

# **UK & Ireland Engineering Education Research Network Symposium 2017: Time for Change! Challenging the Status Quo in Engineering Education**

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# STRUCTURED ABSTRACT

## The knowledge misalignment between engineering and secondary school technology education

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**KEY WORDS: STEM, Teacher Knowledge, Secondary Education.**

### **SUMMARY**

The majority of secondary school engineering education is delivered within Design and Technology. There is a misalignment between the background subject knowledge of these teachers and the subject knowledge of engineering. This paper presents key findings from the London Schools Excellence Fund Reference: LSEFR1210 study where teachers have difficulties in utilising science and math-based resources. This has implications for pupils' receiving a desirable engineering education in school, which may be a factor in the number of pupils choosing to study engineering and technology beyond compulsory education.

### **BACKGROUND / CONTEXT**

A major part of English secondary school technology and engineering education is contained within the Design and Technology (D&T) curriculum. It, therefore, plays a crucial role in developing intrinsic motivation in pupils to study technology and engineering subjects beyond their KS3 compulsory education (Jones, McDermott, Tyrer, & Zanker, 2017). The national curriculum has been well designed to provide pupils with engineering education at a young age. It contains many elements that engineering industry and academics would desire pupils to know, such as materials, machine elements, electronics, programming, technical textiles and manufacturing processes to name a few. However, there is a clear disconnect between the ambitious curriculum and the resultant average pupil's motivation and knowledge in an engineering career. This study investigated the role that teachers' knowledge plays in this equation.

### **AIM AND OBJECTIVES / RESEARCH QUESTION(S)**

The aim of the study was to assess teachers technological teaching competence of the KS3 National Curriculum. To do this the following research questions were investigated:

- What influence does teacher knowledge have on technology education?
- Are teachers confident in teaching the National Curriculum?

### **RATIONALE**

The data for this study were collected as part of the "STEM into Action with D&T" project funded by the Mayor of London's Education Programme: London Schools Excellence Fund (London Schools Excellence Fund Reference: LSEFR1210) (Mitchell et al., 2015). Within this project, the Design and Technology Association and Mindsets provided teachers with a range of continuing professional development (CPD) activities and STEM project kits for pupils. This project was conducted to prepare teachers for delivering the 2015 National

Curriculum By developing a range of resources and associated CPD to address teachers' knowledge and experience gaps while enhancing existing skill levels and helping to develop confidence. This is important to engineering educational research as these teachers are responsible for the majority of the pre-university engineering education that pupils receive.

### METHODOLOGICAL APPROACH

Questionnaires were developed to generate data from teachers before and after the new STEM intervention to study the effect of developing new STEM resources on teacher knowledge. Twenty-five competency statements related to teaching requirements of the D&T national curriculum were developed. The questionnaire asked teachers to self-assess their confidence, as a proxy to competence to improve response rates (Hargreaves, Comber & Galton, 1996; Williams, 2008) in teaching each of these competences using a 7-point Likert scale. Additionally, participants were asked to describe the best and worst aspects of participating to identify any qualitative information that would not be captured by closed answer questions. The number of responses to the questionnaire is given in Table 1.

Table 1 Number of questionnaire responses and missing data

	Number of responses	Number of Complete Responses	Missing Data
Start of project teacher questionnaire	22	19	13.64%
End of project teacher Questionnaire	30	24	20.00%
Both the start and end of project teacher questionnaires	18	15	54.55%
Total unique teachers (n = 33)			

A mixed methods methodology was applied to the design of the questionnaire and the analysis of data. This will address the strengths and weaknesses of both positivist and interpretivist data analysis by combining quantitative and qualitative methods (Johnson & Onwuegbuzie, 2004; Johnson, Onwuegbuzie, & Turner, 2007). The Likert scale scores were analysed using non-parametric descriptive statistics of central tendency and variance. The pre and post-intervention data were compared using Wilcoxon Signed Rank Tests. Qualitative data were analysed using thematic analysis coding (Braun & Clarke, 2006). The processed data was analysed using selected theoretical models of teacher knowledge (Banks et al., 1999; Mishra & Koehler, 2006; Shulman, 1987; Turner-Bisset, 1999)

### KEY FINDINGS

The demographic information about participants in this study revealed that participants were 61.90% (n = 21, 90% CI [44.32%, 79.48%]) BA creative arts and design degrees. This suggests a similarity between the participants of this study and the estimated population data of D&T teachers (Jones, 2016). A z-test for two sample proportions calculated that there is no significant difference between the two proportions ( $Z = .410$ ,  $p > .05$ , two-tailed).

The median and Interquartile range statistics were used to identify teachers' strengths and weaknesses in STEM teaching confidence. On the seven-point Likert scales used, values <4

were negative confidence and >4 were positive confidence. The competences identified are shown in Table 2.

Table 2. Strengths and Weaknesses in teaching confidence

Strengths in teaching confidence	Weaknesses in teaching confidence
Q1. the classifications of materials by structure	Q4. designing products with compound gear trains or other similarly advanced mechanical systems
Q9. using the correct technical vocabulary	Q7. building 3D textiles from simple 2D fabric shapes
Q16. measuring and marking materials and components accurately	Q8. modifying the appearance of textiles using techniques such as dying or applique
Q17. the use of CAM for scale of production	Q13. how to produce products that contain electronic sensors and outputs
Q19. using hand tools and manual machines	Q14. Programming
Q23. health and safety	Q15. incorporating microcontrollers into their products
Q24. performing risk assessments	Q22. using CNC milling/turning/routing machines

A significant difference in start (n = 19, Mdn = 5.4, IQR = 1) and end (n = 24, Mdn = 5.6, IQR = 1) of project scores for all teachers was found using a Wilcoxon Signed Ranks Test of Exact Significance (2-tailed) (n = 15, Z = - 3.150, p = .001, r = .58). There was a significant increase in the scores of teacher confidence in technology teaching. The specific items that were improved across all participants were:

- Q13. how to produce products that contain electronic sensors and outputs (n = 15, Z = -2.121, p = .031, r = .39)
- Q14. programming (n = 15, Z = -2.232, p = .016, r = .41)
- Q15. incorporating microcontrollers into their products (n = 15, Z = -2.251, p = .016, r = .41)

The key findings of qualitative questionnaire analysis are presented in Table 3. The thematically coded responses and the number of codes are shown.

Table 3. Coded analysis of responses to qualitative questions with number of coded responses

Positive Feedback Code	Negative Feedback Code
Developing new schemes of work (14)	Time Constraints (10)
Developing pupils capability (11)	Difficulties with projects (6)
Pupil interest (7)	Cost prohibitive (5)
Discussing work with other teachers (7)	Teacher development (5)
Professional Support (4)	Engaging pupils (2)
Awareness of subject (1)	Content of projects (2)
	Unsustainable in school (1)

## DISCUSSION

The items classified as strengths are based on the making of products and using materials. The weaknesses are about the use of more advanced technology such as systems and

control of mechanics and electronics, also the use of specific 3D manufacturing technologies that require CAD knowledge. The weaknesses in teaching confidence suggest that teachers are least confident about teaching the areas of technology that required mathematics and scientific knowledge. This work does not question teachers' ability to teach, their pedagogic knowledge, but does question if they have all the necessary subject knowledge to teach the more technological aspects of the D&T curriculum. As the majority of teachers do not have a background degree in technology or engineering subjects, and prior degrees are typically the dominant source of background knowledge (Atkinson, 2011; Banks, 1997; Benson, 2009). Teachers do appear to be attempting to improve their STEM knowledge but do not have the time to do so and simply providing resources for students will not directly help to improve teachers' ability to deliver STEM content.

## **CONCLUSIONS & RECOMMENDATIONS**

There is a misalignment between the subject knowledge of technology teachers in school and what is expected of engineering education. This will have a significant effect on the type of technological content taught in schools and may not sufficiently expose pupils to engineering.

This has implications for engineering education in how the undergraduate curriculum should be developed to account for lecturers' expectations in prior knowledge. This issue will continue to expand with the decrease in the number of pupils choosing to study technology subjects. Universities can use this information to assist in outreach and recruitment activities to understand why engineering is not being promoted in schools, as it is unknown to the teachers. The future impact of university outreach activists could be greatly improved by providing teacher development activities to improve schools' own ability to deliver engineering education.

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