Deep-play: developing TPACK for 21st century teachers

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Abstract: A key complication facing teachers who seek to integrate technology in their teaching is the fact that most technologies are not designed for educational purposes. Making a tool an educational technology requires creative input from the teacher to re-design, or maybe even subvert the original intentions of the designer. The learning technology by design (LT/D) framework has been proposed as being an effective instructional technique to develop deeper understanding of technological pedagogical content knowledge. In this paper we expand our description of the LT/D technique to develop what we call a deep-play model for teacher professional development. The deep-play model integrates:

a pedagogy for key 21st century learning skills
b content that cuts across disciplines with trans-disciplinary cognitive tools
c technology by the creative repurposing of tools for pedagogical purposes.

Keywords: technology integration; technological pedagogical content knowledge; TPACK; teaching.

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1 Introduction[1]

> "Technology presumes there is just one right way to do things and there never is. And when you presume there is just one right way to do things, of course the instructions begin and end exclusively with [one predetermined product]…. But if you have to choose among an infinite number of ways to put it together then the relation of the machine to you, and the relation of the machine and you to the rest of the world, has to be considered, because the selection from among many choices, the art of the work is just as dependent upon your own mind and spirit as it is upon the material of the machine." Pirsig (1974, p.160)

Teachers who chose to integrate technology into their classrooms face the difficult task of keeping up with rapidly changing technology, and confront a seemingly endless cycle of learning and relearning technology (Koehler and Mishra, 2008). New technologies bombard teachers from all directions. Facebook, iPhones, iPads, Flickr, blogs, cloud computing, Smart Boards, YouTube, Google Earth, and GPS devices are just some of the most recent examples. Though teachers often consider the possibility that these technologies could have pedagogical value, they frequently lack the skills and dispositions to risk experimenting and playing with them in order to optimise their educational impact. There is an alternative approach in which teachers with 'deep knowledge' create their own technological solutions, as needed, and tailor them to meet their curricular and pedagogical needs. This idea of teachers as designers (Koehler and Mishra, 2008) is important because most technologies are not designed for educational purposes (Mishra et al., 2009).

New technologies are rarely, if ever, designed for educational purposes. That said, teachers can make any tool an educational technology by re-designing it, or maybe even

subverting the original intentions of the designer. In order to do so, teachers need specialised knowledge of their subject matter, pedagogical approaches, and, of course, the technology. They must also draw upon their creativity, find new ways of looking at educational technology, be willing to play with technologies and ideas, and be open to constructing new experiences for students. In doing so, teachers can leverage technologies to become educational technologies, and better serve students by paying attention to deeper and more enduring ideas of teaching.

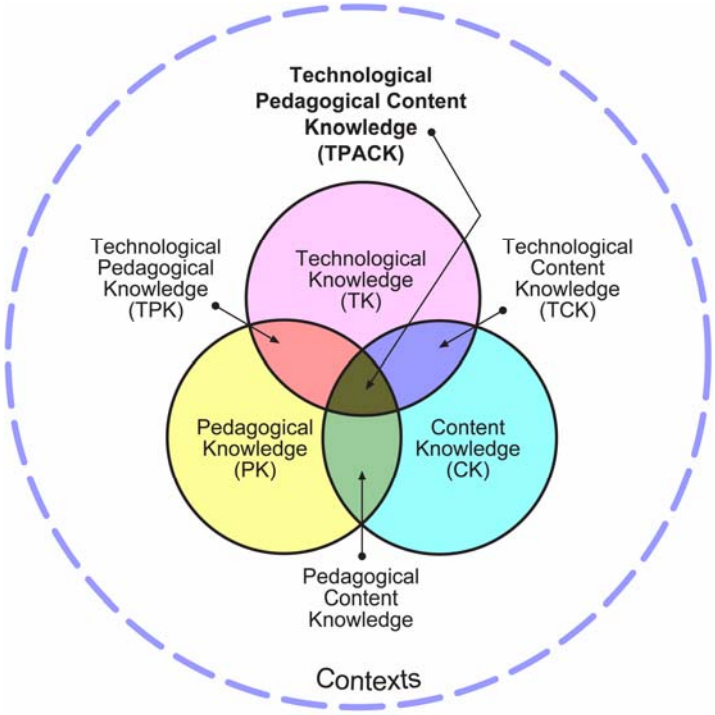
In this paper, we explore both the specialised kinds of knowledge teachers need in order to re-design technology, as well as an approach that uses this knowledge to foster teachers' skills in creativity, design, and playfulness with technology and ideas. We will introduce the technological pedagogical content knowledge (TPACK) framework (Koehler and Mishra, 2008; Mishra and Koehler, 2006) with its emphasis on the integration of three forms of knowledge: content, pedagogy and technology, as being the core knowledge that all teachers need to have in order to effectively integrate technology in their teaching. Having TPACK is necessary but not sufficient for teachers to become creative or innovative in their thinking about using technology for pedagogical purposes. Teacher educators, or those involved in teacher professional development, need to develop techniques that enable educators to explore the technology in rich contexts that allow for the creative interplay of technology, pedagogy, and content. We will then introduce *learning technology by design* (LT/D) (Koehler and Mishra, 2005a, 2005b; Koehler et al., 2004; Peruski and Mishra, 2004; Mishra and Girod, 2006/2007) as an approach to fostering TPACK knowledge, as well as the creative knowledge and skills needed to re-design and repurpose educational technology in classrooms. More specifically, in this paper, we expand our description of the LT/D technique to develop what we call a *deep-play* model for teacher professional development, that is, one that emphasises playfulness, creativity, and new ways of seeing. We conclude with several examples to demonstrate the deep-play at work in our LT/D approach.

2 Integrating technology, pedagogy, and content knowledge

Based on the *TPACK* framework (Koehler and Mishra, 2008; Mishra and Koehler, 2006), we argue that teachers can use creativity to rethink and re-imagine how the demands of the 21st century are changing the boundaries of *content knowledge (CK)* (what they teach) from rigid disciplinary boundaries to cross- and inter-disciplinary thinking. Likewise, creativity plays a role in teachers' use of *pedagogical knowledge (PK)* (how they teach), by helping them adapt to the new demands of going beyond rote test-based learning towards higher-order thinking skills. Finally, and most importantly teachers' creativity is also critical to understanding how teachers can adapt, reuse, and repurpose new technology for use in classrooms (*technology knowledge*).

The TPACK framework (Figure 1) includes these types of knowledge (pedagogical, content, and technology), but also requires teachers to go beyond knowledge of particular disciplines, technologies and pedagogical techniques in isolation. This kind of knowledge is a contingent, flexible kind of knowledge that lies at the intersection of all three of these knowledge bases, requiring teachers to develop deep, complex, fluid and flexible knowledge of all three components of the framework.

Figure 1 Components of the TPACK Framework (from tpack.org) (see online version for colours)



2.1 Developing TPACK, what comes first?

The TPACK framework describes the kind of knowledge teachers need to have but it does not specify exactly how this knowledge is to be developed. At one level, seeing technology as a tool indicates that it should come last in the curricular design process. In other words, educators should focus on specifying content and pedagogy and once that is done, attempt to find the appropriate technology. There are two key limitations to this approach.

First, new technologies often create new opportunities for representing content and pedagogy that did not exist before. By focusing on content and pedagogy at the outset educators can miss these new possibilities that emerge. The advent of the web and rapid growth of online learning is a good example where the advent of a new technology has fundamentally changed how we think about pedagogy and the representation of content (Burgstahler, 2000; Lowy and Ticoll, 1998). Similarly, new tools such as GPS devices, hand-held computers, and Web 2.0 tools have the potential to fundamentally change how and what we teach. Clearly educators need to be knowledgeable about these new tools and develop ways of integrating them into their curriculum. In such contexts, technology actually may be the driver of innovation in pedagogy and representation of content.

Second, it is important to realise that most technologies teachers use have typically not been designed for educational purposes. Technologies including standard productivity or office software, blogs, wikis, and GPS systems were not designed for education, and as such, teachers must repurpose them for use in educational contexts. This is a process

of *melioration,* or "the competence to borrow a concept from a field of knowledge supposedly far removed from his or her domain, and adopt it to a pressing challenge in an area of personal knowledge or interest" (Passig, 2007). Melioration acknowledges the importance and necessity of the cognitive skill of drawing on knowledge from varying domains and combining them in unique and effective ways. Such repurposing is at the heart of melioration and is possible only when the teacher knows the rules of the game, and is *fluent* enough to know which rules to bend, which to break, and which to leave alone. This requires a deep experiential understanding, developed through training and deliberate practice of all the aspects of the TPACK framework and how they interact with each other.

These two ideas, the new possibilities of technologies *and* the fact that many times new technologies have to be repurposed, have received little attention in schools and in teacher preparation programs. The fact that technology changes at a rapid rate means developing such skills or ways of thinking becomes critical. We argue that a combination of the TPACK framework with the idea of melioration provides us with a new framework about how teachers can be trained to develop better insights into teaching with technology, where sometimes it is the content that drives the tools (and their pedagogical use) and sometimes the possibilities of what the tools can do that can drive the pedagogy of the content. Technology is not an add-on but rather integral to teaching performance. In essence, teachers need to be provided contexts for learning that emphasise all three of these knowledge domains taken together, rather than in isolation or in sequence. This is an act of design.

3 Learning technology by design

We argue that one of the best ways to learn about educational technology is to *design* educational technology (Koehler and Mishra, 2005b). Through the design process, learners must constantly work at the nexus of content (what to teach), pedagogy (how to teach it), and technology (using what tools). Many students come to educational technology courses, programs, or professional development expecting to learn very specific skills (how to create web pages, how to use digital video, etc.) and specific software products (Dreamweaver, Adobe Premiere, etc.). A skills-based approach, however, has two important problems associated with it. First, the rapid rate of technological change ensures any knowledge gained about specific technologies or software programs would quite quickly become out of date (Mishra et al., 2009). Second, such learning is often de-contextualised, lacking connection with broader issues of technology integration with actual classroom practice.

Over the past years we have faced this dual challenge (of obsolescence and de-contextualisation) by situating the learning of technology within the context of *design*. Though the idea of learning by design has been used for years in disciplines such as architecture and graphic design it is relatively new within educational technology. Design-based classes involve working collaboratively on solving authentic problems rather than on lectures and demonstrations. The 'LT/D' approach often conflicts with student expectations and prior experience. Students in our courses work on design problems, seeking technological solutions to open-ended problems.

Our approach is loosely based on the "design studio" model (Cossentino and Shaffer, 1999; Hoadley and Kim, 2003; Ronen-Fuhrmann and Kali, 2008; Shaffer, 2002) that is

an integral part of most design professions such as architecture, graphic and product design. In these courses there is little or no direct instruction about technology but rather students become masters of their own fate as they work (either individually or in groups) to design educational technology artefacts. Similarly, we provide little direct instruction about specific technological tools and in fact rarely specify the tools or computer programs students ought to use. Instead students are expected to learn how to use these tools as and when required by the task at hand. The design projects students have produced have varied from semester to semester, but have included creating digital movies on educational topics, redesigning educational web sites, and developing online courses for the college of education (Mishra et al., 2007).

Design also represents the complex reality of practice with more fidelity than top-down approaches. Like teaching with technology, design requires a balancing act between a wide range of factors that often work against each other (features vs. cost, ease of use vs. advanced features, time to market vs. product quality, etc.). It requires the application of a wide array of knowledge, including algorithms, understanding of users, rules of thumb, scientific 'facts', and multidisciplinary connections. According to Smith and Tabor (1996), "design is as much an art as it is a science–spontaneous, unpredictable, and hard to define" (p. 221), much like teaching with technology.

Vygotsky (1978) and Dewey (1934) emphasised the role of dialogue or interplay in learning – as the individual acts on the environment, the environment also acts upon the individual. Design activities bring this interplay directly into focus. It is fundamentally about ideas and transforming oneself and the world through the process of working with those ideas. That is, the environment constrains and thereby acts upon the artefact (and therefore the designers), and the introduction of new artefacts changes the environment. This is especially true of technological artefacts, which exist in a transactional relationship with the world. That is, the artefacts are designed according to the constraints of the environment and, in turn, once these artefacts enter the 'real world' they change the very environment they were designed for. E-mail is a good example of this. E-mail's features, conceptual metaphors, and core operations are adopted from the environment of traditional ('snail') mail. Likewise, e-mail has changed the nature of text-based communication in the information age. Hence, design is essentially a dialogue between ideas and world, theory and its application, a concept and its realisation, tools and goals. We see this dialogue as being at the heart of true inquiry, involving as it does the construction of meaning and the evolution of understanding through a dialogic, transactional process.

The learning by design approach is consistent with current research and literature about teacher learning and professional development (Ball and Cohen, 1999; Borko, 2004; Edelson, 2002; Elmore and Burney, 1999; Garet et al., 2001; Penuel et al., 2007; Putnam and Borko, 2000; Rosenholtz, 1989). This research shows that teacher learning and professional development occurs both in the individual and the interpersonal areas. The learning by design approach allows practitioners to engage with both of these areas. Through engaging in pedagogical design activity with technology around specific content areas teachers not only gain knowledge of content, pedagogy and technology (and their relationships) they also engage in dialogue and collaboration to develop and scaffold their own learning. Thus, learning by design allows teachers to engage in 'deep' conversations about their practice; provides them with opportunities to experiment and 'play' with ideas, tools and subject matter; and offers contexts to reflect on their learning.

Furthermore, design is multi-disciplinary. Design lies in an area that touches upon a variety of disciplines – science, technology, psychology, and art to name just a few (Winograd et al., 1996). It is this multidimensionality that makes the act and process of design so important and so complex. The idea of design is particularly important in the arena of educational technology, where we try to bring the logic of technology to the world of learners and their minds. The ultimate goal of these courses is not just learning technology, but rather, changing the way our students view themselves with respect to technology.

4 Deep-play

The idea of play has received a great deal of scholarly attention in the last half century (Huizinga, 1950).[2] Though difficult to define, most descriptions of play appear to share four key attributes. First, play is voluntary, rather than imposed from outside. Second, play is intrinsically motivating. It is 'fun' for its own sake, independent of external rewards or incentives. Third, play involves significant levels of engagement, physical and cognitive. Though this engagement is often considered in physical terms it is not necessarily the case. Finally, play is significantly different from other behaviours we engage in due to its 'make-believe' quality (Blanchard and Cheska, 1985; Csikszentmihalyi, 1990; Pellegrini, 1995; Pellegrini and Smith, 1993; Yawkey and Pellegrini, 1984). Play has often been contrasted with work, though Blanchard and Cheska have argued this dichotomy is incorrect. They argued a more appropriate distinction maybe between play/not-play and work/leisure. Work, if it is intrinsically motivating (and external rewards are not the prime motivator for action), and has significant levels of engagement, can often be akin to play (Blanchard and Cheska, 1985). Play has been shown to contribute to the development of more flexible brains, leading to mental suppleness and a broader behavioural vocabulary. Play is also creative, akin to "improvisation of a jazz quartet, forcing us to respond rapidly to change" (Henig, 2008).

Pellegrini (1995), and Sutton-Smith (1997), argue that theories of play can be organised around four key themes: play as progress, play as power, play as fantasy and play as self. The theme of play as progress argues that play has an educational purpose (broadly defined), providing opportunities for developing and improving skills and knowledge. Most research in this area has focused on such play as being a crucial mechanism for children to learn to become adults. The theme of play as power focuses on competitive play, with clearly determined winners and losers. Most sports and games seem to fall under this category. Play as fantasy refers to the creative, imaginative or even fantasised world of play. Such play allows the player to engage in creative and imaginative thinking and has often been seen as being closely connected to the idea of play as progress where imagination and creativity become intrinsically motivating goals. Finally, the idea of play as self or play as identity refers to the idea of play to become part of a community or to optimise the player's experiences. This form of play values the intrinsic value of an experience over other outcomes (victory, creativity or learning).

Our vision of play for learning integrates three of the four themes (play as progress, play as fantasy and play as self), though the idea of play as power does appear in certain risk-free contexts. The three themes (progress, fantasy and self) allow us to think of play as being "training for the unexpected" (Spinka et al., 2001). Play, however, can be superficial, without a deep engagement with ideas and without reflection on the

knowledge being gained. Over the years we have explored how elements of deep-play can be incorporated in the Learning by Design approach. This model of teacher professional development emphasises playfulness (as it plays out in the themes above), creativity and new ways of seeing, all contextualised within the intersections of content, pedagogy, and technology.

By deep-play we mean an engagement with rich problems of pedagogy, technology and content and their inter-relationships. Deep-play is creative, seeking to construct new ways of seeing the world, and new approaches to using technology, in order to develop creative pedagogical solutions. By engaging in design with deep-play, educators can see themselves not as passive users of technology, but rather as active designers of technology, who creatively repurpose tools, technologies, and artefacts to meet their own goals and desires. At the heart of the learning technology through design courses is the goal of moving away from instrumental conceptions of technology towards developing a flexible, context sensitive, learner driven approach towards technology. As we have argued elsewhere (Mishra et al., 2009), an important aspect of learning to use technology for teaching requires developing a different mindset towards technology. This mindset is characterised less by an emphasis on learning specific tools than by developing flexible strategies for thinking deeply about the role of technology in the educational process.

Deep-play, as an instructional approach, encourages learners to 'play' with technology even while reflecting on deeper issues related to content and pedagogy. As such these assignments can be described as micro-design tasks that capture the richness and the complexity of the entire domain. This is consistent with recommendations that ill-structured domains, such as teaching with technology (Koehler and Mishra, 2008), are best taught by having students engage with tasks that are 'byte-sized chunks of complexity', i.e., neither simplistic nor too large (Mishra et al., 1996; Spiro et al., 1988). Simplistic tasks misrepresent the domain, and overly complex tasks are too much for the learners to grasp early on in their development.

Play is essential for educators for another important reason. As we have argued above, most technologies have not been designed for educational purposes. It is only through melioration (i.e., the creative repurposing of technology) that teachers can seek to meet the potential of technology for educational purposes. Play is the context within which such melioration/repurposing can occur. Play allows teachers to explore and invent, without fear of failure, to see pedagogical possibilities in the everyday technologies and to think of new ways of representing content.

The ill-structured and complex nature of design makes it difficult to teach. There are no overarching laws of design that apply across all cases and there are no context-free uses of tools (software or hardware). The deep-play approach rejects functional fixedness with respect to tool use and emphasises the value of re-seeing problems to develop unique and creative solutions that apply TK, PK and CK. What is common to all these activities is that they force students to look at the tools they have in terms of their inherent constraints and affordances and asks them to think carefully and creatively about how to leverage these to meet their design goals.

5 Examples of deep-play assignments

For the rest of the chapter we explore a range of different examples taken from a variety of courses we offer to practicing teachers who are students in our Masters in Educational

Technology (MAET) program. The following examples and the progression of the courses follow a spiral developmental pattern in which we can broadly identify three levels: *micro-design projects*, *macro-design projects* and *reflections on the total PACKage*. At each level students engage in open-ended, playful projects that increase in size and complexity as they move through courses in our program. Our goal in developing these assignments is to capture the complexity of the whole within 'byte sized' chunks. As we move through these projects (from micro to macro to reflection) our intention is to connect them to the themes of deep-play so as to scaffold student's growth and development of TPACK.

5.1 Getting started: micro-design projects

Micro-design projects are in a sense 'warm-ups' to get students thinking about design and to introduce them to the design process. The micro-design projects serve as a sort of introduction into the practice of deep-play. There are clear connections to ideas of play as progress, by providing students with creative, imaginative, and intrinsically motivating activities that also provide contexts for learning new technologies or to see old technologies in a new pedagogical light. The micro-design projects are less focused on the TPACK framework as a whole and more focused on getting students comfortable with design and encouraging them to start seeing the world from a new perspective.

- *Véjà du activity:* In a fully online course on creativity we have students do a series of photography assignments that seek to emphasise the key creative habit of mind being discussed at that time. One example is what we have called the véjà du activity. Just as déjà vu is the process by which something strange becomes abruptly and surprisingly familiar, véjà du is the very opposite. It is the seeing of a familiar situation with "fresh eyes," as if you have never seen it before, to make the familiar look strange. Teachers are asked to take a series of pictures of an everyday object in such a manner that viewers cannot easily determine what the item is and share them with the class using a free photo-sharing site such as Flickr or SmugMug. They do not reveal what the item is until the unit being covered is completed. Seeing these pictures leads to some fascinating conversations about representation, seeing, perception, creativity and design. This activity emphasises creativity and also highlights how the specific affordances of technology (in this case, the digital camera) may serve to help facilitate creative thinking or actions. This activity is used early in the semester in order to foreshadow the deep-play we expect during the semester. It requires students to see the world in new ways and also scaffolds the development of new skills (technical and aesthetic) with the digital cameras that allow them to repurpose the technology for new tasks. The students begin to better understand the affordances of the technology at hand and how those affordances can be used to enhance creativity both generally and for a specific purpose.

Other micro-design activities include creating a visual interpretation of a haiku using stop motion animation, writing a short story in 55 words, finding 'letterforms in nature' using digital cameras and so on. Each of these tasks is to be completed in a fixed amount of time (ranging from 30 minutes to two hours). Students find these assignments invigorating and challenging. Through these activities we seek to embody many of the social, collaborative and creative goals we espouse in our program. Work done by the students has been featured on websites and blogs and has served as a great example for

what our teachers could do in their classes. The primary purpose of these projects is to establish and foster the mindsets that will be necessary for design thinking and deep-play. At the same time, the projects often provide surprising insights for the students about the nature of creativity and design. For instance, the assignment on writing a short story in 55 words demonstrates how constraints (both in time and length) can actually encourage creativity, when most students previously believed that creativity necessarily connoted open-ended, time-consuming, unstructured activity.

5.2 Fleshing it out: macro-design projects

The next level of assignments or activities is macro-design projects. These are the first experiences students have with justifying and making explicit their design choices. In contrast to the micro-design activities, where the emphasis is on play as progress, the macro-design activities seek to also include the themes of play as self, where the participants start seeing themselves as designers of technology, pedagogy and content, and through this become part of a broader learning community. The macro-design projects warrant a deeper level of introspection and reflection on the part of the students and typically feature all three knowledge bases of the TPACK framework. In macro-design projects students are asked to complete multi-faceted pedagogical design projects and provide clear rationale for the design choices they made as well as reflect on the long-term learning resultant from engaging with the projects.

- *Understanding understanding:* These design projects helps learners see how entrenched, well-developed naïve conceptions and knowledge structures often interfere with what they are taught in school. Groups of in-service teachers, on a topic of their choosing:
  1. examine prior research of the common conceptions or alternate conceptions of their topic
  2. develop research questions and an interview protocol
  3. select and interview a variety of students to demonstrate understanding and misunderstanding from different ages and perspectives
  4. edit a video to demonstrate a variety of understandings about the topic
  5. create a web page for the project, along with a summary of what they learned.

  The project follows a very specific design process in its unfolding, in order to encourage the in-service teachers to do the same with their own teaching. At the same time, we emphasise creative construction of a web-based summary of the project as well as creative editing of the video clips. The project highlights various affordances of digital video that make the final presentations more easily understood and compelling to its viewers.

During this project, groups have interviewed a variety of subjects on a range of topics including: where shadows come from, thunder, the colour of blood, and how people view money. For instance, in the project about shadows, eight people were interviewed, ranging in age from two to 29 years. Interviewees answered questions for the camera, and also drew pictures of their own understanding (or misunderstanding) of the concept of shadows. They were asked: Where do shadows come from? Do objects/things have shadows all the time? Do you have a shadow at night? How about in a dark room? Can

you touch or step on your shadow? They were then asked to draw a picture showing how a shadow works, and to explain their thought process while drawing. Based on these interviews, an engaging and informative video was constructed to demonstrate the concepts of misconception and contradiction. In this video, it was clear that students between the ages of two and seven were able to contradict themselves regularly in their explanations, a development the group determined to be an invaluable lesson for teaching this age group. It is important to note that the process of synthesising the video clips is highly creative, and critical to the success of this project. For example, even excellent interviews merely stitched together haphazardly clearly did not work as effectively to inform an audience about teaching and learning as clips that were synthesised with the elements of a good story. The process of creating a fluid narrative with this material is when deep-play becomes the focal point in the overall design of the project.

Other macro-design projects include developing instructional websites and collaboratively authoring chapters of a book on creativity. In these macro-design projects, participants fully engage with the TPACK framework by explicitly (or implicitly) navigating the competing tensions between content, pedagogy and technology to solve complex problems of practice.

5.3 Reflecting on the total PACKage

Reflection projects are a chance for students to bring together their experience with basic design (micro-design) with the more complex macro-design to begin to think about their teaching in a fully integrated way with regards to TPACK. Thus, these assignments go beyond helping students flex their design muscles towards helping them step back and reflect on the Total PACKage. These projects capture all the three key themes of play (progress, self and fantasy) in some form or another. One can argue that some aspect of play as power does appear as well since students tend to be inherently competitive. Our experience, however, suggests that discouraging competition (or underplaying and under-emphasising this competitive aspect) is actually a better strategy, leading to greater levels of cooperation and shared communal learning. In these projects students look backwards *and* forwards, reflecting on their learning and developing strategies to continue to learn and explore even after the course or program is over.

- *TPACK related DreamIT proposal*: The TPACK Project has students identify a problem of practice, use the TPACK framework to address the problem, and create a web-based experience that presents his/her problem and solution to his/her peers while explaining the thinking process that led the student to that specific solution as opposed to others. Hence, there are two goals of the project:
  1. have students tackle a specific, authentic problem of practice and consider a plan for a solution
  2. share their problem, plan, and the thinking that went into it with a larger audience (i.e., represent it on the web).

Students come up with divergent authentic problems of practice and very creative projects both in terms of applying the TPACK model and their web-based representations. For example, John sought to address how he could help students engage in higher order thinking in an English class where most students' educational conditioning primarily emphasised memorisation and the idea that an answer is either

right or wrong. In applying the TPACK model, John initially began with searching for how technology could be a solution to this problem. However, John had already integrated a great deal of technology into his teaching. Hence, he concluded he needed to change his pedagogy to work within his specific curricular and technological context. Specifically, John used such technology as PowerPoint to deliver content as well as Blogger, Google docs, and Voicethread. However, he noted he used these in a rather passive manner. The technology supported the students' conditioned style of absorbing information rather than engaging the students in higher level thinking about it. With the same technology, John realised he needed to change the pedagogy of how he approached the classroom and use of the technology within his teaching. In essence, he wanted the technology use to change the way he taught and push his students to demonstrate their higher order thinking by sharing to larger audiences (i.e., producing information) rather than just their historical way of consuming information. In contrast, another student Liz also arrived at technology as a solution to her problem of practice – teaching social studies in a way that makes it come alive and challenges what is written in textbooks. Specifically, she chose to focus on Christopher Columbus for her TPACK project. Using an inquiry-based approach, Liz felt her technology options were limited, but eventually found an appropriate WebQuest that aligned with her pedagogy and curriculum. That is, the affordances of WebQuests matched well with the affordances of inquiry-based learning to address the specific problems she identified with her content (that textbooks represented only one perspective on Columbus).

The goal in these larger reflections on the Total PACKage projects is to develop the kinds of deep situated knowledge that is an essential characteristic of mastery. Clearly the work the students do in these projects does not guarantee mastery. It does, however, set them up to look deeply into the ingrained patterns of teaching subject matter with technology, play with these ideas and their relationships to each other, develop possible solutions and reflect both on their effectiveness and on their personal evolution as teachers. Teachers develop their TPACK through this iterative process of play and design with Technology, Pedagogy and Content, and the contexts within which they are embedded.

5.4 Does deep-play work?

The participants in our classrooms have often stated just how much they enjoy the classes and the deep-play based design-activities. Over the past couple of years, we have attempted to systematically study whether engagement in these activities actually helps develop TPACK (Shin et al., 2010). For this we have utilised the *survey of teachers' knowledge of teaching and technology* (Schmidt et al., 2009a, 2009b; Shin et al., 2009). The survey contained 47 self-report items that measured students' self-assessments regarding teaching and technology. Participants were asked to rate the extent to which they agreed or disagreed with statements about their perception of the relationships between technology and teaching on a five-point Likert scale. The survey consisted of the following seven sub-scales: technological knowledge (TK), CK, PK, pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK. The internal consistency reliability (Cronbach's alpha) ranged from .75 to .92.

We administered the *survey of teachers' knowledge of teaching and technology* at the beginning and the end of a master's level summer course that specifically dealt with

technology integration in teaching. The course was taught as an integrated seminar over the course of two face-to-face weeks and one month online. Participants, who were mostly in-service teachers, worked on a range of deep-play assignments as described above. Specifically, these assignments included multiple micro-design tasks, the understanding-understanding video, the TPACK based DreamIT project, as well as the personal manifesto project.

Across the two summers, forty-six graduate students enrolled in this seminar of which a total of thirty-four students completed both the pre- and post-test surveys. Thirty-two of them were in-service teachers from K-12 settings. The results of our study show that in-service teachers' understanding of teaching and technology evolved as a result of a course experience. They reported becoming more knowledgeable about technology (TK), the use of technology in their subject matter (TCK), technology implementation in their teaching (TPK), and multi-faceted interactions of content, pedagogy, and technology knowledge (TPACK) compared to when they first started the course (Shin et al., 2010).

6 Conclusions

These deep-play activities *introduce students to the idea of design, design as process and product.* As they work on these open-ended, creative design tasks, students begin to understand there are no straightforward and predetermined ways to solve ill-structured problems. Solutions have to be developed through an *iterative process of negotiation and dialogue*. This dialogue has many forms. It can be among the individuals in the groups, but more importantly it is a dialogue between materials and ideas, between concepts and realisations, between technologies and the evolving artefacts. This aspect of how the materials "talk back" (Schon, 1983) to the designers is closely related to the idea of design being a process of negotiating with multiple constraints to develop creative solutions.

Students learn that despite the emphasis on the *process* of design, what counts at the end of the day is the *product* (i.e., the artefact finally presented). *This artefact has to stand on its own, independent of the creators,* since the designer is rarely there to suggest how it would work. The user is the final arbitrator of whether a design solution succeeds or fails. This is emphasised in our activities through the public presentation that all our teachers have to do. Students are often surprised to see just how differently people sometimes interpret what they have constructed. This also underscores the value of user-testing and cyclic nature of design – i.e., repeated iterations of applying user feedback to the redesign of the artefact.

By choosing tasks that are either very concrete or extremely abstract and pairing them with different media, students are forced to consider *the relationship between content, pedagogy and technology*. The relationship between these three is not straightforward – and as we have argued elsewhere, they exist in a transactional relationship with each other. These deep-play activities force teachers to understand this dynamic, transactional relationship, primarily through their focus on the idea of play as progress, fantasy and self. These assignments allow participants to learn technologies in context (*micro-design*), develop their identity as technology savvy teachers of content (*macro-design*) and allow them to visualise possible futures for themselves (*reflecting on the total PACKage*).

Our goal thorough these design and deep-play activities is to go beyond the transfer of information to the development of knowledge (Friedman, 1997). Information is static, stored in information systems (books or computers). Knowledge, however suggests agency and purpose. It is embodied in human beings and is a fundamentally human act. As Drucker (1990) said,

> "Knowledge is information that changes something or somebody—either by becoming grounds for action, or by making an individual (or an institution) capable of different and more effective action." Drucker (1990, p.242)

It is this change (either in individuals or institutions) that we seek to achieve through our deep-play activities.

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Notes

1 Authorship from the third author onwards is alphabetical. The first two authors alternate authorship in publications that they have written together to indicate equal contribution to the final papers.

2 We need to make an important distinction here between gaming and playing. There has been a great deal of research and scholarly attention paid to the idea of learning from games (e.g., Gee, 2003), particularly digital games (e.g., Gee, 2007; Oblinger, 2006; Prensky, 2006). Though we see games (digital or otherwise) as being an important realm for research and having great potential for learning, our focus is broader. In our approach, we see play as being a lager construct that includes gaming but also much more. Games by their very nature are constrained by rules and inform and structure the kinds of moves that are allowed and those that are not. Play, in our view, is more open-ended, where even the rules are possibly up for discussion and negotiation. We believe that this framework, with its flexible and open-ended nature, provides a better context for learning, as it respects the variability in how individuals and groups develop their processes and goals for the activities they are engaged in.