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

and social contexts where context-specific interventions are planned and learning communities of teachers are established (e.g., groups of teachers from a single school or neighboring schools working in the same educational level). The teachers experience IBL themselves through their involvement in iterative cycles of design-implementation-reflection. To ensure widespread participation, the project adopts a scaling-up approach aiming to engage a large number of teachers in PD activities through a pyramid model based on the use of multipliers. Being one of the multipliers in the current year, my objective was to engage a group of 12 mathematics and science teachers in integrating technology, IBL and WoW in their designs and practice under a broadly constructionist perspective. It was expected that this integration would be facilitated through the teachers' engagement in adapting Mascil tasks or developing their own in the same spirit, based on authentic situations of workplace mathematics and/or science. The teachers were organized in a learning community that met regularly in face-to-face meetings (i.e., before and after implementations) and also had the choice to communicate asynchronously through a teachers' communication platform. Below, I use Brennan's categorization to describe briefly the tensions that I had to address/negotiate in the context of the community. I also highlight emergent implications /questions for in-service teachers' mathematics and science education.

Tension between tool and learning

« 3 » In developing their designs, the participating teachers faced the challenge of addressing the need to have a balance between a focus on the use of tools in the context of specific tasks (e.g., modeling the construction of a parking) and the students' learning of mathematics. This tension was resolved in the community through reflection on the nature of the emergent mathematical concepts in different types of designs (e.g., situation specific, open-ended) aiming to bridge school and out-of-school mathematics.

Tension between direction and discovery

« 4 » The tension between direction and discovery in Mascil was primarily based on the opposition between guided learning and IBL (Artigue & Blomhøj 2013). Since most of the teachers chose to develop their own tasks, they faced the dilemma of how much "exploration" could be integrated in their designs. One success that emerged in the evolution of implementation was that the newly developed tasks by the teachers were progressively less structured and more inquiry oriented. The factors that seemed to support this development were related to particular features of the PD courses such as the discussion of the IBL features of specific tasks as well as the sharing of successful implementations during the reflective sessions of the group.

Tension between individual and group

« 5 » The challenge of collaboration constituted a distinct feature of Mascil. Teachers were encouraged to develop their designs collaboratively so as to have a common ground for reflection after the classroom implementations. One emerging tension – that could probably be used to define new category or sub-category of tensions – concerned the teachers' reluctance to collaborate with colleagues that had a different discipline from their own (i.e., mathematics teachers vs. science teachers). This tension was resolved in the PD meetings by creating a space of making connections between pieces of content knowledge involved in mathematics and science tasks and reflecting on the potential of these connections for students' learning.

Tensions between expert and novice

« 6 » Most of the participating teachers in Mascil were experienced teachers. However, extensive classroom experience was not a condition adequate for considering these teachers as "experts." For instance, some of them did not have a "constructionist background," or they were never engaged in designing a classroom innovation. Thus, it was necessary for me to re-conceptualize the meaning of the opposition expert-novice in relation to the teachers' "readiness" to adopt an IBL approach in their lesson, as a first step in the direction of recognizing the learning potential of a subsequent constructionist experience in their classroom.

Tension between actual and aspirational

« 7 » Integration of WoW in classroom tasks constitutes an innovative challenge for teachers (Wake 2014; Hoyles, Noss, Kent & Bakker 2010). There are a number of emerging tensions underlying the distance between actual and aspirational in teachers' designs and implementations in Mascil. At the beginning of PD courses, the majority of teachers found it difficult to recognize the potential of integrating the WoW in their educational activities, invoking constraints posed by the curriculum and the available teaching time. However, the reflective practices cultivated within the group seemed to support them to appreciate gradually the potential value of integrating the WoW in their classroom teaching.

« 8 » The above description of the tensions I experienced when trying to support mathematics and science teachers to embed IBL and workplace in their teaching under a broadly constructionist approach indicates that the Brennan's model offers us a useful lens to address the tensions inherent in the process of educating teachers to adopt constructivist/constructionist approaches in different PD contexts. A number of questions can be raised to challenge her to extend her work. What structures can support teachers to engage in designing and implementing classroom innovations under a constructivist/constructionist approach? What is the role of other resources (e.g., tasks) or contexts (e.g., workplace) that might support teachers' constructionist approaches in the classroom? What are the features of the teachers' learning communities and the practices in which they are engaged (e.g., types of inquiry) that can support their explorations and experiences with constructionist approaches in the classroom? How do these features/practices influence the nature of the emerging tensions in teachers' PD activities? How can these tensions can be negotiated by the teacher educators so as to enhance the teachers' professional learning?

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Author's Response:
The Critical Context of Teacher Attitudes and Beliefs

Karen Brennan

> Upshot • The OPC responses aptly identified numerous factors teachers encounter that can impede changes in pedagogical practice in the classroom. Although some of these factors are external, beyond a teacher's control, I discuss one internal factor – a teacher's attitudes and beliefs about their role and the learners they support – that was raised in the responses.

A tale of two teachers

« 1 » Several years ago, I co-facilitated an introductory Scratch workshop, hosted at a regional technology conference for teachers. After the 20 participants arrived, we showed them three or four projects created by young learners, to give them a sense of what might be possible to create with Scratch. Then, we transitioned to hands-on time for the teachers. The activity was *Pass-It-On*, in which the teachers collaboratively worked on a project connected to the theme of Halloween (which happened to be on the upcoming weekend). We started the activity by modeling – this enabled us to introduce the basic mechanisms of Scratch (e.g., snapping blocks together, running the program), giving participants what we hoped was enough scaffolding to get started. After the modeling, pairs of teachers had 15 minutes to start their stories. After 15 minutes elapsed, each pair stood up, left their computer, and moved to another computer, where they continued the story that they found at the new computer. After another 15 minutes, the pairs rotated again, and then eventually returned to their original computers to see how the other sets of partners had modified their initial creations. Participants were usually surprised and delighted by the evolution of the projects in their absence. (Although some people were sensitive about changes to their original vision.)

« 2 » We asked participants to talk about their experiences with the activity and how such an activity might work in their own classrooms. One teacher expressed doubt about adding the activity into her lessons. "This was great for me, but I couldn't let my students get started this way. I'd need to show them more, right? I couldn't just let them play, right?" She looked around the room at the other teachers for confirmation.

« 3 » A teacher on the other side of the room quickly jumped in:

> "I don't think you need to be so structured. I've been using Scratch for about three years. I started using the Scratch cards with kids because I thought that was a good way to introduce it to them. So I asked them to go through each of the twelve cards before they could start their own project. But that was a big mistake because they got very bored with those cards immediately. Today, what I do with the cards is that I leave them on the table and the kids know the cards are there. They can look for a particular card when they need it. The kids want to be able to just work on their projects and be a little freer."

« 4 » Another teacher, sitting at the back of the room, forcefully raised her arm, while shaking her head:

> "I teach it a different way – I don't let them go and do it, because they just sit there and say, 'I don't know how to make the cat move!' So, I lead them through Scratch step-by-step. It takes me three or four weeks to go through all that. Because if I just ask them to make something, some of the kids – some of them are creative and do produce something – but a lot of them just make something dancing on a screen saying, 'Hi! Hi! Hi! Hi! Oh, you're cool! Hi! Hi!'"

Teacher attitudes and beliefs as context

« 5 » I was reminded of this experience as I read the responses from **Hugh Gash** and **Thomas McCloughlin**, **Carina Girvan**, and **Giorgos Psycharis**. All three responses raised important questions about the significance of context in supporting (or suppressing) constructionist approaches to learning in the classroom. In some cases, these questions focused on external factors – issues and constraints that individual teachers are subjected to as part of their lived contextual experience, but essentially beyond their control. For example, **Girvan** highlighted the constraining function that national assessments can exert on teachers experimenting with new pedagogical practices.

« 6 » Equally important, as the responses argued, a teacher's own attitudes and beliefs play a critical role in directing and shaping their interest, willingness, and ability to include constructionist approaches to learning in the classroom. This is what reminded me of the workshop experience. These two teachers – who were contextually similar, subjected to the same geographic, socioeconomic, grade-level, subject-area, and policy factors – differed primarily in their attitudes and beliefs about their role as teacher and the role and capacities of their students, a type of "internal" context.

« 7 » Too often, professional learning experiences are designed around a facile compliance model – one in which teachers have an experience that they are then expected, without attention or sensitivity to contextual variations, to execute faithfully in the classroom (Lieberman & Pointer Mace 2008). In fact, there is significant complexity in translating professional learning experiences into practice as teachers negotiate external and internal contextual factors (Windschitl 2002). And, although both sets of factors are important, given the limited control that most teachers have over external factors, I argue that it is critically important to engage the internal contextual factors in teachers' professional learning experiences.

« 8 » But what might this engagement look like? In the vision for professional learn-