Does the Science, Technology, Engineering and Mathematics (STEM) agenda need separate curricular input in the realms of undergraduate Initial Teacher Education (ITE)?

David Wooff, Design and Technology Education, Edge Hill University, wooffd@edgehill.ac.uk
Chris Hughes, Department of Higher Education Research, Lancaster University, chughes22@fsmail.net
Dawne Bell, Design and Technology Education, Edge Hill University, belld@edgehill.ac.uk

Abstract

The work presented here will look at how those involved with Initial Teacher Education (ITE) prepare trainee teachers to deliver and work within the area of Science Technology Engineering and Mathematics (STEM). Taking cognisance of the work of Barlex (2007; 2009) who argues for the inclusion of STEM and recognition of it as a curriculum entity. This work presents the views, opinions and reflections of those who are currently following an undergraduate route to achieve Qualified Teacher Status (QTS) with regard to their ability to both engage with and deliver the STEM agenda within the secondary curriculum. Following this, discussion and analysis of the findings will lead to an overall response to the research question posed as the title to this paper.

Introduction

It is almost ten years since Sir Gareth Roberts (2002) reported to government minsters in the United Kingdom (UK) about the necessity to consider the significance of Science Technology Engineering and Mathematics (STEM) within the United Kingdom (UK). Since then, industrialists and educators (Sainsbury (2007), Barlex (2007; 2009)) have helped develop and evolve the STEM agenda both in an educational and industrial context.

Sainsbury (2007) considered the impact on the economy of reduced numbers of school students pursuing science, technology and mathematics examinable qualifications. It was in this report that Sainsbury first introduced the term STEM within the context of school curricula;

> *"Demand for Science, Technology, Engineering and Mathematics (STEM) skills will continue to grow. The UK has a reasonable stock of STEM graduates, but potential problems lie ahead.... ....the review recommends a major campaign to address the STEM issues in schools. This will raise the numbers of qualified STEM teachers by introducing, for example, new sources of recruitment, financial incentives for conversion courses, and mentoring for Newly Qualified Teachers [NQT's]".*

Sainsbury (2007)

This report, lays out the case for NQT's to be trained in the delivery of STEM. This was further reinforced by an announcement in early 2008:

> *"[English] Schools Minister Jim Knight today outlined a £140 million strategy to educate the next generation of scientists and mathematicians... ... the government wants the very best teachers to increase the number of young people opting for Science, Technology, Engineering and Mathematics (STEM) subjects and following a related career".*

Department for Children, Schools and Families (DCSF; 2008)

Coinciding with this, also in 2008, the Design And Technology Association (DATA), which is a UK professional body for Design and Technology teachers, appointed a defined STEM ambassador.

Recent work (Barlex 2009; 2010) reviews how trainee teachers visualise the links between the constituent subjects attributable to STEM. This served to galvanise the thinking of this team of researchers and focus their attention on how a group of undergraduate trainee teachers view their own abilities and understanding of STEM without having studied it as a discrete subject. This is also timely as due to the academic cycle of revalidation within English Higher Education Institutions (HEI's), there is an opportunity to consider and develop a STEM module across the undergraduate programme in which participants in this study are enrolled.

Methods and Methodology

A grounded theory approach (Charmaz, 2005; 2006), has been taken from the inception of this work so as to ensure that participants have not been influenced in their responses to the study as the principle researchers are engaged in the delivery of the programme on which the participants are enrolled. As grounded theory allows for the evolution of the directionality of work undertaken, it has been possible to meaningfully extend the study beyond final year degree trainee teachers to consider the thoughts and practices of those in their first year of employment as Newly Qualified Teachers (NQTs). With regard to the work so far presented from this study, data has been gathered by questionnaires using open ended questions to identify those who would be willing to undertake semi structured interviews, and one-to-one interviews were undertaken in the first part of 2011.

Ethics

All work was carried out in accordance with the British Educational Research Association (BERA) (2007) principles governing ethical research. Participants in the study were all given full explanations of the work involved and the anticipated outcome with respect to reporting. They were also provided with a guarantee of anonymity coupled with their right to withdraw their participation in the study and consent for use of the data and information they had provided. As participants within the study have been drawn from those engaged within ITE then it is likely that some may be trainees at the institutions where the researchers undertaking this study work or have links. Consequently, there may be a willingness for respondents "to please" in this case it will be necessary to ensure that no bias occurs and that the data remains robust and impartial.

Results

The sample used for this part of the research involved trainee teachers (n=28) from an undergraduate programme allowing for two year, three year and four year routes through to the end award. As such the background of participants is acknowledged to be variable, but as this study considers the views and opinions of trainees at a specific point in time it was not considered to be relevant as all trainees had followed the same modular content and in terms of their studies, they had arrived at the same point when the research commenced.

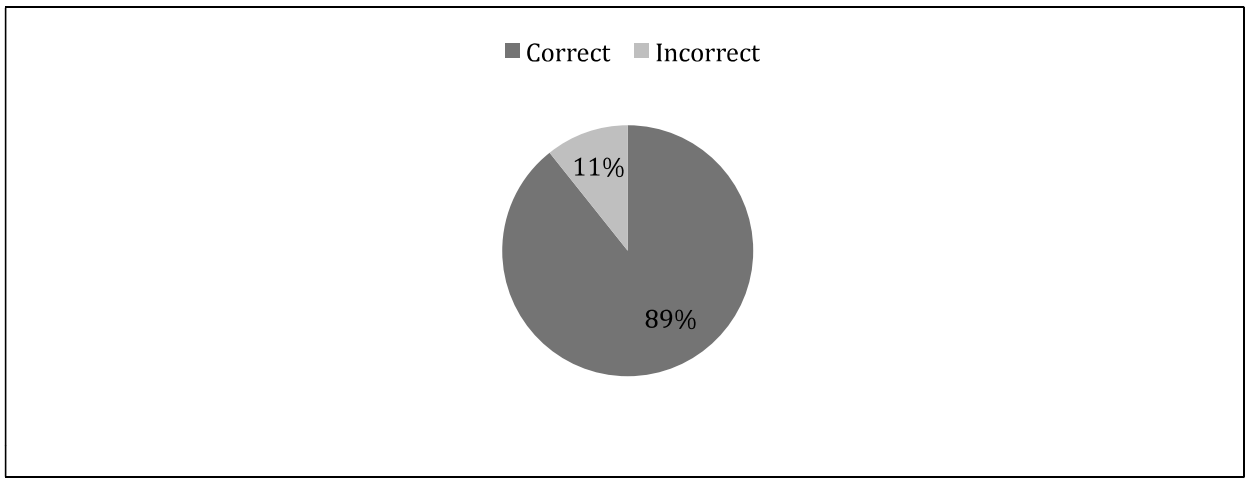

Fig. 1. The ability of respondents to correctly identify the subjects that make up STEM.

At the start of the survey, all respondents were asked to identify correctly what the acronym STEM stands for. All respondents answered this question, although not all could correctly identify the constituent areas making up STEM. Incorrect answers included those who had missed out the Engineering aspect of STEM and one response that incorrectly identified the "M" as being representative of Manufacturing.

Not all respondents stated that they felt that they were able to deliver lessons with a STEM focus, with 21% stating that they were unsure. Although it was an option, no one responded by returning a 'no' response. Respondents were further asked to qualify their belief in their own ability to deliver such lessons, typical responses include:

> *"I feel I am able to deliver lessons with STEM focus as I am currently training as a Design Technology teacher and so all of my lessons are based on a particular area of Technology. I hope to specialise in Electronics which involves Mathematics and i have previous experience in Engineering and the Maths and Physics (Science) that Engineering involves".*
>
> *Respondent 12*
>
> *"I have a good technology/engineering background - Mathematics and Science - I won't be worried to try and teach it [STEM]"*
>
> *Respondent 16*

The next question asked how respondents thought a defined range of Design and Technology subjects could be taught with a STEM focus. The results of this were:

	Very Easily	Easily	Not Very Easily	Not Possible
Graphic Products	25%	43%	32%	0%
Electronic Products	50%	32%	18%	0%
Systems and Control	50%	32%	18%	0%
Product Design	32%	61%	7%	0%
Resistant Materials	57%	25%	18%	0%
Textiles Technology	32%	32%	36%	0%
Food Technology	32%	43%	25%	0%
Catering	32%	43%	25%	0%
Manufacturing	61%	32%	7%	0%
Engineering	68%	25%	7%	0%

Fig. 2. Responses to the question relating Design and Technology subjects to STEM.

Rather worryingly some respondents felt that engineering could not be easily linked to STEM. It was checked to see if the trainees that responded in this fashion were the ones that could not define what STEM stood for, this was found not to be the case.

To broaden this, respondents were then asked which non Design and Technology based subjects they felt could be linked to STEM. The definition or tenuousness of this link was not defined and left to the cognisance of the respondents. Figure 3 shows the responses recorded.

Fig. 3 shows that all respondents felt that 'Art and Design' was applicable to STEM whilst only 81% of respondents recognised that Mathematics could be linked to STEM. This is similar to Science and ICT both of which 89% of respondents felt could be linked into STEM. Clearly this is alarming as Fig. 1 shows that more than 81% of respondents could identify the constituent subjects that compose STEM so one would question when asked to specify corollary subjects why would these respondents not be able to link Mathematics directly to STEM?

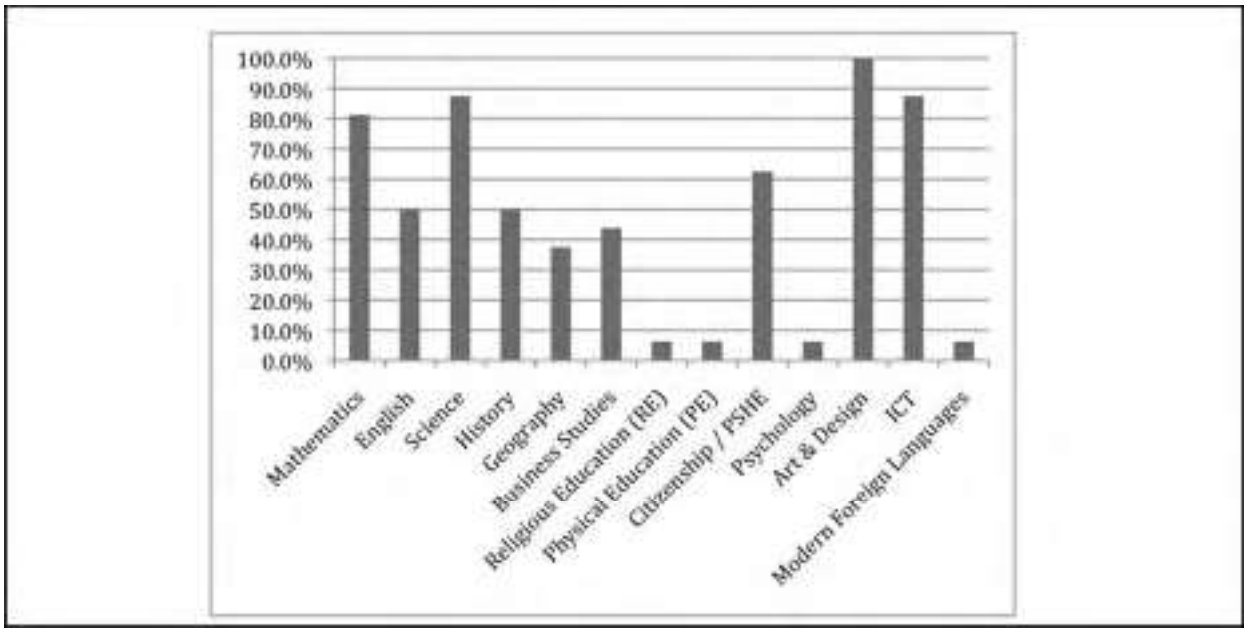

Fig. 3. Opinion about which non Design and Technology based subjects could be linked to STEM.

The following question encouraged respondents to discuss lesson topics that they felt would be suitable for a lesson with a cross curricular focus on STEM subjects. All respondents answered this question and responses ranged from;

> "*Sustainability*"
>
> Respondent 8

to

> "*An electronics lesson involving PIC [Programmable Interface Controller] chips showing the engineering of the PIC, using maths to solve equations, introducing science to justify the reaction that takes place within a circuit and using the subject area to explain the step by step process in making the circuit*".
>
> Respondent 21

This question then fed into one asking about the rationale to teach lessons with a STEM focus. Again, all participants in the survey chose to answer this and provide some reasoning for the validity of STEM. Answers provided show that there is a clear passion for technological education and the emphasis on STEM is no less considered. Responses typically took the application of mathematics and science in a technological context, and this is epitomised thus:

> "*I think it [STEM] is important as a lot of students might think that there is no point to certain lessons and that they have no use for them. But by connecting all subjects together pupils will see that there is use for the information they are being taught. It may be that pupils may learn*

the information better being taught in a different subject. Also a different teacher may teach in a style better suited to some students. And lastly the more that information is covered (reflected or taught) the more likely they are to remember and learn it".

Respondent 16

However, not one respondent chose to cover explicitly or mention engineering in their answer to this question.

Analysis

Initial findings show that despite the lack of direct input labelling the content of work as something covering the STEM agenda, some trainees are clearly able to determine that certain aspects of their work are directly applicable to STEM more so than some of their peers. They are also able to link many subjects together and potentially see the possible links to STEM that they may offer – both internal to Design and Technology (Fig 1.) and external to Design and Technology (Fig. 2).

There are differing perspectives on the necessity to incorporate STEM into the curriculum let alone those linked to the inclusion of STEM into ITE. Findings from this initial study allude to this, the following is a response from respondent number three who identifies that they are an NQT:

"As a technology teacher, I would feel hard pressed to deliver a lesson that does not include any technology. I've always found that science and maths integrate very well with DT, so that's not a problem. It's getting the focus towards engineering that is the problem. Good role models, not the usual white middle class males, are hard to find. Examples of engineering are everywhere, but interesting and exciting examples not so. I've always found it useful to say to students 'what you've just done (maybe having made something with some complexity) was engineering', then start to tackle the whole question of 'what's engineering, sir?'

This is common in essence and sentiment to a number of answers from respondents to the study, but it is clear from this particular respondent that he has a belief in his own ability to deliver and cover STEM. The response belies the fact that this respondent is only an NQT in the first year of their career as a teacher. This is the sort of response that one would potentially anticipate from someone who has many more years teaching than an NQT.

Due to the diverse demographic from which the course, and consequently that of the respondents are drawn from, no cognisance is made of their prior knowledge, skill or experience before commencing the course. As a result, it is possible that the individual that recorded this response has been in a teaching situation, or a classroom situation as maybe a Teaching Assistant (TA) or unqualified teacher prior to commencing the course.

Not all respondents to the survey come from the same initial stance, and it is clear that there are differing views regarding the validity of STEM as a defined subject (or topic) within the curriculum.

Respondent number twenty highlights this in the comments made in the general comments section of the survey:

"I believe that STEM is not a subject, more an initiative that we will need to be teaching as the government will introduce it like it did for AfL (Assessment for learning), Literacy and Numeracy for example. I also think that as we do all of this anyway is there any need to classify it as more than cross curricular links?"

Conclusions and Recommendations for Further Work

It is clear that those involved in the study believe that they have an ability to deliver STEM within the educational setting of lessons. Analysis of their responses to simple questioning indicates that this is an overconfidence that should be challenged. Some of the respondents agreed to be interviewed as a postscript to their initial engagement in the study.

Interviews have already taken place and detailed analysis of the outcomes and transcripts are still to take place. However, it is clear from the initial work undertaken and these semi-structured interviews

that those engaged in this study lack some understanding of STEM and they also lack the ability to reflect critically on their own skills and ability in relation to STEM as a discrete topic.

Many researchers and theorists (Atkins & Murphy,1994; Boud et al,1985; Brookfield,1994; Gibbs,1989; Goodman,1984; Johns, 1995; Mezirow,1990; Smyth,1989) have looked at the process of self-reflection. In the work to be undertaken following this initial investigation the basic taxonomy introduced by Smyth (1989) will be used by the authors of this study to analyse and establish the viewpoint from which further work can be undertaken. This has been chosen in preference to that of others including Brookfield (1994) and Mezirow (1990), as it is underpinned by research in the field of adult education, and teacher education and it is a framework which the authors of this study feel an ability to engage with critically.

Due to the academic cycle in which those involved in this study find themselves, it has not been possible to actually observe any of the participants delivering lessons with a STEM foundation. Consequently, this is one of the future intentions of the authors, as it may highlight the ability of trainee teachers and newly qualified teachers to deliver such lessons whilst exposing an inability to recognise them as such.

This also leads to the necessity to determine what exactly is a STEM lesson? Is it a lesson that incorporates a number of elements of the STEM agenda or is it a lesson that by necessity incorporates all elements of STEM? Once a clear definition has been arrived at and accepted by the education community as a whole it will be possible to definitively comment on a lesson's content with respect to STEM, until that point the assessment of something to fully contribute to the STEM agenda will always be subjective.

These early findings indicate that it would be highly advantageous if specific attention was drawn to STEM for undergraduate students participating in ITE. Whilst some teacher training providers and providers in other countries may already include STEM in their provision, it is clear that trainee teachers need direction and a definitive source of reference to understand what STEM actually is. Therefore, following the assumption that STEM should be an important part of a modern curriculum, it must be considered that it is essential to include a discrete STEM element within teacher training. This should be titled as such to avoid ambiguity and it should be an integral part of teacher training provision so there can be no mistake by trainees to its content, context and value.

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