Constructivist principles in maths lessons: Pi in the sky?

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Constructivist ideas about learning mathematics have existed at least since the second half of the 20th century, advocating learner sense-making through experience and discussion, and indicating the futility of lecturing and drill for long term understanding and retention. Governments and educational institutions internationally have endorsed these ideas, yet teaching in many cases remains transmissive and exam-focused and results in many students resisting further compulsory study after 16. This presentation reports on the results of a survey of over 500 sixth formers regarding their experiences of school mathematics teaching across ten constructivist principles, and compares their experiences in maths with experiences in science, ICT and English. The findings indicate that student experiences are diverse, but that many maths lessons do not embrace constructivist principles.

Keywords: constructivist, maths lessons, student experiences.

Introduction

Constructivist principles are the stock in trade of much teaching literature, initial teacher training courses and CPD. Piaget's seminal work in the last century in which he found that making sense of experience was the key to learning (eg Piaget, 1952), and Vygotsky's similarly important studies regarding the significance of social mediation (eg Vygotsky 1978) have been enormously influential in our understanding of education. An emergent constructivist perspective (Cobb & Yackel, 1996) recognises that both constructed and socio-cultural experiences are the building blocks of learning, yet this is still a theory of learning not teaching. A theory of teaching that utilises these principles would focus on the creation of opportunities to construct understanding (Pirie & Kieren, 1992).

There is a broad continuum of teaching methods, from didactic (reliance on teacher explanation, control of subject matter, memorisation) to discovery (investigation, collaboration, utilisation of manipulatives, problem-solving and reasoning). It is rarely advocated that one or the other should be used in all situations, but instead strategies should be selected in consideration of student need rather than teacher agenda. Traditional didactic techniques are frequently found to be unsatisfactory for long term understanding (OECD, 2016), engagement and enjoyment, (Boaler & Sengupta-Irving, 2016) and can result in students resisting the subject at A level and in their daily practices (Brown, Brown & Bibby, 2007).

A constructivist perspective focusing on student need is ostensibly endorsed in teacher education. Although not specifically directed by the Department for Education, the focus on fluency and reasoning, building understanding from prior learning and related topics, linking with other subjects in the National Curriculum guidance (DfE, 2014) and the focus on guiding pupils to reflect on progress, giving feedback, and recognising how children learn in the Teaching Standards (DfE, 2011), all indicate the expectation of constructivist, student-led approaches. And while

Ofsted have stated categorically that they do not have a preferred teaching style (Ofsted, 2017), a review of their reports (Peal, 2014) indicated that child-led lessons were consistently rated highly, while excessive teacher dominance was criticised (much to the disgust of the author!).

Similarly, a constructivist perspective is recommended within the sphere of maths education. The Association of Teachers of Mathematics (in the United Kingdom) includes in its website the statement:

> The power to learn rests with the learner. Teaching has a subordinate role. ('Aims and guiding principles' page, ATM, n.d.)

while the National Council of Teachers of Mathematics (in the United States) makes eight recommendations for effective teaching practices, all of which revolve around constructivist principles of reasoning and discussion (NCTM, 2014).

Yet O'Shea and Leavy (2013) describe how difficult it is to apply these principles in practice, even when teachers are motivated to do so. Challenges presented by large class sizes, the breadth of the curriculum, the mixture of abilities and the orchestration of group work, lead to the preference for safe, controllable didactic delivery. O'Shea and Leavy identify individual reasons for failure to implement student-led lessons including deeply rooted beliefs in traditional instruction due to its being the way the teachers themselves learned, and the temptation to intervene and direct because of the pressure of ensuring the outcomes that various stakeholders expect.

Study

Colleagues in the economics and education departments at the University of Reading collaborated on a questionnaire to be completed by the year 12 students in six local secondary schools: four comprehensives, one grammar and one church school. 528 responses were received, roughly equally distributed between male and female. The questionnaire was administered in the early weeks of the first term of sixth form in order to allow students the opportunity to recall their GCSE experiences. All year 12 students were surveyed in order to get the experiences of those who had and had not been successful in each of the subjects, but the sample was limited by not addressing those students who had not decided to stay on at sixth form, who may have had very different experiences. This is indicated by the very small proportion of students who did not get a C or above at GCSE.

The questionnaire asked about students' experience of lessons in maths, science, ICT and English, and was designed to focus on the following constructivist principles:

- Discussion
- Student agency
- Student reflection
- Relating to experience or the real world
- Individualising instruction
- Respect for different answers
- Wider focus than exam
- Teacher's unquestioned expertise

Other aspects of constructivist learning were not included for reasons of inter-subject consistency, eg the use of manipulatives was not relevant to English. Students were

asked to respond by indicating a position on a continuum between teacher-led and student-led lessons, where 1 was strongly teacher-led and 7 strongly student-led.

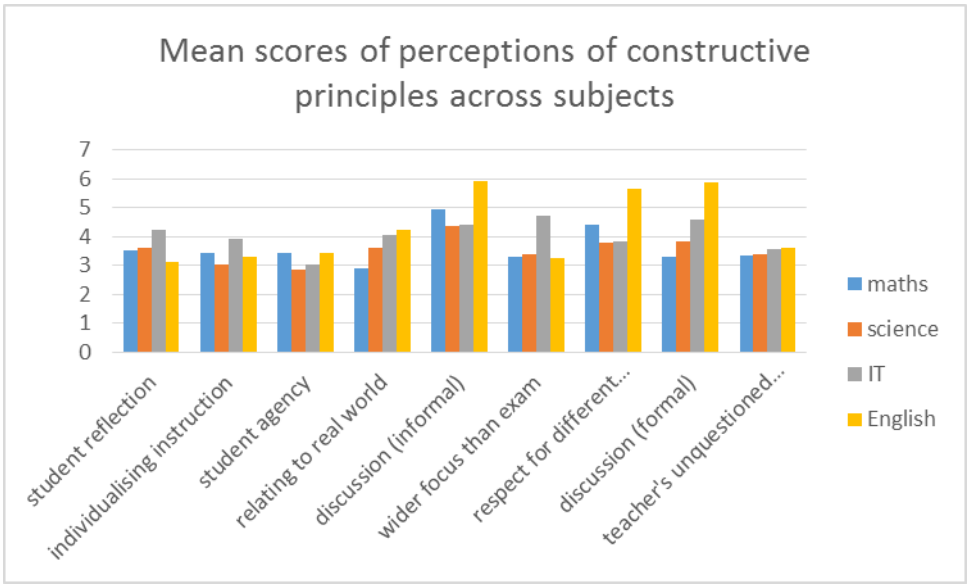

Figure 1: Mean scores of perceptions of constructivist principles across subjects

Calculations of central tendency indicated that students generally found that there was a balance of teacher-led and student-led factors (ie averaging at a score of approximately 4) in their lessons, with English frequently scoring more highly on student-led factors.

However these calculations of average mask the great variety of opinions given. There was very little consistency across the different principles, in that a lesson could be perceived to be strongly teacher-led in one respect and strongly student-led in another. The data was re-examined to look at factors that students felt strongly about, by looking at responses of 1 or 2 (strongly teacher-led factors) and 6 or 7 (strongly student-led factors).

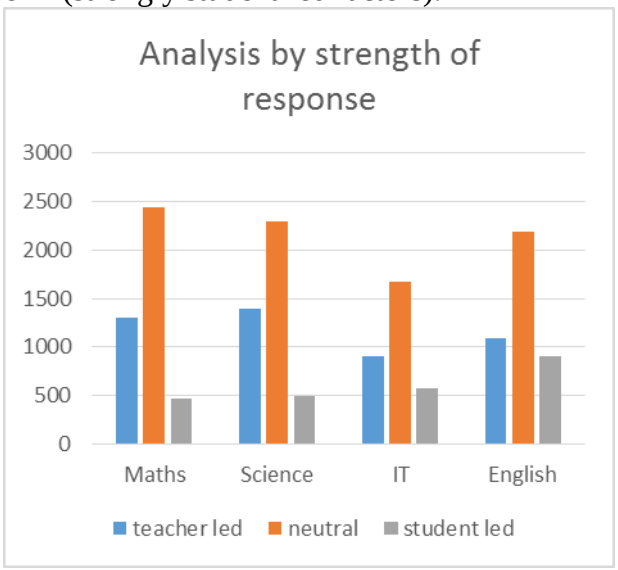

Figure 2: Breakdown of strongly teacher-led perceptions, neutral and strongly student-led perceptions.

The data indicated that perceptions of maths lessons were the least student-led of all the subjects, and closely followed science in perceptions of being teacher-led.

IT was perceived as the least teacher-led and English perceived as the most student-led.

An analysis of the different areas of constructivist principles indicated that maths lessons are relatively strong in not dismissing different answers, although they are far less likely than English lessons to view different answers very positively. Individualising instruction and encouraging student reflection are not common features of maths lessons, but better than science and English. Maths was seen as particularly unlikely to relate to the real world and personal experience, and while all subjects had a heavy focus on exams, maths lessons were seen as least likely to have any other focus. Student agency and teacher expertise were areas in which students were less likely to experience student-led approaches than in any other subject. Discussion was split into both informal (being allowed to chat to peers while working) and formal (being encouraged to give personal contributions to whole class discussion). Informal discussion was experienced by many, but formal discussion was considerably more rarely experienced than in any of the other subjects.

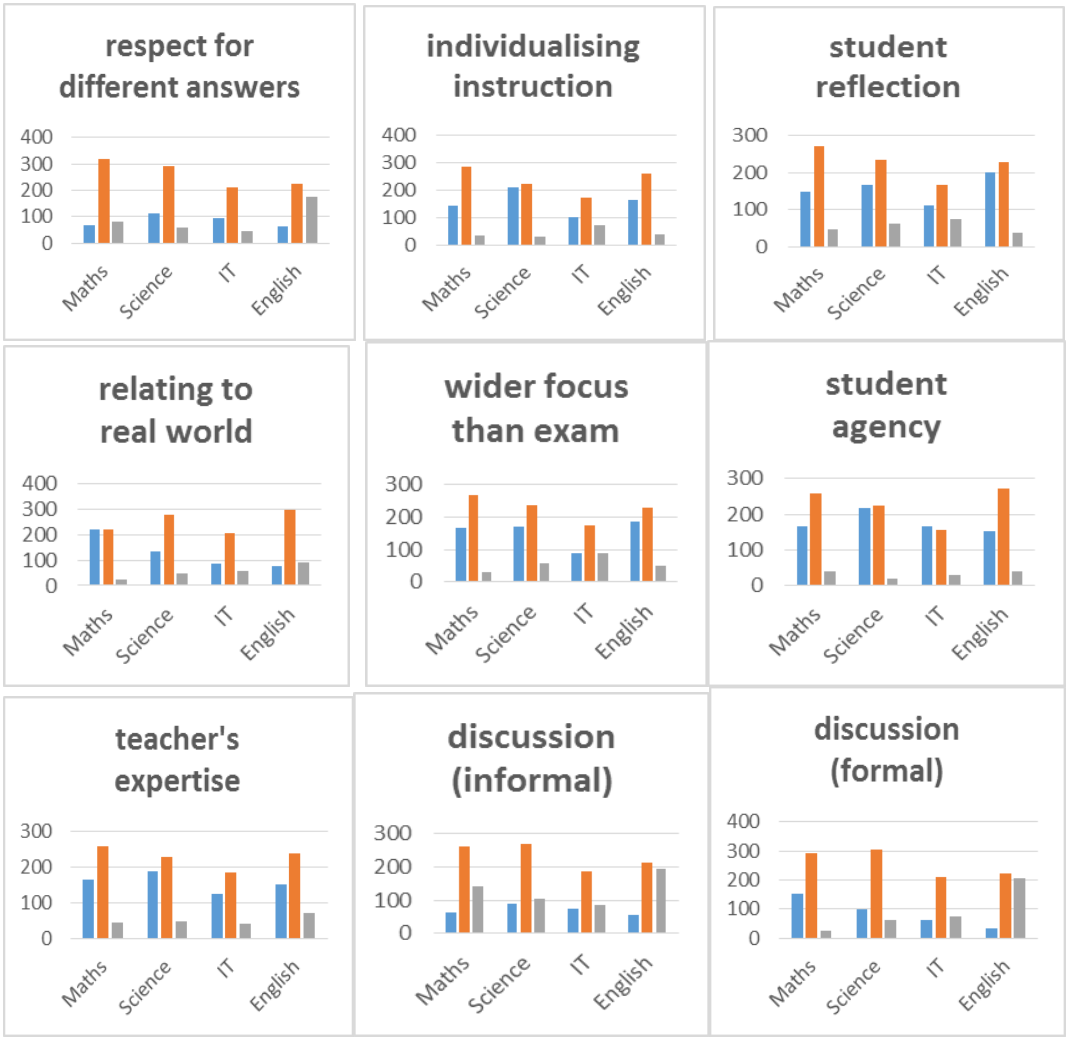

Figure 3-11: Analysis of strength of response in each of the constructivist principles

The data was investigated for differences between schools, or teacher gender differences but no clear picture emerged. There was consistency across schools regarding the absence of relating maths to the real world, and attitudes towards discussion. Experiences were most diverse regarding the degree of student agency.

Girls experienced the lessons as significantly less student-led in respect of reflection, exam focus and agency, but had higher perceptions of discussion and teacher not being an inviolable expert.

The survey's limitation in sampling only students who had stayed on to A level, and therefore excluding many of the low attaining students, means that there is a limited usefulness in linking responses regarding the perceptions of constructivist principles and GCSE grade. Nevertheless, the literature might lead one to expect to see greater success amongst students who had reported experiencing constructivist lessons – either because constructivist lessons are actually more effective, or at least because successful pupils might be more likely to see themselves as more influential in the lessons. In fact there was no correlation whatsoever between the respondents' perceptions of each of the constructivist principles investigated and the GCSE grade of the respondent. Students achieving A* grades were as likely or unlikely to rate their lessons as student-led as students achieving D grades. This corresponds to the findings of Stronge, Ward and Grant (2011) that there is no predictive relevance to the style of instruction.

Discussion

The lack of consistency between teacher-led and student-led principles within responses regarding the same lesson implies that strategies are not adopted as part of an overall theory of education, in that a teacher who was committed to a particular style of teaching would be expected to be consistent across different principles. Instead it appears that teachers are using different strategies in an eclectic way that do not conform to an integrated theory. If this is the case, what influences their choice? Is it an unconscious choice that has arisen over time, or a conscious choice of what works on an evidence basis? And if a choice of what works, to what end: student exam success, curriculum coverage, behaviour management or some other objective? The lack of correlation between perceptions of the utilisation of principles and GCSE scores does not provide evidence for a decision based on exam success. Further research is needed.

Conclusion

The constructivist and social-constructivist approaches have been influential on teacher training and teacher professional development in England for many years. The literature has made claims for greater understanding, greater engagement and greater enjoyment when constructivist principles are adopted. This survey finds that maths is the least likely of all subjects to create a strongly positive constructivist environment and a close rival to science in creating a strongly negative constructivist environment. Maths is particularly weak in connecting the subject to the real world or students' experiences, and is particularly likely to justify study only in terms of exam performance, and to venerate the teacher's position as expert.

Yet this survey indicates that the utilisation of constructivist principles has no correlation (within the limits of this study) on student success. Is this indicative that constructivist theory is fine in principle but not sustainable in everyday real-world schools, nor necessary for exam success – that it is just pie in the sky? Or does more have to be done to recognize the difficulty of implementation and offer teachers and students better resources and support? By advocating behaviour that is impossible to put into practice, and by failing to provide guidance on theoretical frameworks, we are setting up our teachers, as well as our students, for failure.

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