"the ways knowledge about tools and their affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners or difficult to be represented by teachers can be transformed and taught more effectively with technology in ways that signify its added value." (Angeli & Valanides 2009: 154)

Punya Mishra and Matthew Koehler (2006) examined three key components of ICT-TPCK, namely:

1 | competing resources; and
2 | lack of confidence both in the science content *and*
3 | the competency in using digital learning.

These are often too disparate to synthesize, since synthesis requires components that coalesce at some point, so consideration of the stability of the dimensions of a teacher's approach is prescient since it was a content focussed study – learning about science through technology. However, for Brennan, technology is the goal of the learning itself and this might also be considered as technocentric, except that Brennan uses Scratch as an affordance to higher-order thinking processes such as "creating," and "middle-order" thinking processes involved in social interaction. The three experiments outlined by Brennan were designed to disrupt technocentrism, but how successful was that?

« 7 » Brennan's work could be viewed within the framework of ICT-TPCK, and we particularly support her approach of focussing on pedagogical knowledge as opposed to content knowledge. However, we would suggest that there is a close relationship between the two and teachers may on the one hand find dealing with the pedagogical issues simpler, whilst their externally imposed learning outcomes may require an emphasis on content. Her work on challenging "technocentrism" is prescient since the constructivist is concerned with overall cognitive and emotional development not governed by an external objective reality. Technology can sometimes become such a reality, and in doing so, the user becomes the servant, and technology becomes the beginning, middle and end of learning.

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Changing Teacher Beliefs: Moving towards Constructionism

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> Upshot • If we are to move beyond technocentricism, we need not only to equip teachers with pedagogical approaches but to support a change in their beliefs, values and assumptions. While factors such as assessment practices and institutional norms can limit the impact of professional development by considering the ways in which teachers form their teacher-identity and the factors that can motivate change, we can begin to develop approaches to professional development that can have lasting impact on teachers and their learners.

« 1 » Teacher-role identity is influenced by the experiences that teachers have had as learners themselves. Many of our current teachers experienced a technocentric integration of technology into their own education and so this may be seen to be an acceptable norm. In asking how we can defend against technocentricism, Karen Brennan suggests that an extreme approach is to exclude digital technologies from core classroom experiences. Yet, unfortunately, this is not an uncommon practice. There can be a tendency to treat ICT or computing as discrete subjects, taught in silos by experts, particularly in secondary-level education. This is emphasised by the allocation of a specific timeslot in the timetable and an expectation that the "skills" are learnt there. This is just one way in which the "invisible curriculum" can be seen not only to influence learning but also teaching. There can be an expectation that students will have developed the skills required, either from these discrete classes or from their use of technology at home. This can result in a belief that teachers need not integrate the use of technology into learner-centred approaches as that "Key Skill" has been covered by someone else (in much the same way as numeracy and literacy skills are assumed to be covered in maths and English classes). Thus, in the classroom, ICT is used for ICT's sake (Bertam & Waldrip 2013), in a teacher-centred approach and to "tick-off" a requirement. On the other hand, it can also result in an assumption that students are able to use the technologies teachers ask them to, both effectively for learning and responsibly, when they may never have encountered them, least of all used them to learn *with* or *through*. Thus the teacher may find themselves frustrated at the lack of student progress on specific tasks, resorting to technocentric teaching of skills or avoidance of technology altogether.

« 2 » One approach to resolving technocentric teaching is to restructure the school day, providing support for teachers to collaborate, teach in teams and develop interdisciplinary lessons. This is used in the Bridge21 model for teaching and learning (Conneely et al. 2015), which emphasises the use of technology to mediate learning but is not dependent upon it. In a Bridge21 lesson, learners collaborate in teams in

which technical skills are developed alongside subject-specific knowledge. There is no expectation that learners will have separate ICT "training" to develop skills. Rather, skills are developed as required to facilitate the completion of projects. Importantly, the technical skills, along with developing knowledge and understanding, are held at the level of the team, not requiring any one individual to know "how-to" or for the whole team to gain, necessarily, a specific skill.

« 3 » Maria Daskolia, Chronis Kynigos and Katerina Makri (this issue) present an excellent example of some of the complexity that surrounds the use of technology to support learning through collaborative constructionist activities. The article highlights that the technology had to be learned and learners skills in the use of specific applications have the potential to constrain the final digital story that learners created. However, an interesting question remains – did the lack of these skills become a barrier to learning? As Brennan suggest, a technocentric view of technology in the classroom would lead to the answer "yes." However in this constructionist learning activity, learners were free to choose the technologies they felt would enable them to demonstrate their understanding and create their digital story. While a lack of technical skills may have limited their creative vision, there is no evidence to suggest it limited learning.

« 4 » So how can we best support teachers through professional development to move away from technocentric approaches to the use of technology in the classroom? It is essential that in any professional development programme, we address the underpinning ideas, beliefs and values of teachers, which Robin Alexander (2008) describes as informing, justifying and sustaining their existing practices. Pre-existing teacher-role identity (Knowles 1992) influences these ideas, beliefs and values, which are reinforced by pressures from national assessments and cultures of compliance within schools. These factors can limit the effectiveness of any new initiative and limit the potential for teachers to develop their practice beyond existing norms.

« 5 » Caroline Daly, Norbert Pachler and Caroline Pelletier (2009), in their review of CPD in ICT for the UK agency BECTA, recognise the importance of teachers taking personal responsibility for their learning and for CPD to be flexible enough to support personal learning journeys. Initial education and professional development courses can be seen to present an idealistic view of teaching and learning that does not always take into consideration curriculum and assessment pressures or the normalising effect of individual institutions. One approach that allows us to address this, and resonates with Brennan's article, is that of TeachMeets, which provide opportunities for professional development through a network of teachers who meet, share and discuss their practice, potentially alleviating these concerns. As a route to understanding the practices of others, this also has the potential to influence teacher-role identity.

« 6 » A final factor that Brennan and others may wish to consider in future work is the influence of student outcomes on teachers' ideas, beliefs and values. Thomas Guskey (2022) identifies positive changes in student outcomes as one motivating factor for teachers to change their own practice. While this may be the ultimate aim of CPD, I suggest that we should engage this motivational factor early on in the professional development process, demonstrating positive outcomes for students' learning at the beginning of the CPD process. This needs to be facilitated in an authentic manner that resonates with teachers' professional practice, is contextually sensitive and ideally provides an opportunity for teachers to observe and reflect upon the activities and outcomes for their learners without the distraction of managing learning.

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Embedding Inquiry and Workplace in a Constructionist Approach to Mathematics and Science Teachers' Education

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> Upshot · Brennan describes ways by which teachers can be supported to bypass a technocentric view of learning with technology in the classroom, from a constructionist perspective. She reports on the development of a corresponding model of professional development (PD) by describing the elements of the model and its design principles as well as the tensions that arose while trying to support teachers' explorations and experiences in the classroom. Questions arise about the potential of the model to be exploited to address issues underlying teachers' professional development in different contexts.

« 1 » My choice here is to explore further Karen Brennan's implication that the tensions she needed to negotiate with the teachers are not specific to her study and "can serve as a more general model for PD designers to scrutinize and critique" (structured abstract). I will try to link my experience as a teacher educator with Brennan's work, based on my current involvement in the European Union-funded project "Mathematics and Science in Life" (Mascil). It aims to promote a widespread use of inquiry-based mathematics and science teaching in primary and secondary schools through the connection between inquiry-based learning (IBL) and the world of work (WoW). The project runs PD courses of different types (e.g., face-to-face, e-learning) in all participating (13 in total) European countries. It provides an initial body of generic classroom tasks and a document containing guidelines for teachers to develop their own tasks by connecting IBL and workplace contexts.

« 2 » A distinctive feature of implementation in Mascil is its systemic character in terms of involving different institutional