INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
4 & 5 SEPTEMBER 2014, UNIVERSITY OF TWENTE, THE NETHERLANDS

SUPPORTING THE STEM TRANSITION BETWEEN SCHOOL AND UNIVERSITY

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ABSTRACT
This paper sets out to review the relationship between Schools and Universities in the West of Scotland with the strategic aim of widening access to STEM (Science, Technology, Engineering and Mathematics) based subjects. With the changing nature of education in Scottish schools because of the Curriculum for Excellence and the requirement for increasing, the number of students who participate in STEM subjects at university. An eight-person research team was assembled at the University of Strathclyde to investigate, support and raise awareness of the key factors affecting successful STEM transition from secondary school to university. The group made up from students and academics was a novel approach and aimed at developing their knowledge of the current Scottish education system whilst developing partnerships with secondary schools in the local Glasgow area.
Several peer discussion groups were conducted as part of the methodology and it was through these that ideas, such as a student elective scheme allowing university students to enter schools and run project based learning workshops, could benefit the transition strategy for young people to enter the STEM based disciplines at university. The outlined proposals, when implemented, have the possibility of negating the previous inconsistency of previous attempts to address the problem of successful STEM transition. Four key project deliverables were identified that had the potential to develop the strategy necessary to encourage and develop school pupils into the STEM subject areas and with the help of staff and pupils, the researchers were able to identify potential ideas and solutions to facilitate this.

Keywords: Transition, school, university, STEM, widening access

1 INTRODUCTION AND BACKGROUND

The UK and in particular Scotland there is a lack of students continuing into higher education within the STEM based subject areas. This is of note in the Glasgow area of the Scottish education system, which has recently changed to the new Curriculum for Excellence (CfE) system [1]. The CfE aims to provide pupils with the skills for learning, life and work; although the potential benefits of the new system have clearly been outlined by the SQA there remains a lack of clarity about certain associated details, such as the effectiveness of a broad general education (BGE) in preparing pupils for senior phases of secondary education. Issues of this manner have a direct impact on the progression of young people's learning and consequently their advancement and suitability for higher education [2].
In order to address this situation an eight person team was assembled from across the faculties of Engineering and Science with the aim of exploring ways of designing and developing links between local schools to encourage, support and enhance the pupils awareness and appreciation of STEM activities. The research team conducted a literature research into CfE, met and discussed all aspects of the problem with teachers and pupils in local schools. The resulting output from these findings, proposing activities and ideas generated would potentially improve the STEM transition from school to university. The secondary schools that participated in the project were Eastbank Academy, Govan High, John Paul Academy and Smithycroft Secondary all local comprehensive schools. A brief partnership with Glasgow Academy a private fee paying school was established which provided diversity in data collection and enabled the researchers to draw comparisons between government and independent schools. This proved to be an extremely valuable experience and contributed significantly towards the aims of the project. With the help of staff and pupils in the schools, it was possible to identify potential ideas and solutions to the four key project deliverables the researchers identified at an early stage. These included:

- Ensure staff at school and university understand the key factors involved in successful STEM transition
- To prepare a specification for pre-university material to support STEM activities
- Investigate the potential and feasibility of summer schools
- Outline student led mentoring for university students

The research team who conducted the detail of the research came from a wide range of backgrounds and educational routes. Because of this, the backgrounds and experiences of the researchers provided yet another valuable source of information through peer discussion groups and reflection upon personal experiences [3]. Under the guidance of researchers' supervisors, the project has successfully identified key factors that would contribute to successful transition and generated potential ideas for implementation. There were a number of key stages in this project. Initially background research including literature, interviews and school visits was conducted to identify the main requirements. Requirements were then captured in a specification allowing solutions to be generated and evaluated and clear recommendations to emerge. Each of the main project phases are presented in the remainder of the paper.

2 BACKGROUND RESEARCH

2.1 Introduction

A literature review, semi-structured interviews and questionnaires were carried out to capture data relating to CfE (Curriculum for Excellence), current practice in schools, understanding stakeholder requirements (pupils, parents and teachers) and existing relevant STEM initiatives and events.

2.2 Curriculum for Excellence (CfE)

At present, schools and universities appear to have a lack of clarity about the details associated with CfE. A key part of the research process was to investigate CfE, identifying strengths and weaknesses and consequently ways in which pre-university material could aid teachers without adding to their already increasing workload [1],[4]. From the research conducted in to the curriculum for excellence table 1 below depicts the year differences, which the majority of school pupils will follow during their period in a Secondary School education programme.

Table 1. Comparison of educational achievement

Year	S1	S2	S3	S4	S5	S6
Old System	General Education	General Education Choose Subjects	Standard Grades	Sit Exams Foundation/Access 3 General/Intermediate 1 Credit/Intermediate 2	Sit Credit/ Int 2/ Highers	Sit Highers/ Advanced Highers
New System	Broad General Education (BGE)	BGE	BGE Choose Nationals/Highers	Only National 5/ Higher examined externally National 3 National 4 National 5 New Higher	Sit National 5/ Highers	Sit Highers/ Advanced Highers

As can be viewed from the analysis the new curriculum places less emphasis on assessment and a fact filled curriculum and more on "skills for learning, life and work" and interdisciplinary learning. In practise, this means that students will choose subjects a year later and in some cases may only face exams in 5th year. Also, whilst the new Higher graphic communication, engineering science, mathematics remain similar to the old Highers in content - physics is the exception with the introduction of new topics such as space and relativity into the syllabus – more teacher discretion will

be required in assessment and there will be greater room for projects and investigations. The latter will provide scope for cross-curricula skills based learning [4].
The interviews conducted by the researchers from the schools highlighted strengths and weaknesses in the CfE and this would help the design of the recommendations to promote STEM success through to University level.

Strengths:

- Good skills development and increased proportion of project based work.
- Students not rushed to perform at a new level. There is more freedom and time to work with each student's level of ability.
- CfE construction allows more pupils to gain qualifications.
- National 4 may suit many more peoples with a better balance between learning and assessment.

Weaknesses:

- Lack of rigour in primary school combined with BGE in secondary is failing to prepare students, which may restrict the possibility of students attaining Highers where a lot of foundation knowledge is required (e.g. Maths).
- Some felt that CfE would not sufficiently push the more academic pupils. Whilst more pupils will pass exams and get qualifications, the standard of achievement may decrease.
- National 4 courses will be assessed by teachers through coursework assessment and not externally assessed. This may lack credibility. It is possible to pass a National 4 without knowing the basics of a subject.

The research conducted indicates that the new curriculum will be beneficial to STEM subjects in instances where there is more practical and project work since this will allow students to see their subjects from a hands-on point of view. The new practical approach will demonstrate to the student the practical application of physics and maths solves problems, therefore, giving pupils a greater contextual understanding. It would also appear that there is more room for pupils to undertake the curriculum at their own pace and even sit more advanced subject levels in 4th year rather than 5th or 6th years. Unfortunately, a skills based approach also means that inevitably pupils will not have the same depth of knowledge and understanding. For STEM university/college degrees, a significant amount of foundation knowledge is required [5] and the new curriculum may not provide this sufficiently. There is a real concern over the level of numeracy pupils will attain in primary and as part of BGE in secondary. Even at National 4 level, rigour may be lacking in courses, which lack externally assessment. Academic high achievers could "coast" to through secondary education if left unchallenged.

2.2 School Visits

Before schools closed for the summer holidays several school visits were initiated to Govan High School, Smithycroft Secondary School, John Paul Academy, Eastbank Academy and Glasgow Academy. In addition correspondence with Westhill Academy, a school in Aberdeenshire with strong links to the oil and gas sector contributed to findings. Two questions were asked in each school, a summary of responses are shown below:

How do the schools currently promote STEM subject?

- Former Students make occasional visits.
- Individual teachers can be a source of inspiration.
- Money Week alongside the Credit Union.
- Leadership program (Individual project for senior pupils).
- Future Skills Day – a day of fun workshop with industry and educational establishments.
- Science and music project (Paragon Ensemble and Glasgow University).
- Industrial visits to school e.g. BAE systems.
- Field trips e.g. Shipyard visits.
- One-off design projects e.g. Rocket Design.
- After school clubs e.g. Science Club.

What current links do the schools have with the schools, Colleges and Universities?

- None in some cases – sometimes they rely on pupil initiative and principal teachers.
- Anniesland, Stow & Glasgow City College – Skills for Work and Electrical Engineering scholarship.

- Strathclyde University to provide UK Maths Challenge.
- Strathclyde Naval Architecture Department.
- Space Programme with Glasgow University.
- Aileen Hamilton (STEM Ambassador for West of Scotland) helps to promote STEM subjects within the school.

Discussions with staff and students in each school focussed on how the university could best engage and support schools in STEM. A common finding was the need for pupils to have their imagination challenged through workshops and activities. Running problem solving, maths and engineering workshops with current university students would not only challenge pupils through new educational approaches but it would also provide school pupils with an insight to the life and expectations of university life through their interaction with students. Engagement of this nature was of strong importance for the teachers, as it would provide an example of aspirational leadership through engagement and inspiration. Modern ideas were another common theme. Schools were keen to encourage the study of STEM subjects through examining current technologies such as mobile apps. Another key initiative suggested was school pupils could visit university and experience up to date technology such as prosthetics labs and 3D printers in DMEM.

In conclusion, it was apparent that university schemes and STEM projects have found consistency and long-term sustainability difficult to achieve in schools. One-off projects seem to occur on a semi-regular basis; however, it is difficult to create lasting partnerships and initiatives. In the midst of CfE it is perhaps even more difficult to create links with schools given teacher's increasing workloads and limited time. On the other hand, teachers did indicate that pupil engagement via workshops would have potential and relate well to the skills based cross curricula learning at the heart of CfE. Given these findings, the team established four broad deliverables that would create the STEM learning and support structures required. The deliverables contain a series of ideas that add different value to achieving the goals of the research. An overview of each of the deliverables is in the following section.

3 REQUIREMENT CAPTURE AND SPECIFICATION

Project deliverables were revisited to focus and prioritise key requirements:

- **Deliverable 1,** involved widening Access to the STEM subjects to "ensure staffs at schools and university understand the key factors involved in successful STEM transition".
- **Deliverable 2,** main purpose was to prepare a specification for pre-university material to support STEM activities.
- **Deliverable 3,** implementation of a Summer school activity. By attending summer schools, the pupils can gain a vital insight into studying at University and University life in general. This deliverable focuses on improving the transition between school and university by providing extra academic support and essential university skills for school pupils who could potentially struggle in their first year of university.
- **Deliverable 4,** develop a Student mentoring programme in order to give students a helping hand at all times. The mentoring programme enables a successful, highly motivated student from the year above the mentee to be trained in the programme and then placed as a mentor for one of the students in the year below them, 1st year. As the student progresses they will be expected to do the same for the years below and keep the cycle going.

The research team began speaking to schools about the four deliverables and assessing what teachers and pupils required to improve STEM transition and support i.e. what were their priorities. The conclusion reached was to join deliverables one and two since both provide a powerful solution when integrated together. Deliverables 3 and 4 were more of a long-term solution and while important to the overall structure both and would be developed and implemented later.

A list of specifications for each of the deliverables was generated to facilitate brainstorming of solutions to meet these conditions. Ideas generated from the brainstorming session were then analysed and assessed against the set specifications. The key specifications used to evaluate the deliverable ideas against are as follows:

- ***pupil engagement*** **:** must be geared to motivate and inspire students
- ***time:*** must be relevant to the world today and not require a huge investment of time

- ***feasibility:*** create a solution that is practical and inclusive of all schools irrespective of current progression to higher education
- ***innovation:*** must give a positive and realistic view of university life in STEM subjects
- ***sustainable:*** capable of building and sustaining strong links
- ***teacher effort:*** be easy for teachers who already have a lot of commitment to implement

4 SOLUTION GENERATION AND EVALUATION

Team brainstorming generated 11 ideas of potential solutions across both deliverables:

Deliverable 1:

- Booklet for Staff
- News Bulletin
- Teacher Evening at University

Deliverable 2:

- App Software
- Film
- Lunch/After School Club
- Student Elective Class
- Request Box
- Year-Long School Project
- Booklet for pupils
- Apprentice Challenge

Evaluation of ideas was then carried out. The team split into small groups and listed the positives and the negatives of each individual idea. This process highlighted any flaws and future issues that could develop. The next stage was to put the ideas into a matrix this would show the top few ideas, as there are too many ideas to implement them all. Table 2 shows the scales used whilst table 3 shows matrix classification system.

Table 2. Idea Evaluation Scale

Scale 1-5	1 is Negative	5 is Positive
Sustainability	Short	Long
Timeliness	Long Time	Little Time
Innovation	Not	Very
Teacher Effort	Lots of Effort	No Effort
Feasibility	Hard to do	Do-able
Pupil Engagement	Not	Very

Table 3. Evaluated Ideas from Deliverables 1 & 2

Ideas from Deliverable 1 & 2	Sustain-ability	Time	Innovation	Teacher Effort	Feasibility	Pupil Engagement	Total
App Software	4	3	5	5	2	3	22
Student Elective Class	5	2	5	3	2	4	21
Booklet for pupils	5	4	1	4	5	1	20
Film	2	1	3	5	4	3	18
Request Box	4	2	3	2	4	3	18
Booklet for Staff	5	4	1	2	5	1	18
News Bulletin	5	2	3	3	4	1	18
Apprentice Challenge	3	2	3	2	3	4	17
Teacher Evening at University	3	2	4	1	3	1	14
Lunch/After School Club	3	2	3	1	3	2	14
Year Long School Project	2	1	3	1	2	5	14

5 CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK

The research group recommended that the key factors derived from this investigation was to maintain consistency with the schools; pupils must be engaged; to develop and run more engineering oriented activities; finally enable pupils have a clear understanding of University and Engineering practices.

In conclusion, the most successful idea was the app and this was popular because it uses technology to present STEM information. However, the student elective class would provide the most sustainable method of information deployment and the team felt that the student elective class had all of the best interactive ideas included. It also gave students an incentive to complete it and do it well. At the same time, it would help teachers understand the key issues involved with STEM transition since they would be present while the class workshops were taking place.

The research team felt the Student Elective is likely to be the most successful, innovative and sustainable idea since it ensure both university and school staff have insight to the factors involved with successful STEM transition. It promotes STEM subjects to school pupils in an interactive environment and gives University students the incentive to be involved because they are able to gain credits toward their degree. The Student Elective also has the potential to establish strong links between the university and Glasgow schools in a way that will be consistent and long term.

To prove that the selection process is sound the university are currently running a pilot Elective Class which commenced in February 2014. Five MEng students are enrolled in the class and are engaging with 2 local secondary schools. Findings from the pilot study will inform future expansion and roll out of the initiative.

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