Perceptions of STEM, within the context of teaching D&T in secondary schools: A phenomenographically inspired study

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Context

The teaching and learning of Science, Technology, Engineering and Mathematics (STEM) as an area is high on the educational agenda of governments both nationally and internationally. In the United Kingdom (UK) the supply of highly qualified scientists, technologists, engineers and mathematicians is perceived as vital in securing the future of the UK's economy (Roberts 2002).

Amidst the spending cuts across the English educational system, STEM thus far has escaped, as this Initial Teacher Training (ITT) related quotation illustrates:

> *"The Review recommends a major campaign to address the STEM issues in schools. This will raise the numbers of qualified STEM teachers by introducing...new sources of recruitment, financial incentives...and mentoring for newly qualified teachers."*
>
> Sainsbury (2007)

Worryingly however this investment has not been extended to include those aspiring to train to teach Design and Technology (D&T). Previously classified as a 'shortage subject' by the Teacher Development Agency (TDA:2010) the latest documentation (DfE 2011) presents a £9,000 bursary for those holding a first class honours degree (those holding a 2:1 classification will be awarded £5,000 and those with a 2:2 will receive no bursary) however for those holding a first in physics the bursary has been increased to £20,000 (DfE 2011).

D&T has much to offer the STEM agenda, however as Barlex (2008) notes, its' position in relation to STEM has *"oscillated between insignificance to [that of] valued contributor"'* for some time, and this perceived lowering of status, illustrated through the inequality of ITT bursary's is not the only cause for concern. These changes come at a time when the majority of schools are introducing the English Baccalaureate (Ebacc), which does not include D&T and as a comparatively expensive subject, which when coupled with this non compulsory status, presents a threat to its survival.

As a relatively new curriculum area, introduction as a result of the 1988 Education reform Act, the then Secretary of State for Education, Sir Kenneth Baker defined D&T as a subject:

> *'...in which pupils design and make useful objects or systems, thus developing their ability to solve practical problems"*

Baker was clear in his remit, defining a context for how this new subject would operate and highlighting the preferred curriculum allegiances:

> *"The working group should assume that pupils will draw on knowledge and skills from a range of subject areas, but always involving science or mathematics"*
>
> Department for Education and Schools,(DfES 1988)

When delivered effectively, D&T can help children better understand, through practical application, theoretical aspects of science and maths and it is upon these principles that the subject was first conceived. However the preoccupation with STEM has led some D&T teachers to express concern in relation to the potential loss of individual subject identity. This has created pockets of resistance, with some teachers reluctant to engage in the STEM agenda. This debate (Lewis et al, 2007, Barlex 2009; Pitt, 2009; Williams, 2011) about D&T's value and place within the curriculum provides the context for this study.

Methodology

At the outset of this study, the intended methodological approach was phenomenography.

As an approach, phenomenography seeks to identify multiple perspectives held by a particular group in relation to the same phenomenon, with the purpose being to highlight variation in the collective and in doing so present alternative views rather than focussing upon the individual experience (Åkerlind 2005). According to Åkerlind (2005) phenomenography emerged from an empirical background, as opposed to a theoretical or philosophical one, and may be defined as the study of ways in which various phenomena are experienced, conceptualised and understood (Marton 1994). '*Reality is a human construct*' (Wellington 2000) which presents itself as an interpretivist epistemology, and from this perspective there is no single view of the world, a real (objective) world 'out there' and a subjective (mental representation) one 'in here' (Marton and Booth 1997) which leads to a non dualistic ontological approach (Marton 2000).

It is through this approach that I sought to explore the lived experiences of D&T teachers in relation to their understanding of STEM. When using phenomenography as a tool to identify different perceptionial understandings, as originally intended in this study, it is vital that the researcher understands that people may experience the same 'thing' in different ways because what we experience is our reality, whilst our 'natural attitude' is however to assume that our world view is the same as experienced by others (Fazey and Marton 2002).

Critisim of phenomenography as a research approach (Sandbergh 1997, Webb 1997) focuses upon the researcher's inability to set aside their own preconceived ideas as data is sorted, which is vital in avoiding bias in order to prevent the misrepresentation or distortion of findings.

In this study, as a beginning researcher, whilst the data has been gathered using phenomenographic strategies, analysis of the data has not been analysed as it should, in order to produce the qualities and outcomes expected for a phenomenographic study. This paper therefore presents findings, derived from the 'raw data', which are influenced by phenomenography.

Ethics

Research has been conducted in accordance with the ethical guidance described by British Educational Research Association (BERA 2011). Informed consent was obtained and assurance given with respect to confidentiality, anonymity, and the rights of withdrawal.

Sample

In this study the sample size was nineteen (n=19). In line with phenomenographical selection criteria, participants were selected to encompass as much demographic variation as possible, and as such met the following criteria;

- All held Qualified Teacher Status (QTS)
- All were employed in mainstream secondary education in England
- All were teaching D&T (National Curriculum)

In relation to D&T; participants held expertise in; catering, hospitality, food, child development, product design, resistant materials, electronics, systems and control, textiles (including art textiles and Textronics), graphics, engineering and motor vehicle maintenance.

Three participants taught only one area of D&T, whilst nine delivered four or more. Three taught areas considered to be 'outside' of the subject including; mathematics, science, Information Communication Technology (ICT), art, Personal Social and Health Education (PSHE), and Religious Education (RE). The group comprised of ten women and nine men. The cohort age ranged between twenty-eight and sixty-two years old. Years in service ranged from one to thirty-nine. All participants were working within their respective institutions on a full time basis and had spent between one and thirty-one years working within their current school.

With regard to Teaching and Learning Responsibility (TLR), management or other allowances held, one was second in department, four were heads of department and one was an assistant head teacher. A further four held allowances for pastoral positions, one was an Advanced Skills Teacher (AST), one was head of PHSE and another was the schools Special Education Needs Co-ordinator (SENCo). One was a STEM co-ordinator and two ran post school STEM clubs.

Geographically participants worked within six local authorities across the North West of England, with one teaching outside of England, but following the English National Curriculum. Six schools were designated as technology or engineering colleges, one was classified by Ofsted as being in '*special measures*' and another had been served with *'notice to improve'*.

Research design

Semi-structured interviews designed to gather 'the lived experiences of participants' were undertaken using phenomenographical procedures advocated by Kvale (1996) and Bowden and Green (2005). The same 'initial' question was posed, with supplemental questions asked if the natural flow of conversation began to cease. Participants were asked to talk about their favourite D&T project, and as the conversation developed participants were encouraged to articulate the skills, knowledge and understandings embedded within the project. In order to elicit rich, detailed descriptions further questions sought to ask '*why?*' rather than '*what?*' (Åkerlind 2005). Participants were encouraged to discuss how the project linked to areas of the curriculum and only as conversation closed was a question about STEM posed. Depending upon the interviewee's response this either brought the interview to a close or enabled its continuance.

Interviews lasted between forty-five and sixty-five minutes, were transcribed verbatim (Ashworth and Lucas 2000), which involved participants verification of their accounts to ensure that perceptions had been accurately captured, following which all interviews were anonymised.

Analysis

Phenomenographic analysis strategies vary, Walsh (1994) advocates whole transcript analysis, whereas Svennson and Theman (1983) and Prosser (1993) prefer to explore segments and smaller section analysis. The approach taken in this study sought to consider the transcripts as a whole. A simple coding system was used to illuminate similarities and highlight differences. An iterative, analytical approach was adopted, which involved checking and continually sorting and comparing data. This is a phenomenographic technique through which analysis continues until no new data emerges. The data is then treated as a single transcript, with different perceptions being used to produce "*conceptions from a pool of meanings*" Åkerlind (2005).

Analysis then attempted to focus upon the identification of the qualitative differences in variation, with the 'space' in-between each being derived from the variation of importance. It is through this process that conceptions are aligned not to individuals, but to the group, giving rise to the formation of conceptions which can be organised to create a hierarchical set of understandings which are referred to as 'outcome spaces' or 'categories of description' (Marton 1994).

As a beginning researcher I applied the knowledge I had of phenomenography to generate the data set being considered and create a series of hierarchical outcome spaces. However, upon reflection, it is clear that having analysed the emergent data I have generated outcome spaces which in reality served to describe the participants understanding of the acronym 'STEM'. This is in contrast to that which I know to be the desired realisation of "outcome spaces" that reflect participant's lived experience (deep understanding) of the phenomena under consideration.

As shown below (fig.1.), initial attempts to analyse the data using phenomenographical techniques led to the creation of four hierarchically empirically grounded outcome spaces:

	Outcome Space
1	Demonstrates no awareness of STEM
2	Demonstrates an awareness of STEM; Maybe able to define the acronym, but is unable to link STEM to the work they undertake.
3	Demonstrates an understanding of STEM; Able to define STEM, and illustrates through examples how STEM can be delivered and links to their own teaching
4	Fully aware; Demonstrates a deep level of knowledge and understanding, is able to articulate citing fully and in-depth examples easily and confidently

Fig.1. – Initial outcome spaces derived from iterative DATA analysis.

However as the table illustrates (Fig.1.), the spaces are descriptive, illustrating only the participants ability to define STEM. Despite being driven by methods suitable to a phenomenographic methodology I have not been able to derive an outcome that strictly adheres to the principles of phenomenography. However, following analysis, the results I have arrived at have given rise to several findings which are of significance.

Raw Data; Presentation, Analysis and Discussion

Within the research sample, seven (7/19) participants held a food related background. During data collection two participants (2/19) described projects which integrated a significant number tasks which would be considered to be 'STEM' as this quotation illustrates;

> *"We teach a project on multi-cultural foods. Pupils are taught about cereals, cooking skills, presentation and packaging... it links to RE, PSHE and literacy... what? Does it link to STEM? No I don't think so ... I don't know what that is sorry"*

However both participants, whilst delivering exceptional lessons that clearly contribute to the STEM agenda, had no awareness of STEM, and consequently were therefore unaware that they are doing so. Of the participants (7/19) who described food related projects (all of which demonstrated clear links to STEM) two (2/7) had no awareness, three (3/7) demonstrated a limited awareness, and two (2/7) expressed confidently links in relation to the agenda they were effectively contributing to. Whilst it is some time ago (in England) that this area became known as Food Technology, much to the frustration of many, it is not uncommon to find previous titles, 'domestic science' and 'home economics' still in common use. This in itself creates an interesting paradox, as aspects of both previous titles make specific reference to STEM.

Seven participants (7/19) were able to demonstrate an awareness of STEM, but were not able to accurately define the acronym. Their language demonstrated a knowledge deficit in relation to an in-depth understanding, and they were not always fully aware that they were delivering aspects of STEM within their own practice.

The majority of teachers however (12/19) were easily and accurately able to define STEM. Their responses articulated how almost any task taught within design and technology can address aspects of STEM, however during analysis it became clear that whilst knowledge was not an issue, the participant's personal opinion of STEM and its place within the D&T curriculum was. In this study advocates sought to promote STEM which was in direct contrast to those 'opposing' STEM, who perceive the development of the agenda as being detrimental to D&T:

> *"Yes it links to STEM but no I don't make that explicit to the children….in my opinion D&T shouldn't be used as a vehicle for science and maths to realise their own curriculum"*

A further finding was the perception, cited by a significant number of participants (10/19) in relation to the difficulties they frequently faced in their attempts to deliver STEM. From the research group only one participant had a specific period of allocated time during their teaching day to deliver STEM. Where STEM was cultured in other settings, this was developed within the teachers own time with delivery taking place 'after school'. Lack of support or engagement from staff in STEM related subjects / departments and working in isolation were cited as barriers to effective delivery. In contrast some participants cited feelings of exclusion from the funding and organisational arrangements within their own institutions.

Conclusion

Whilst not phenomenographical as originally intended, this study brings to the fore several issues;

As findings from this study indicate, a number of participants express concern about STEM seeing it as a threat which could consume D&T as a subject within its own right. The latent 'power' of the teacher's personal perspective and their potential to either impact or sabotage the successfully embedment of STEM should not be underestimated.

Despite the argument for 'dispositions' (Hardy et al, 2008), currently within the English education system, STEM is not delivered as a single curriculum area. Frequently it is addressed through individual subject disciplines and STEM interrelated initiatives, such as science and engineering clubs (Mannion and Coldwell, 2008).

Findings presented here would suggest that in reality, despite the best efforts of those who have been tasked with implementing the STEM agenda in schools, as aspects of the STEM cohesion programme final report echo (DFE 2011), dissemination and equality of access in relation to STEM in schools is not as effective as it perhaps could be. There are a number of teachers (of D&T) who are unaware that they are delivering STEM, or who are unsure of the contributions that they can and do make.

Furthermore findings highlight tensions in relation to the actual delivery of STEM. With some (teachers of D&T) being unsure if it is within their remit and responsibility to engage, whilst others (with a desire to be involved) cite barriers which excluded them from doing so. Where participants believe themselves to be engaged in the delivery of STEM, the majority reported that they were doing so within their own time (after school) and / or in isolation of other STEM subject related colleagues.

It is intended that the data yielded from the interviews will be reanalysed using phenomenographical methods to produce outcome spaces which reflect 'the lived experiences of design and technology teachers' as this methodological approach originally intended in addition to the findings already arrived at through previous analysis of the data (Fig.1).

References

Åkerlind, G.S. (2005). *Variation and commonality in phenomenographic research methods*, Higher Education Research and Development, Vol. 24, pp. 321-334.

Ashworth, P. and Lucas, U. (2000). *Achieving empathy and engagement; A practical approach to the + design, conduct and reporting of phenomenographic research,* Studies in Higher Education, Taylor Francis, Vol 25:3, 295-308.

Barlex, D. (2008). *STEM - can we still be cheerful?* DATA news February 2008, DATA:Wellesbourne.

Barlex, D. (2009). *The STEM Programme in England – help or hindrance for design & technology education?* PATT22 Conference, Delft, Netherlands, Available at: http://www.iteaconnect.org/Conference/PATT/PATT22/Barlex.pdf

BERA (2011). *Ethical Guidelines for Educational Research*, Available at: http://www.bera.ac.uk/publications/ethical-guidelines

Bowden, J. and Green, P. (eds) (2005). *Doing Developmental Phenomenography,* RMIT University Press, Melbourne.

Walsh. E. (1994). *Phenomenographic analysis of interview transcripts,* In Bowden, J. and Walsh, E. (eds) *Phenomenographic research; variations in method (p17-30)* The Warburton Symposium, Melbourne, The Royal Melbourne Institute of Technology.

DFE (Department for Education) (2010). *The Importance of Teaching,* Available from: https://www.education.gov.uk/publications/standard/publicationdetail/page1/CM%20 7980

DFE (Department for Education) (2011). *Training our next Generation of Outstanding Teachers,* Available from: http://www.education.gov.uk/schools/careers/traininganddevelopment/a0078019/training-outstanding-teachers.

DFE (Department for Education) (2011). The STEM cohesion programme: Final report, Available at: https://www.education.gov.uk/publications/eOrderingDownload/DFE-RR147.pdf

DES (Department for Education and Skills) (1988). Terms of reference of the Design and Technology Working Group National.

Fazey, J.A. and Marton, F. (2002). *Understanding the Space of Experiential Variation,* Active Learning in Higher Education 3; 234, Available from: http://alh.sagepub.com/cgi/content/abstract/3/3/234,

Hardy, G. Howes, A. Spendlove, D. and Wake, G. (2008). *Opportunities to confront and cross subject boundaries: Trainee teachers' perceptions of the differences and interrelationships between STEM subjects,* Paper presented at the British Educational Research Association Annual Conference, Heriot-Watt University, Edinburgh.

Kvale, S. (1996). *Interviews: An introduction to Qualitative research Interviewing*, Sage Publications,Thousand Oaks, California.

Lewis, T. Barlex, D. Chapman C. and Christer, K. (2007). *Investigating interaction between science and D&T (D&T) in the secondary school – a case study approach,* Research in Science and Technology Education, 25, 1, 37-58 Routledge, UK.

Mannion, K. and Coldwell, M. (2008). After-school Science and Engineering Clubs Evaluation: Final Report, Available from: https://www.education.gov.uk/publications/standard/publicationdetail/page1/DCSF-RW071

Marton, F. (1994). Phenomenography, in T.Husen and T.N. Postlethwaite (eds) *International Encyclopaedia of Education,* Vol. 8, second edition: 4424-29, Oxford: Pergamon

Marton, F. (2000). The structure of awareness, in J. Bowden and E. Walsh (eds), *Phenomenography,* Melbourne: RMIT University Press

Marton, F. and Booth, S. (1997). *Learning and Awareness Mahwah,* New Jersey: Lawrence Erlbaum Associates.

Pitt, J. (2009). *Blurring the Boundaries – STEM education and Education for Sustainable Development,* D&T Education; an International Journal, Vol 14, No 1.

Prosser, M. (1993). *Phenomenography and the Principles and Practice of Learning,* Higher Education Research and Development, Vol. 12(1):21-31.

Roberts, G. (2002). *SET for success: The supply of people with science, technology, engineering and mathematics skills,* Her Majesty's Stationary Office (HMSO), London, Available from: http://www.hm-treasury.gov.uk/ent_res_roberts.htm

Sainsbury, D. (2007). *The Race to the Top: A Review of Government's Science and Innovation Policies,* Her Majesty's Stationary Office (HMSO), London, Available from: http://www.hm-treasury.gov.uk/sainsbury_index.htm

Sandburg, J. (1997). *Are Phenomenographic results reliable?,* Higher Education and Research Development, Vol16:2, 203-212.

Svensson, L. and Theman, (1983). The relation between categories of description and an interview protocol in a case of phenomenographic research, paper presented at: Second annual human science research conference.

Webb, G. (1997). *Reconstructing deep and surface: Towards a critique of Phenomenography,* Higher education Vol 3 (2):195-212.

Wellington, J. (2000). Education research: Contemporary issues and practical approaches. London, UK: Continuum.

Williams, J. (2011). *STEM Education: Proceed with caution,* D&T Education; an International Journal, Vol 16, No 1.