clear progression pathway (e.g. in Psychology, where most universities do not specify particular pre-tertiary subjects as pre-requisites, and subjects like Astronomy and Engineering, where, although there are clearly related subjects, such as Physics and Maths, students do not usually have the opportunity to study their chosen discipline to any great extent at pre-tertiary level, although some pre-tertiary qualifications do exist and are delivered in some institutions).

This has meant that some students have prior knowledge of the discipline as it is presented through pre-tertiary curricula, whilst others do not, and this has consequences for higher education curriculum delivery that has the potential to impact negatively on both types of student. This was particularly problematic in Psychology, where students may have had no prior exposure whatsoever to the subject, whereas others may have studied it at AS or A-level (or equivalent), creating some unique challenges related to diversity of prior learning around transition within Psychology. In other disciplines for which transition is not a straightforward progression from pre-tertiary qualifications to higher education qualifications in the same discipline, it will usually be the case that the majority of students will share a similar lack of subject-specific experience, and the early part of the higher education curriculum will be devoted to supporting their transition into a novel area. This situation contrasts starkly with the situation in the Built Environment disciplines, where many students enter higher education via vocational learning routes, and thus have previous experience of studying their subject in an applied context. This might explain why this issue was not raised at all in Built Environment:

*"Approx 58.5% of Psychology UGs have Psychology level three qualifications (eg A-level) and no university requires it – this has two implications: a) Many students don't know what to expect in a Psychology degree, in particular around statistical, biological and other 'scientific' content, and are simply*

not prepared for it; b) Universities teach first years in a way that presumes no prior knowledge – so those who have done level three qualifications can get bored and complacent” (post-event email regarding Psychology event).

“Now understand that one of the major problems in Psychology transition is the fact that universities don’t require A-level Psychology as a pre-requisite for the course – and are unlikely ever to do so” (Psychology publisher).

“Prior knowledge of astronomy is not assumed – very few students arrive with more than a minimal level (typically gained in a single optional module at AS/A2-level, the actual content varying with the particular syllabus followed) – general Physics/Maths/IT skills are considered more important, with astronomical knowledge being gained throughout the university course” (Astronomy post-event report).

Even where there is a clear progression route within a discipline, the diversity of pre-tertiary curricula means that the academic curricula can never fully take students’ prior learning into account:

“There is the fact that different exam boards require different skills and areas of knowledge which results in sixth form students going to universities with backgrounds of different learning experiences” (Geography post-event report).

“Students come to undergraduate psychology from diverse educational backgrounds. Furthermore, there are a number of A-level exam boards (...) with different syllabi. Even if HE lecturers were familiar with all syllabi, 40% of psychology undergraduates haven’t studied psychology before... So how can you create first year modules that don’t confuse some students and bore others?” (Psychology blog written after the event by an academic delegate).

Nevertheless, taking account of prior learning was considered desirable within higher education curricula:

“Easing the transition is best helped by building on past material learned at school” (Engineering delegate).

“Making connections with what the students know already before taking them further on – this makes them feel more at ease and confident to progress” (Engineering academic).

Delegates at the tackling transition in STEM disciplines events were exceptionally clear about their feelings that there is currently insufficient awareness of differences across the sectors, particularly around curricular issues. This has issues for both sides of the transitional divide – for teachers, it means preparing students for a future that they do not understand, and for academics, it means developing and delivering university curricula without taking into account the prior learning of their students. There are clear links here between curricula and skills, too, with a perception from delegates that the prescribed focus on large amounts of content within the pre-tertiary curricula did not facilitate skills development as required for study in higher education. The enthusiasm of delegates for ongoing dialogue and interaction between different groups of stakeholders and across the sectors cannot be over-estimated; this was a theme from all discipline communities, from the youngest pre-tertiary students through to the most senior academics. It has implications for the HEA, and for professional and subject-related bodies, who are seen as best placed to facilitate this ongoing collaboration and sharing of knowledge and practice. Educational policy makers and organisations with oversight of quality in the pre-tertiary and higher education sectors are also seen as necessary participants in the discussion. However, the most important perspectives appear to be those of students themselves, who, having experienced transition first hand, are perfectly positioned both to inform the discussion amongst educators, but also to help to inform their pre-tertiary peers about what to expect and how to prepare for the transition to higher education in a particular discipline area.

## 4.5 Change and collaborative initiatives to ease transition in STEM

Consistent with the ideas discussed around awareness and communication (section 3.4), the final theme identified from the data related to delegates' action plans in terms of moving forwards into the future and to proactively tackle transition. This was an important objective for the events and the overall project, so it is not surprising that it emerges clearly from the delegates' comments. However, the variety of ideas, the level of commitment to change and collaborative working, and the enthusiasm they display is quite striking even in this context, and was clearly in existence across all STEM disciplines and in all stakeholder groups.

A key feature of delegates' comments on this topic focused on the need for what might be termed 'two-way traffic' of both staff and students between pre-tertiary and higher education institutions, built upon strengthened relationships between institutions within the same regional area. Some ideas were highly practical, some were based on existing good practice, and others were more innovative in their nature, needing to be piloted, discussed, and explored more thoroughly before being rolled out. Some were expressed in less specific terms, and simply communicated a desire and commitment to work collaboratively:

*"Academics could offer guest lectures/workshops for students on their areas of research – could there be a central database where academics could register their topics of interest and availability – check out STEMNET... Take students to schools to answer pupils' questions... create a forum between HEI and local schools – for pupils/students or teachers/academics... teachers to attend lectures as students to give them a feel for what level we expect first years to be at... invite A-level students to sit in on a first year lecture... University staff invited to a school to talk about up to date research relevant to the A-level curriculum – may work as a conference, it would certainly be more scalable"* (Computing post-event report).

*"Mentoring – prior to attending, summer schools to aid transition, school outreach activities (universities linking with schools to support National Curriculum/sharing teaching and learning), [University] working with secondary schools to understand the education system that students have been educated in to A-level"* (Biosciences delegate).

*"If time allows, I'd like to look for an opportunity to share teaching experiences with secondary teachers (eg exchange visits) to understand better where first year students are coming from"* (Biosciences academic).

*"Gaining commitment from FE college and school staff to take part in an annual meeting at the University to discuss transition issues"* (MSOR academic).

*"I would like to try and facilitate better communications between school teachers and university lecturers, as that seems like a vital step in addressing the various issues that were raised"* (Astronomy delegate).

*"A college-university collaborative conference"* (Psychology delegate).

*"University students could take their dissertation work into schools to show students and teachers their work on particular topics"* (Geography post-event report).

*"Our ideas were that research methods and statistics training could be co-delivered by FE and HE lecturers, we could host joint conferences where students present their work..."* (post-event blog by Psychology academic).

A case study of particularly good practice was well received by delegates at an Engineering event and made particularly effective use of collaborative working across the sectors:

*"[University] (Engineering) have an innovative solution which has had great results, they now have a tiny drop-out rate. They employ school teachers (A-level Physics/Chem/etc) to teach first years... They use language that first years are familiar with and they really use the whole year's teaching to 'tackle transition' – brilliant!"* (post-event email from Engineering event organiser).

In Built Environment, and to a lesser extent Geography and Astronomy, subject ambassadors were seen as being central to these processes:

*“Formal links between schools and the sector via construction ambassador visits...site visit for pupils and students would give them more opportunity to see the reality of the work...taster days to give people the opportunity to try out activities. The transitions event could be tailored for specific year groups in schools to be carried out across a day. Open days could be more hands on incorporating some form of experience. This would require collaborations between universities and employers that could be effective...the use of ambassadors who could come into schools and colleges and engage with staff as well as students...”* (Built Environment post-event report).

*“Explore the option of ambassadors coming into school to discuss careers and the different routes available”* (Built Environment, pre-tertiary teacher).

*“I will try to organise more opportunities for teachers to hear university lectures and will proactively introduce our geography ambassadors to schools”* (Geography academic).

It is important, however, that subject ambassadors are themselves aware of transitional issues:

*“I work with STEM ambassadors who go into schools and feel that they should be aware of the issues as they may help with bridging the gap between school and HE”* (Astronomy delegate).

*“To arrange for the training of Geography ambassadors and arrange for them to visit schools in the region”* (Geography subject association representative).

Some delegates went further and suggested that partnership and collaborative relationships would be fruitful in a much wider context, for example, including primary schools, employers, and others:

*“The [professional body] primary school was interesting – I am wondering if this is something we could suggest to schools to maybe run as part of their transition days for six into seven and work in collaboration with the [professional body] ie borrow resources/ideas”* (Built Environment delegate).

*“To develop links with local authorities”* (Geography teacher trainer).

These sorts of relationships were talked about in ways that implied long-term, sustainable interactions, mutual benefit, and needed to be “meaningful” and engaging in terms of the pre-tertiary students’ learning and transition, rather than “tokenistic” or motivated by the higher education providers’ need to recruit students or engage in outreach activity:

*“It has been reinforced that there is a mutual value in terms of striving for active engagement activities – sometimes it has felt like HEIs are trying to ‘tick a box’ in terms of engaging with us (widening access agenda) and that meetings have been promising but have often not produced fruitful outcomes for learners or my staff. We will be re-energising activities in this area asap!”* (Biosciences teacher).

*“The general agreement that it was necessary for universities to be proactive in reaching out to schools and in the process work out good strategies to help transition”* (MSOR delegate).

*“Communication between colleges and universities that are not principally focused on college students’ attendance of a university”* (Psychology delegate).

The enthusiasm for this sort of partnership working was tempered somewhat by recognition of workload issues and competing priorities in both the pre-tertiary and higher education sector, which for some delegates were perceived to be insurmountable:

*“Also reassured that HEIs are keen to foster the links we are trying to develop and that they are suffering the same constraints and restrictions we (in FE) are facing (time for staff to do these activities, logistics of organising etc)”* (Biosciences teacher).

*“I say ‘yes’ – but the ways we have identified to implement change (more effective use of teaching teams especially in year one) are very hard to implement with some academic staff whose priorities may not be teaching”* (Biosciences academic).

*“Ideas of creating partnerships with schools. Wish we had time to pursue this further and work out how we could achieve this practically”* (Geography academic).

*“The event introduced me to others...due to a high workload I feel that it is very difficult in the HE sector to do any more to prepare them for Uni than we are doing at present” (MSOR academic).*

*“The Research Assessment Exercise has altered the balance between teaching and learning at universities; the continuous changing of the National Curriculum and the GCSE and AS/A2 specification has led to an erosion of time and human resources” (Geography post-event report).*

*“Emphasis on research in HE at the expense of pedagogy” (Geography teacher).*

The possibility of students supporting other students through the transitional experience was also raised frequently here, both once they arrived in higher education, and where possible across the sectors, although it was recognised that there were practical considerations that would need to be solved before this work could be widely implemented. A key message running through these quotes is that students who have gone through transition will be able to convey a better understanding of reality to their less experienced peers, to “tell them how it is”, and that perhaps they will be more credible messengers than staff:

*“The effort to link students and graduates back to their schools in some way, with them telling like it is at HE level, should get more support” (Geography delegate).*

*“Getting experienced students to help first years + facilitating students going into schools” (Engineering academic).*

*“University students to act as mentors for A-level students – needs careful monitoring – maybe use online discussion forum to supplement face- to-face time, could help students prepare for university – would they need CRB checks?” (Computing post-event report).*

*“Sending students back into schools (to tell them what it’s like)” (Engineering academic).*

*“I am pleased that university students from the [University] geography courses will be contacting schools and updating on progress” (Geography academic).*

*“It’s important to change younger people’s perceptions of site and professional roles. This could be done by using university or early career ambassadors and have them return to their own schools so that they can demonstrate real evidence of progression in a way that pupils can relate to” (Built Environment post-event report).*

Students also recognised the value of this, and were enthusiastic volunteers, offering their own time and effort to communicate with pre-tertiary students to help facilitate transition:

*“I believe in the future I will make a conscientious effort to try and relay something back to my school that will help ease the transition of their students to prospective education, be that through talks, presentations or even just organising a meeting with a representative from my university” (Geography student).*

*“I will present a lecture to Access students” (Psychology student).*

*“I will sign up to peer mentoring so I can use my knowledge of the transition from college to university to help guide others through the process” (Psychology student).*

*“Make more contacts with students and teachers before they come to university” (Psychology postgraduate student).*

Pre-tertiary students who attended a tackling transition event found talking to people from the higher education sector informative and enlightening, and were supportive of the idea of more communication to help them to prepare for the transition into higher education:

*“...I am a student currently looking forward to university life and talking to people who also attended the event opened my eyes to the world around me surrounding education” (Geography pre-tertiary student).*

*“I will communicate with other students at my sixth form and my teachers about the event” (Geography pre-tertiary student).*

Delegates from both the pre-tertiary and higher education sectors across a wide range of STEM disciplines were very keen on the idea of observation and shadowing of teaching in the opposite sector to find out about teaching and assessment practice and thus inform their own teaching to support students through transition:

*“The idea to go into a school and observe what happens in A-level teaching” (MSOR academic).*

*“It was a real eye-opener. Work shadowing would be really useful for both sectors” (Psychology teacher).*

*“Peer observation across the transition – teacher observing lecturer and lecturer observing teacher – sharing best practice swapping opportunity. There could be the possibility of doing a swap for one lesson/lecture between schools and universities. There could be a comparison of both teaching and assessment styles/modes” (Geography post-event report).*

*“Some form of ‘placement’ programme, allowing teachers to experience first year undergrad Physics courses (particularly practical work) , and a similar placement of university staff in schools to see what A2 students learnt (and how) would be very useful” (Astronomy post-event report).*

There was considerable enthusiasm for resources designed collaboratively by people from both sectors working within the same discipline areas, again with a view to supporting students through transition, but also to help pre-tertiary colleagues to access up-to-date, research-informed materials that would support students with both knowledge and skills appropriate for entry to higher education. A need was recognised to catalogue existing resources to further these aims. One delegate felt that it would be useful for academics to contribute to A-level text books, but was concerned that this was not recognised as appropriate scholarly activity within the university context, while an academic suggested that his writing for academic journals could be made more accessible to the pre-tertiary community, along with production of written materials specifically for pre-tertiary teachers:

*“Create a video showing what computing at university is like – these videos exists in other countries and on YouTube, do we just need to collate them? However a research video on uni courses could be useful, promoting breadth and depth of subject... Catalogue resources there are a lot, they are just hard to find” (Computing post-event report).*

*“Development of resources on common themes taught at A-level as well as during the first year of a degree course” (Computing exam board representative).*

*“There needs to be a certain amount of co-operation with sharing resources and teaching ideas between HE and schools so that the transition can be smoother. Possibly outreach from universities could be organised to support teachers” (MSOR delegate).*

*“An attempt by universities to look at the National Curriculum and specifications for Computing exams and produce resources/training/assistance for specific issues that teachers face” (Computing teacher)*

*“The need for Physics and Astronomy books aimed at 16-18 year olds” (Astronomy delegate).*

*“Academics could write/contribute to A-level textbooks but not recognised in REF” (Geography delegate).*

*“Regularly write in an accessible manner for both teachers and A-level students in the [named] magazine (available online) about geographical issues that have relevance to them. To publish in a pedagogic manner that is also accessible to Geography and Environment teachers of A-level” (Geography academic).*

Another practical step that was recommended by delegates to support pre-tertiary students transiting to higher education was to provide additional teaching in the discipline area, possibly over the summer gap between the end of pre-tertiary examinations and the start of undergraduate study. In Geography, it was suggested that this might go further than simple delivery, and provide a residential, immersive ‘taster’ experience for students, with a focus on field work:

*“On our table I found out of a specific transition project that was happening in [...] Sciences which I can investigate. This e-module makes sure that students do some pre-learning before they arrive” (Biosciences delegate).*

*“...pre-university top-up or refresher courses” (MSOR academic).*

*“Jointly developed summer schools that link to the A-level curriculum. There could be a Geography university life taster week. Different schools (Geography students only) stay in halls for approx. a week (?). It would also develop the social side. They would spend time doing fieldwork and research, lectures, library orientation, meeting lecturers and the use of resources other than textbooks. In the practical sessions, data could be generated and analysed. Another model could be a residential with students and university staff spending three days analysing fieldwork data. On a smaller scale it could be a practice day with groups coming in to follow a typical day of lectures and practicals getting students to use skills like note-taking” (Geography post-event report).*

*“This could be in the form of post-A-level exam courses, or through a booklet/website that detailed what would be required for university-level studies... This would cover key skills, Maths and Physics content, and also including information on referencing, research skills and plagiarism. Formulate a list of ‘required knowledge’, both subject-based and generic... Core prep reading (e.g. a basic history of astronomy to be done before arrival at university. ‘Crash course’ for new students – get them all to a similar level before starting the course content properly. Broad range of knowledge and skills, even with A\* students in Physics and Maths” (Astronomy post-event report).*

Other ideas from delegates included using technological and social media tools to enhance student learning and prepare students for transition to higher education. These interventions focused partly on providing academic information, partly on providing information for pre-tertiary teaching staff to use, and partly on providing students with pastoral-type preparation for higher education, by giving them an insight into university life. An added benefit of this approach was that it would help students to understand appropriate use of social media in an academic or professional context. Finally, social media was perceived as a way to influence perceptions of a particular discipline area, particularly in Built Environment:

*“The use of social media in providing support mechanisms for new students. Opportunities to ensure students understand the boundaries of and problems with social media” (Biosciences delegate).*

*“The use of social media, Twitter, Facebook etc together with more female ambassadors to work with pupils could foster a cultural shift” (Built Environment post-event report).*

*“Year 12 students could be texted by university students once a month so that they could see what being at university involved. There could be a Twitter feed with monthly updates and the use of social media to share ideas” (Geography post-event report).*

*“One particular aspect of interest to me is the role that social media and digital technologies can play in adapting to university study – we could connect psychology students in schools, colleges and universities via social networking platforms, and create opportunities for school and college students to join online undergraduate psychology teaching sessions via Blackboard Collaborate” (post-event blog by Psychology academic).*

In response to the challenges faced by schools and colleges in providing resources, time and laboratory space for students to engage in practical activities, and thus to develop practical and experimental skills through ‘hands-on’ learning, another popular suggestion was that universities might be able to provide access to labs and other facilities for local schools and colleges. This idea was warmly welcomed by pre-tertiary delegates, and enthusiastically offered by academic delegates:

*“That we can work in partnership with universities and use some of their facilities!” (Geography teacher).*

*“University space such as GIS labs and other specialist labs could be used by schools when the universities are not teaching. Schools find it difficult to fund GIS software” (Geography post-event report).*

*“...run ‘taster’ events for students to experience university lab facilities” (post-event blog by Psychology academic).*

*“Look into making connections with local universities, hoping to take a group in to carry out some practical experiments” (Psychology teacher).*

A further challenge faced by delegates from the pre-tertiary sector was that they sometimes found it difficult to access up-to-date information about academic research in the subject they were teaching, and to provide students with new knowledge. This difficulty was exacerbated by the fact that pre-tertiary textbooks rarely incorporated cutting edge or modern research. A number of colleagues, again from across a range of STEM disciplines, proposed solutions to this problem:

*“I would particularly like to make use of opportunities for my students to be participants in PhD student research”* (Psychology teacher).

*“A collaborative conference between students (A-level and undergraduate) teaching staff and university staff to share research ideas. There is a range of voices to be heard...”* (Geography delegate).

*“Pairing of teachers and lecturers to share current research (and to avoid textbook problems) and to develop new case studies. These pairs could develop teaching materials based on recent research. Use of technology, e.g. Twitter, to communicate between schools and university. This could be used as stepping stones to independent research eventually but could start as a forum for sharing ideas”* (Geography post-event report).

*“Other ideas centred on creating opportunities to participate in current research projects to give insight into undergraduate dissertation projects and what psychology looks like when it is applied”* (post-event blog by Psychology academic).

*“The idea of building links and being able to access academic knowledge was seen as crucial, thus something like a day of talks aimed at A-level students on the hot/new topics in Geography would be equally beneficial to the teachers that need to get up to speed on these areas”* (Geography post-event report).

*“Contact [People] from the [Department] regarding the possibility of third year students visiting the school to present their research, or to arrange for school pupils to visit the [Department]”* (Psychology teacher).

Many of the solutions proposed for supporting students through transition to higher education were novel and creative. However, there was also a desire among delegates to engage with and develop the evidence base through pedagogic research about transition:

*“Commission a study about why teachers are not engaging early enough in the new A-level curriculum”* (Computing academic).

*“I would be interested in a research project that investigates how students and their teachers can develop these skills”* (Chemistry delegate).

*“That there exist studies about entry-level Maths students”* (MSOR academic).

*“When researching student engagement, explore experiences of transition and identify particular difficulties. Aim to get students to suggest ideas to address these via roles of multiple parties. Generate ideas for facilitating contact with A-level students via the input of undergraduate Psychology students”* (Psychology academic).

Delegates also felt that there would be potential benefit in the delivery of professional development to pre-tertiary and trainee teachers in their discipline areas with information about student transition from pre-tertiary into higher education. There were two main issues here. Firstly, delegates were keen to see good graduates enter the teaching profession in their subjects, and new graduates from the relevant discipline area would have relatively recent experience of higher education study in that discipline. In addition, in some disciplines (especially those not typically taught pre-16 as part of the National Curriculum), pre-tertiary teacher training opportunities are relatively limited, meaning that some pre-tertiary teachers can be teaching subjects in which they are not specialists (e.g. Computing and Psychology). For these teachers, it was felt that universities could be supportive by providing subject-specific training. Working with trainee teachers, as well as with qualified teachers, would ensure that new teachers entering the profession would start their practice in a way that was supportive of transition. A novel suggestion was for academic staff to cover for teachers so that the teachers could get out of schools and colleges to attend training and development sessions. Whether this would work practically is questionable, particularly in schools where teachers need enhanced criminal records checks and to be qualified to teach a particular age group, but there would be advantages in terms of

exposing pre-tertiary students to higher education-style teaching and learning opportunities from a subject expert. The provision of professional development and training opportunities by higher education staff was welcomed by academics, teachers and teacher trainers:

*“Psychology has only been taught in school since September, and I am a non-specialist. Although I did do some topics in my Biological Sciences degree which linked to Psychology, I was worried that as a non-specialist I may ‘hold back’ students who want to go on from A-level to university level study. I wanted to know if there was anything else I could be doing to ensure these students would have a smooth transition”* (Psychology teacher).

*“[Person], teacher educator from [University] then reflected on the links between schools and universities from a PGCE perspective suggesting that PGCE students completed the circle of communication...An issue which needed to be considered being the need for PGCE trainees to have an holistic approach to the teaching of the subject after three years of undergraduate specialism”* (Geography post-event report).

*“University teachers who are subject experts working with student teachers – build links early”* (Computing academic).

In recognition of comments relating to student preparedness for higher education, and particularly around the ‘skills gap’ noted above (section 3.3), some pre-tertiary delegates explored ways of supporting students to prepare for transition by making changes to their own practice:

*“I will try to build some more report writing into schemes of work if/where appropriate”* (Maths/Science teacher at Engineering event).

*“To include report writing/Maths/research eg project for Materials Testing Unit at L3 BTEC”* (Maths/Science teacher at Engineering event).

*“Allow failure of practicals”* (Maths/Science teacher at Engineering event).

*“I also decided to talk to my department about how we can adjust our independent study assessments to allow for more investigative and independent learning (albeit through enrichment activities)”* (MSOR teacher).

For their part, academics across many STEM disciplines also committed to making changes to practice in higher education to support new students entering their programmes. These changes sometimes focused on providing information to students through induction and similar activities, and sometimes related more to delivery of teaching and assessment to make these processes more supportive and provide a more scaffolded experience for students. An interesting sub-set of these proposed changes considered who delivered first year teaching, alongside those suggesting what or how might be delivered:

*“Considering a team of individuals to deliver year one of the curriculum”* (Biosciences delegate).

*“Propose reorganisation of welcome meeting”* (Biosciences academic).

*“Will discuss the approach taken at [University] to use school teachers to integrate first years”* (Engineering academic).

*“It may be helpful to have more structured first year and then smooth transition to second and third year. It’s also important that all module convenors should be involved to this transition”* (Engineering academic).

*“Reduce coursework to allow students to take increased responsibility for their learning”* (Engineering academic).

*“Look at the content provided at the early weeks of year one, make it exciting but do not rush it”* (MSOR academic).

Some delegates identified organisations that were already working to establish collaboration and sharing across sectors, and suggested that these examples could inform future collaborative practices. Examples included:

- *Smallpeice Trust*, a charitable organisation that arranges workshops for students and teachers around STEM and particularly Engineering (Computing post-event report);
- *Computing At School* (Computing post-event report);
- *CITB* (Built Environment post-event report).
- *Geographical Association* (Geography post-event report).
- *Teacher Science Network* (Geography post-event report).

Clearly, the views expressed by delegates involved in the tackling transition events suggest that there is some existing practice within both the pre-tertiary and higher education sectors attempting to smooth the student transitional experience, but also that there is genuine enthusiasm, and some very creative ideas, to do more. Harnessing this enthusiasm and continuing to share good practice where it is already occurring seem to be high priorities for stakeholders from all disciplines and stages of the educational system.

## 5. Impact on transitional practices

Since the tackling transition in STEM events took place, some of the ideas that were generated have been put into practice, and communicated back to the event organisers. Reports have been positive. Two examples from Psychology are presented here; it is hoped that over the coming months, more information will be forthcoming from other disciplines.

### 5.1 Library day

*“[Person] from [School], and myself made a pledge on a postcard to organise a specific library-based session for lower sixth students. Well, we finally did it yesterday and we just wanted to let you know what happened! Whilst the day included the usual activities, such as a campus tour and info. about the Uni, we also put on a more specific Psychology session that was intended to do more than just be enthusiastic about what a great topic it is to study. Instead, we had a brief lecture and some computer-based exercises to show students how they could access original research articles without necessarily having to pay. In the sessions we looked briefly at the original text of both Sperry and Bandura, as well as using a free database to search for articles around a topic. This last part was specifically aligned to a task they were completing at school at the time, their psychology project. At the end the students left with a bit more insight into literature searching, what is available open access, and how to get at some of it. The hope is that this will not only help their Psychology project now, but improve their applications (if they say they've learnt how to search literature, or have read original articles that have inspired them), as well as equipping them a little better for that first year of uni where it becomes all the more important no matter what subject they eventually take. In terms of feedback, 95% of the students rated it as good or very good, with many commenting that for them it was the best part of the day which I guess has to be positive, especially given it was essentially just an informatics talk and we made them do some actual work! From a Uni side of things I also found it more rewarding as I felt they left with something tangible that would help them out now and in the future no matter what they studied, so a genuine attempt to aid that transition in terms of skills” (joint email from Psychology academic and Psychology teacher).*

This particular intervention offers solutions to problems experienced in schools and colleges when trying to access disciplinary research, as well as giving pre-tertiary students insight and practice in a skill set that will be important when entering higher education, and experience of higher education teaching methods and styles.

### 5.2 Academic and undergraduate student school visit

*“I was invited to [School] to give a talk to their Upper Sixth students. [Person] who teaches Psychology there and I met at the workshop in Brighton and she gave my details. I gave a 30 min talk on what they should expect academically when they arrive at University (title: transition to HE). One of our best students who is the Psychology Student Representative and leads the [University] Psychology Association, also talked to the students about what to expect in terms of accommodation, finance, friendships, roommates etc. She also discussed mental illness and drug abuse since she is a Residence Assistant for our Uni. I thought this combination of perspectives worked well and [Person] asked if we can present there annually. I will be emailing soon to touch base with them because they were discussing talking to their younger students who have not made University decisions yet” (email from Psychology academic).*

This visit appears to have allowed pre-tertiary students to gain some insight into both academic and pastoral issues that they may face when starting university, from both a staff and student perspective. The suggestion of annual visits, extended to include younger students, suggest that it was well received by the school, as well as being seen as a valuable exercise by the university representatives.

### 5.3 Potential benefits of collaborative interventions

Both of these reports suggest that collaborative work between pre-tertiary and higher education staff and students can be effective and rewarding for all those involved. The longer term benefits of such initiatives to tackle transition remain to be seen, but preliminary feedback certainly suggests that cross-sector working may be a valuable strategy to support pre-tertiary students to develop realistic expectations and better understanding, and to be informed and prepared for a variety of aspects of their transition into higher education.

## 6. Discussion

As discussed earlier, the qualitative methods used within this project involved an inductive approach to thematic analysis. As such, the views of delegates have been interpreted within section 5 without applying a theoretical lens. This section of the report will review the key themes identified within the qualitative data in the context of the research and policy literature, to allow theoretical consideration of the issues arising. This in turn will inform recommendations for STEM providers and the higher education sector (section 7).

### 6.1 Strategic importance of student transition into higher education in STEM

Delegates were agreed without exception that supporting students through transition into higher education was a strategic priority for everyone involved in education, and particularly for students themselves. Whilst this may be unsurprising, given that delegates were presumably interested in the topic before they came to the events, the strength of the consensus is notable, and is consistent with the recent wealth of literature relating to student transitions. For example, a Google Scholar search on 'student transition to higher education' produces over two million hits, and even narrowing the search to 'student transition to higher education UK' produces 387,000. The strategic importance of understanding, and supporting students through, transition as highlighted by these events is highly consistent with the national and global importance placed upon it in the literature.

There are likely to be several drivers that have produced this emphasis on student transitions within the sector. Firstly, the marketisation of higher education means that universities and colleges delivering higher education programmes are in competition with each other (e.g. Brennan and Shah, 2011). Retention and success are important performance indicators for universities, informing student choice and thus impacting upon university league tables, recruitment figures and ultimately university finances (Salmi and Saroyan, 2007; Hazelkorn, 2007; Hazelkorn, 2008); institutional managers are therefore understandably eager to prioritise enhancement of the transitional experience and thus retention and success, and this priority is very likely to be communicated to academics and other higher education staff. Students themselves, paying high fees for higher education, are also putting pressure onto institutions to support them well, through transition and beyond. However, commercial factors are not the only issues motivating the work on supporting student transition, nor are it the major factor. Teachers, academics, students and other stakeholders strongly expressed views suggesting a genuine interest in student progression, and in equipping students for a successful learning journey. Delegates at the tackling transition events across all of the STEM disciplines shared a common desire to put student support, student engagement and a positive student experience at the centre of their practice.

It was clear from delegates' comments that there is already good practice evident within the education system, with some delegates from a variety of stakeholder groups having job roles directly related to supporting students in making the transition into higher education. This appeared to be more common within higher education than in other groups, and it was evident that universities are already focusing considerable resources on tackling transition. However, there was also an enthusiasm for finding out about others' practice and sharing experiences, which suggests that perhaps existing practice may have arisen on an institution-by-institution basis, and that there may be benefits of facilitating greater sharing and collaboration, both within the higher education sector, and across the different educational sectors. This is consistent with Kitching and Hulme's (2013) suggestion that further collaboration between schools, colleges and universities is important for tackling transition.

## 6.2 The STEM student journey

A strongly emerging theme from the qualitative data in this study related to the concept of a student journey. The transition of students from pre-tertiary into higher education was sometimes expressed as just one step along this journey, which begins in primary school and potentially ends in old age. It was recognised that students make transitions before arriving at university, including the transition from primary to secondary school, and that they continue to make transitions after their undergraduate education is complete, for example into postgraduate education or training (Wakeling and Hampden-Thompson, 2013), teacher training or directly into employment, or later through changes of career.

There is a wealth of literature on early educational transfers and transitions (e.g. Green, 1997; Galton et al., 2000; Demetriou et al., 2000; West et al., 2010; Tobbell and O'Donnell, 2014). Within this literature, several aspects of transition are considered, including academic achievement, student expectations, and socio-cultural and psychosocial adjustment to the new educational context. Given that these were issues raised by delegates attending the tackling transition events that formed the basis for this project, further exploration of possible learning from early schooling experiences would seem worthwhile, particularly with regard to informing interventions to assist transition into and out of higher education (Winstone, 2014). It may also be possible for students themselves to reflect on earlier transitional experiences to inform their behaviours at subsequent transitional stages in their learning journeys.

The primary to secondary school transition has also been considered an important influence on students' continued engagement with STEM; Tytler et al. (2008) cite evidence that for many students, life aspirations are well formed by the age of 14, and that subsequent engagement in STEM is more challenging in later years. This has important consequences for the transition to higher education and into STEM careers, and implies that early engagement with STEM disciplines is vital for successful recruitment and transition into undergraduate study within these disciplines.

Student engagement with STEM education was recognised as important at national level, not just at a level personal to each student. Within the UK currently there is a widely and politically recognised need to increase the numbers of graduates with strong STEM skills (House of Lords Select Committee on Science and Technology, 2012). A similar need is evident within the European labour market (Joyce, 2014), Australia (Tytler et al., 2008) and in the United States (Atkinson and Mayo, 2010; Carnevale et al., 2011). In some of the STEM discipline areas, and particularly within Built Environment, this need was perceived as particularly urgent to meet the direct needs for skilled workers within the related industries. Again, this perception of need amongst delegates at the tackling transition events is consistent with reports in the literature (e.g. MacKenzie et al., 2010). It is apparent that delegates are in agreement with global and national policy in recognising the need to increase recruitment to their disciplines. Delegates themselves made several suggestions to further this agenda, including creating engaging experiences with their subject areas during formative school years, perhaps led by people from the higher education sector, including academics and students, and from industry. Many delegates also expressed enthusiasm about the idea of having discipline 'ambassadors', who would help to promote public engagement with STEM education and careers.

However, while it was considered important for STEM recruitment generally to increase, it was also clear that widening participation was also important, and gender issues were a matter of particular concern. Within Built Environment and Engineering, engaging more women was raised repeatedly. Again, this is consistent with the literature across several STEM discipline areas, where recruitment of women into STEM is often referred to as a 'leaky pipeline', with women being 'lost' increasingly as they progress further through the educational and employment journey, despite high-level interventions to attempt to redress the balance (Smith, 2011). For example, literature relating to low female uptake of STEM subjects can be found in Built Environment (Fielden et al., 2010), Computing (Sax, 2012), Engineering (Wallace and Sheldon, 2014), Mathematics (Boaler et al., 2011) and Physics (McCullough, 2004). In Biosciences, GEES and Psychology, recruitment of women into undergraduate level study is not problematic, and in fact women may be over-represented in these disciplines. The gender imbalance in different STEM subjects is perhaps most striking when considered in the context of national statistics for participation in higher education. In 2012-13, for example, approximately 55% of all UK

first-degree students were female (Universities UK, 2013). In Biosciences disciplines, this rose to over 60% of students being female (Universities UK, 2013), whereas in Engineering, the subject in which the lowest proportion of females participate, the figure fell to less than 20% (Universities UK, 2013). However, there may be a problem in terms of career progression even in disciplines that engage female students more extensively; for example, in Biosciences, only 15% of professors were women (Kirkup et al., 2010).

It may be that examples used in the classroom and in assessment serve to reinforce stereotypes of certain disciplines as more appropriate to males or females, and that educators at all levels may need to address this issue in order to address the balance of gender engagement within the STEM disciplines (McCullough, 2004). Indeed, gender stereotyping of STEM disciplines is a clear topic of interest in the literature (e.g. Barnard et al., 2010), and addressing these stereotypes may be an effective way to increase cross-gender participation in STEM disciplines at all levels (Nosek and Smyth, 2011).

### 6.3 Student preparedness for transition from pre-tertiary to higher education in STEM

A perceived skills gap was frequently mentioned by delegates at the tackling transition, with a view that students were not well-prepared for their transition to learning in higher education. Skills mentioned most often included practical skills, mathematical skills, writing skills, time management, critical thinking and independent learning. This is reflective of the 'deficiency model' reported in the pedagogic literature, whereby students are seen to be lacking in key skills that are involved in 'learning to learn' (Wingate, 2007). Wingate suggests that this model is unhelpful in supporting the student body in general, serving rather to remedy the problems of individual students, and that the apparent skills deficit is best addressed through a 'holistic, subject-specific approach' designed to support students by informing their understanding of what is expected of them at university, helping them to develop better understandings of learning and the learning process, and facilitating them in becoming independent learners who can construct knowledge in their discipline. The tackling transition delegates sometimes echoed this set of beliefs, identifying issues such as 'thinking like a' professional scientist, and developing learning skills that were progressively built upon throughout the undergraduate curriculum.

Delegates noted some strong contrasts between the pre-tertiary and higher education sectors in terms of the emphasis placed on different approaches to learning (strategic, assessment-focused and rote learning in pre-tertiary environments, and deeper, more intrinsically-motivated learning in universities) and on different approaches to teaching (smaller groups with more direction and personalisation in pre-tertiary classrooms, larger groups with less direction, more independent learning and less personalisation in higher education). These differences were seen as underpinning to a large extent the perceived skills deficits of students entering higher education, and delegates were keen to see steps taken both within the pre-tertiary and higher education sectors to support students in making the transition, with pre-tertiary teaching attempting to incorporate some approaches typical of higher education practice and vice versa. These types of issues are discussed by Yorke and Longden (2008), who argue that the mismatch of teaching approaches across the sectors is related to 'weakness in teaching quality' within higher education. In response, they suggest that, upon entry to university, students should be:

*"...quickly engaged in academic work and are given formative feedback from an early stage, so that they can begin to gain an appreciation of expectations and standards in a way that cannot be achieved by statements of learning outcomes and exhortations alone. Low levels of contact hours may initially be insufficient to motivate students to undertake the expected levels of independent study. There is a corollary: cost. However, if the stance is adopted (as it has been in some institutions) that the first year is critically important for student success, then at least four things follow:*

- *The allocation of resources has to reflect the importance of the first year (often the most favourable student/staff ratios are found in the final year by which time, if all has gone to plan, students should be demonstrating independence in learning);*

- *The teaching approach has to be focused on student development within the subject area(s) concerned;*
- *Ways need to be found to enhance the chances of students developing the supportive network of peers that can sustain them when difficulties arise (both phases of this study have pointed to the importance of friendship formation and, for some, unhappiness that this has not occurred);*
- *Those teaching first-year students should have a strong commitment to teaching and student learning.”*

(Yorke and Longden, 2008, p 47-48).

There is resonance here with the Vygotskian concept of scaffolding of learning (Vygotsky, 1978), whereby learners are facilitated in moving beyond their existing knowledge in small, structured and supported steps towards a new learning goal. Application of this concept within higher education, within a disciplinary context, particularly with first-year undergraduates, has been historically successful (e.g. Lonka and Ahola, 1995; Durkin and Main, 2002) and has also informed the increasingly popular practices of peer-supported learning and assessment (e.g. Topping, 1998, 2005) and problem-based learning (e.g. Harland, 2003; Norton, 2004). Adapting teaching within first-year undergraduate programmes to incorporate more scaffolded learning opportunities, including use of discipline-based skills tuition, peer learning and problem-based learning could be beneficial for supporting transition of students into STEM disciplines in higher education, and potentially bridging the gap between the different teaching and learning styles encountered at different stages of the student learning journey.

In addition to skills and learning approaches, delegates at the tackling transition events were also aware that students needed to make psychosocial adjustments when making the transition to university. Concepts such as resilience and confidence were noted to be of importance to making a successful transition. There is a wealth of psychological literature surrounding these concepts, but even just within the pedagogic literature focusing on higher education, there is considerable evidence suggesting that there may be positive correlations between resilience and confidence (or academic self-efficacy) and academic retention and success (e.g. Andrew, 1998; McKenzie and Schweitzer, 2001; Hutchison et al., 2006; Hartley, 2011). Macaskill and Denovan (2013) reported that a psycho-educational intervention designed to improve students confidence (including self-efficacy and self-esteem) not only increased confidence, but also increased students' levels of autonomous learning. This suggests that providing psychological support with the transition to university may also help to develop students' learning of skills, as discussed above. One possible means of supporting students in developing the psychological resources to successfully transit into higher education, and to persist into a second year of study involves using personal development planning within the curriculum to enhance students' emotional intelligence (Qualter et al., 2009). Interventions to reduce class sizes within higher education were also suggested by delegates attending the tackling transition events to be useful in easing the psychological transition.

The *HEA STEM Mathematical transitions* (Hodgen et al., 2014) series of reports is also relevant here; this was a separate project which considered transition solely in terms of mathematical and statistical skills within a range of STEM disciplines, including Chemistry, Geography and Psychology, and some non-STEM disciplines. The project explored the preparedness of students for mathematical and statistical content of their degrees on transition to higher education, and scoped teaching, support and challenges associated with this aspect of teaching. Similarly, Porkess (2014) explored the articulation between the pre-tertiary and higher education delivery of Statistics within disparate disciplines, and identified opportunities for improving students' skills and confidence in the application of Statistics. The mathematical and statistical preparation of students has thus received some considerable attention recently, and, from the perspective of this report on transition in STEM subjects, it is important that these skills are considered and facilitated in the context of supporting students through transition holistically.

## 6.4 Awareness, communication and transition from pre-tertiary to higher education curricula in STEM

A clear theme across all of the STEM disciplines involved in this project was a shared lack of awareness among pre-tertiary teachers and higher education staff about the curricula taught within the 'other' sector, and expression of a strong realisation that awareness across the two sectors needed to be raised. In general, this was discussed in terms of preparing pre-tertiary students for transition (giving them knowledge, skills and experiences that would be relevant to subsequent study in higher education), and in terms of allowing undergraduate curricula and delivery to be designed to take into account the prior learning of new students in higher education. A need was also recognised for STEM providers within the higher education sector to signal clearly to those involved in pre-tertiary policy and practice the nature of study (including curriculum, skills and learning and teaching approaches) within the discipline at higher education level, to support them in better preparing students for transition. The underpinning concept that unites the perspectives of delegates from the two different educational sectors is that learning should be progressive, with pre-tertiary learning providing a foundation for higher education, which in turn builds deliberately upon the foundation laid at pre-tertiary level.

The discourse employed by delegates when talking about student learning in this context was consistent with the experiential learning literature (Kolb, 1984). Kolb defines experiential learning as: *"the process by whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience"* (p41). Thus students must be given opportunities to recognise and assimilate new information, and then to actively synthesise it, testing it, applying it and integrating it into their existing knowledge set. In this way, the knowledge is transformed, and further knowledge acquisition can occur and allow the students' understanding to continue to evolve. By failing to either provide necessary learning at pre-tertiary level, or by failing to address prior learning at undergraduate level, the opportunity for students' learning to progress smoothly and experientially from pre-tertiary to higher education is missed.

The importance of building upon students' prior scientific learning has been recognised in the educational literature for many years (Hewson and Hewson, 1983; Osborne and Whitrock, 1983). Indeed, there is some suggestion that interest increases when studying topics that are related to prior knowledge, and that increased interest in turn enhances motivation, depth and effectiveness of learning (Tobias, 1994). In other words, student learning is a cumulative process, adding new knowledge into a cognitive framework of what is already known (Shuell, 1986). More recent research indicates that teaching needs to be delivered in a way that not only takes account of students' prior learning, but also gives students time and space to cognitively process new information and to work out how it fits with their existing knowledge; thus new information should be presented 'just in time' (i.e. only when it is needed), not all at once, to avoid overloading students during the learning process, and to allow effective integration of knowledge, skills and attitudes (van Merriënboer and Sweller, 2005). Research also suggests that learning may be most effective when it is socially constructed, so that students collaborate to make sense of new learning; this can be achieved using peer-learning techniques such as problem-based learning (Wheatley, 1991).

This emphasis on the need to build on prior learning and to incorporate opportunities for active learning is concordant with current higher education policy and practice emphasising the need for students to develop transferable skills and employability during their undergraduate education. Higher education itself has evolved in recent years, as the focus has moved away from learning pure knowledge, and onto becoming lifelong learners, creative and independent individuals with critical and analytical skills, able to apply knowledge, solve novel problems and work collegiately (e.g. Pegg et al., 2012). A report commissioned by the Australian Higher Education Council (Candy, Crebert and O'Leary, 1994) recommended that these characteristics were achieved through undergraduate learning opportunities that "provide for the incremental development of self-directed-learning" (p12); in other words, that students are allowed to build upon prior learning to progress their own further learning of both skills and content. The same report went on to suggest that this type of learning could be achieved only through use of peer-learning and experiential learning techniques, including techniques such as problem-based learning, and incorporating opportunities for reflection. The authors also

recommended that real-world assessment techniques should also be used to enhance students' ability to transfer learning to the real world.

The importance of the transferability of learning has been echoed in the recent literature relating to authentic assessment (Wiggins, 1990). According to Gulikers et al. (2004):

*“Authentic assessment means that: (a) tasks must appropriately reflect the competency that needs to be assessed, (B) the content of an assessment involves authentic tasks that represent real-life problems of the knowledge domain assessed, and (c) the thinking professions that experts use to solve the problem in real life are also required by the assessment task” (p68).*

A recent paper by Ashford-Rowe et al. (2014) suggests that authentic assessment should be have eight critical elements: it should (i) be challenging; (ii) test demonstrable outcomes or performance; (iii) ensure knowledge transfer; (iv) incorporate metacognition (self-monitoring of learning); (v) be accurate in its measurement of student acquisition of knowledge and the skills to apply it authentically; (vi) be delivered within an authentic environment and context; (vii) formally incorporate opportunities to discuss and provide feedback; and (viii) include opportunities for collaboration and social learning.

It could be argued that authentic assessment ensures constructive alignment (Biggs, 1996) of assessment tasks with learning outcomes that specify the development of real-world skills. If teachers and academics intend their students to be well prepared for their next stage in life, whether that be transition to university, or from university onwards to postgraduate study or employment, then the concept of constructive alignment requires curricula to specify this in the learning outcomes, for teaching staff to provide opportunities for students to learn about, acquire and practice the required skill sets, and for assessments to test whether they have acquired the specified skills (Biggs, 1996; Boud and Falchikov, 2006). Authentic assessment is also closely tied to the concepts of reliability and validity of assessment (Brown et al., 1997) and social constructivist learning models (Boud and Molloy, 2013). It is closely related to the ideas surrounding the development of students' scientific literacy (e.g. McFarlane, 2013) and discipline-specific literacies (for example, psychological literacy; Mair et al., 2013), which in turn often emphasise the ways in which learning about a particular discipline can enhance students' and graduates' contributions to society as global citizens (e.g., in Biosciences, Savage and Jude, 2014; in GEES, Carano and Berson, 2010; in Psychology, Cranney and Dunn, 2011). Finally, this theme is also related to the literature surrounding assessment of, for and as learning (Earl, 2003; Bloxham and Boyd, 2007; HEA, 2012),

The implications for transition of the theoretical bases described here are that pre-tertiary curricula developers may wish to consider elements designed to prepare students (in terms of both skills and knowledge) for transition to higher education. Likewise, higher education providers should be planning to develop any necessary but missing skills early in the undergraduate programme by incorporating appropriately skills-based learning outcomes, teaching and learning opportunities and authentic assessments into the first-year curriculum. This can only be achieved if communication between the sectors ensures that pre-tertiary providers and curriculum developers are fully aware of what is required for entrance and transition to higher education, and if higher education providers and curriculum developers in turn are fully aware of the range of prior learning experiences (and gaps) of their incoming students. Once both sectors are appropriately informed, student progression and transition can then be supported through constructive alignment, experiential learning and authentic assessment in curricula either side of the transition. This may be best achieved through use of active learning and peer-learning models within the classroom, but will also require collaborative planning and consultation across the sectors to continue into the longer term future. The HEA, discipline-specific professional bodies, examination boards, teachers, academics and students themselves (see also HEA, 2014a) will all have a part to play in delivering this level of communication.

## 6.5 Change and collaborative initiatives to ease transition in STEM

The majority of delegates who discussed this theme talked about practical initiatives that they were already undertaking, or that they thought would be useful to ease the transition process of students entering university. Many of the remarks here offered practical solutions to the perceived challenges that students face when making this transition, as discussed in the preceding sections of this report. ‘Two-way traffic’ of staff and students across the two sectors was recommended by a substantial number of delegates from different STEM disciplines, including various types of visits of staff and students between institutional types (see also section 5 of this report). Relating this theme to the theoretical context within the literature is challenging, since action research and evaluation of interventions tend to be more frequently reported in this context than theory-driven research, and thus this section of the report has necessarily adopted a more pragmatic approach than the preceding Discussion sections.

Mentoring of staff and students in the pre-tertiary sector by higher education staff and students was one sub-theme that arose here. Peer mentoring is a well-established practice within education (Topping, 1996; Terrion and Leonard, 2007; Heirdsfeld et al., 2008; Colvin and Ashman, 2010), and within teacher and lecturer training and education (Huling-Austin, 1992; Beaty, 2006), which is frequently used to support transitions into new roles or phases of education. Similarly, several of the delegates suggested cross-sector peer observations by teachers, and classroom visits by students, as a way of raising awareness of teaching and learning in other educational contexts. Peer observation is an accepted requirement of teachers throughout the education system, with a strong evidence base presented in the learning and teaching literature as an important aspect of reflective practice (Donnelly, 2007; Bell and Mladenovic, 2008; Atkinson and Bolt, 2010; Avalos, 2011). These sorts of initiatives are not new; Cotton (2001) reports visiting ten university Chemistry departments to gain insight into university Chemistry teaching from a teacher’s perspective, and surveying their staff and students, to inform his thinking about the transition from pre-tertiary to higher education in Chemistry.

Teachers were also interested in the idea of discipline-specific continuing professional development, aimed at keeping them up to date with subject knowledge and research, provided by research-active academics. A number of delegates suggested that co-production of resources (such as text books and websites) by teachers and academics working collaboratively would ensure that teachers and pre-tertiary students had access to current information in their field, and that academics could disseminate knowledge effectively in an accessible way to a non-academic audience. These resources would be intended for pre-tertiary and first-year undergraduate students, and might help to bridge the gap for students making the transition.

A subset of delegates proposed that social media and other learning technologies could be used to support interactions between the sectors. There is evidence of existing practice in this area that suggests that this may provide an effective way of supporting students through transition (e.g. generically, see Trinder et al., 2008; and in Mathematics, see Kelly et al., 2014). The popular ResourceD (2014) website provides a forum for pre-tertiary Psychology teachers to share ideas and resources, and this is occasionally frequented by academics; it has over 170,000 members at the time of writing, suggesting that a willingness to share openly is not problematic. There is no obvious reason that similar initiatives should not be used to encourage collaboration between academics and pre-tertiary teachers.

Resource sharing and development was also seen as a possible benefit of interactions between the pre-tertiary and higher education sectors. Typically, delegates from schools and colleges reported low availability of resources that were commonly available in universities, including access to journals and to physical resources such as laboratory equipment. A previously successful example of a similar initiative was reported by Paris et al. (1998) in the context of Biosciences education in the US, which resulted in a significant increase in students’ engagement and interest in science, and improved problem-solving ability. Interestingly, these effects were particularly strong in girls; as noted above, there is considerable interest in the UK and elsewhere in increasing girls’ engagement with STEM subjects. In Psychology, another successful, but shorter-term resource sharing activity, focusing on information literacy, was presented earlier in this report (section 5.1).

Several delegates suggested outreach projects to allow universities to interact with school and college students. This is another common activity which has been undertaken by many universities for quite some time, particularly in the context of widening participation (Stuart, 2002). Likewise, subject ambassadors were often seen by delegates as providing effective links between schools and colleges, universities and employers, and similar evidence has been reported in the literature (e.g. Harrison and Shallcross, 2007).

Given that so many of these initiatives are already well established, creating such relationships between volunteer teachers and academics, and pre-tertiary and undergraduate students should be relatively straightforward to achieve, and, according to delegates at the tackling transition events, may be highly effective. It is important to note that in all of these cases, delegates were recommending that relationships, interactions and collaborations should occur within a disciplinary context, to ensure optimal learning from across the sectors. Delegates also reported challenges that needed to be overcome in order that these types of interactions, not least issues related to workload, the focus of academics on research at the expense of teaching and pedagogy, and ensuring meaningful engagement and collaborations. Student partnership was often offered as a means of ensuring that collaborative work was meaningful and emphasised the student experience of transition over and above any agenda that might be prioritised by teachers and lecturers. There is extensive evidence already within the higher education sector that supports a genuine need for work with students as partners in order to maximise the effectiveness and impact of learning, teaching and interventions within education (HEA, 2014b). It is worth noting that delegates were keen to see the evidence base developed further, to inform their own and their institutional practice, and some of them were enthusiastic in their desire to participate in and conduct such further research.

## 7. Recommendations

The *Tackling transition in STEM disciplines* project set out with several initial aims: to facilitate knowledge sharing and discussion across the sectors; to provide a platform whereby new collaborative work, across the sectors, could be initiated to ease student transitions; to identify key issues relating to transition in each of the STEM disciplines; and to inform the HEA's work on transition in the STEM disciplines by providing evidence of current issues related to student transition. The qualitative analysis conducted here has provided a wealth of information relating to the experiences and perceptions of a diverse collection of stakeholders, including students, teachers, academics and other interested groups. The commitment of all of these stakeholder groups to improve the student transitional experience is striking, and reflects the high level of importance placed on this issue across the piece. Examples of existing good practice, as well as some innovative ideas, were shared at the tackling transition events, and initial feedback suggests that ongoing collaboration is positive and impactful. There was a high level of agreement across the different STEM disciplines about the current priorities for educators in order to improve the student transitional experience, but some interesting discipline-specific issues were also recorded.

The *Tackling transition in STEM disciplines* project has clearly met its aims in all of these regards, and as such provided an interesting springboard to inform both future HEA working and practice within the higher education sector. The HEA's national remit focuses specifically upon UK higher education, rather than the pre-tertiary sector or other stakeholder groups involved in the project; therefore, recommendations will be restricted here to those working in higher education. However, it is hoped that the report will be useful to the wider range of stakeholders, and that those from groups and organisations outside of the higher education sector will be motivated to use the information contained within to develop their own policy and practice to support student transition into higher education. Numbers in brackets after each recommendation indicate the section from the Discussion of this report from which each recommendation arises.

1. Prioritise the sharing of knowledge, experience and practice within and across different educational sectors (6.1), and learn from practice around transitions at other stages in the student journey (6.2). Continue and further develop mechanisms for cross-sector collaboration and consultation, including working with students as partners (6.4, 6.5), to support students and inform curriculum development within higher education that takes account of prior disciplinary learning (6.5). Examples of collaborative working could include:
  - mentoring and peer-observation relationships between lecturers and their pre-tertiary counterparts, and between undergraduate students and their pre-tertiary counterparts, through face-to-face and technology-mediated interactions (6.5);
  - sharing of laboratory spaces and equipment by universities to enable pre-tertiary student research and practical disciplinary learning (6.5);
  - accessible sharing of research and up-to-date disciplinary knowledge by academics with their pre-tertiary colleagues within related STEM disciplines (6.5);
  - provision of discipline-specific outreach events by higher education providers (6.5);
2. Facilitate engagement with STEM disciplines during early educational stages, to improve students' understanding and expectations relating to studying in STEM, and to encourage recruitment into STEM within higher education (6.2);
3. Develop examples for teaching and assessment within STEM disciplines that help to break gender stereotypes, improve inclusivity and widen participation, and disseminate these examples and case studies (6.2);
4. Enhance the quality of first-year undergraduate teaching in STEM disciplines to introduce more scaffolded learning opportunities, supporting students to make the transition by building on prior learning, and identifying areas in which gaps need to be addressed upon entry to higher education (6.3,

- 6.5). In part, can be achieved by incorporating opportunities for peer learning, active learning and problem-based learning into the early STEM undergraduate experience (6.3, 6.4, 6.5);
5. Mathematical and statistical skills are one aspect of transition that can prove challenging for STEM students, and should be supported and facilitated in line with the recommendations of previous reports (Hodgen et al.,2014; Porkess, 2014), alongside broader support for all other aspects of transition (6.3);
  6. Provide clear signalling to those involved in pre-tertiary policy and delivery of relevant STEM subjects, to better inform preparation of students, so that they are equipped in terms of what to expect from the curriculum, the skills they will need and the learning and teaching approaches they are likely to encounter within higher education (6.4);
  7. Consider psychosocial interventions and smaller class sizes to develop students' confidence and resilience during transition (6.4);
  8. Incorporate authentic assessment, constructive alignment, and assessment as learning, into undergraduate STEM curricula (6.5);
  9. Conduct further research and wider consultation with a specific focus on tackling transition in specific STEM disciplines. (This could focus on theoretical issues, such as the psychosocial development and experiential learning of students to support successful transition [6.2 and 6.3], on curriculum design issues, such as consultations around A-levels [6.4], on pedagogical issues, such as authentic assessment [6.4], or providing case studies and evidence of existing good practice (such as the initiatives proposed in section 6.5).

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## Contact us

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**The Higher Education Academy**  
**Innovation Way**  
**York Science Park**  
**Heslington**  
**York**  
**YO10 5BR**

**+44 (0)1904 717500**  
**enquiries@heacademy.ac.uk**

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