TECHNOLOGICAL TOOLS: FROM TECHNICAL AFFORDANCES TO EDUCATIONAL AFFORDANCES

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Modern technology is transforming in an accelerating rate our physical, economic, cultural and educational environments. The new generation of learners, both adults and students of all ages, is surrounded by a multitude of technological tools, and these tools (computers, robots, software, internet etc.) are used ubiquitously not only in learning environments, but in daily life as well. Today's children are furthermore characterized as "*digital natives*" and are clearly distinguished from their teachers and adults who constitute the generation of "*digital immigrants*" (Prensky, 2001). Visual programming languages, specifically designed for young learners, provide additional programming tools that are integrated in robotics education as well, while additional advances provide support to the idea of following the STEM (Science, Technology and Engineering and Mathematics) approach.

The integration of these tools in education and in authentic and effective learning/teaching environments has become an issue of great concern among educators, researchers and other related audiences. All emphasize the need to design and develop technology-enhanced curricula and teaching/learning environments (formal, non-formal and informal) that are developmentally appropriate for young and/or older learners. The vision is to integrate the tools and their associated technical affordance in teaching/learning environments in such a way, so that all learners, irrespective of their cognitive differences and abilities, could increase their learning gains, and develop the abilities and skills that are needed for citizens of the 21st century.

Learning however how to teach with technological tools is a complex task and necessitates not only to know the tools and their technical affordances, but, most importantly, how to take advantage of tools' affordances for designing developmentally appropriate learning activities. The focus is, or should be, on how to transform the technical affordances of the tools to educational affordances and design powerful learning environments, which can help learners to analyze, express, organize and evaluate their thoughts, in clear and precise ways, during solving authentic real-life problems.

More specifically, affordances are properties of the relationship between an agent and its physical environment. These properties allow and facilitate specific types of interaction between the agent (student, teacher, or any other person) and its physical environment, or part of it. Gibson (1977) defined affordances as the totality of all the perceived action possibilities that are latent in the environment. These action possibilities can be however objectively measurable and independent of the individual's experience, knowledge, culture, or ability to recognize them. Norman's (1990) conceptualization of affordances differs from Gibson's conceptualization. Norman (1990) defined an affordance as something that emerges only when actual and perceived properties are combined. Thus, an affordance is described as a relationship that holds between an object in the environment and any individual who is acting on the object.

From the literature on teachers' understandings of technology functions (affordances), it is evident that (a) teachers cannot easily distinguish between the technical functions (affor-

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dances) of technology and its educational affordances (Angeli & Valanides, 2005; Valanides & Angeli, 2008a, 2008b), (b) teachers are not always aware of the cognitive processes involved in using the affordances of a particular technology (Yoon & Hedberg, 2005), and (c) teachers' formation of mental models of technology affordances largely depends upon their training and their professional development (Krauskopf, Zahn, & Hesse, 2012).

Based on the findings, going from knowing how to use a tool to knowing how to teach with a tool, or going from knowing about the technical affordances of technology to perceiving the educational affordances of technology, does not occur automatically. Therefore, it becomes necessary that teacher educators make this process explicit during teacher training. Teaching pre-service or in-service teachers how to teach with technology involves more than just making the educational affordances of technology explicit to them. For example, a course on teaching teachers how to teach with a tool involves, among other things, teaching the tool itself. In such cases, teacher educators first teach students how to use the tool, and then they illustrate through various examples how the tool can be integrated in classroom teaching. The time devoted to teaching the tools themselves is usually more than the time left to teach students how to teach with the tools. This approach is for the most part fragmented and decontextualized, because the majority of the time is devoted to demonstrating, one by one, the technical functions of the tools, and not on illustrating the educational affordances of the tools in relation to content and pedagogy within the context of a design task. Additionally, an approach that focuses on teaching one at a time the technical functions of technology prevents learners from developing adequate and holistic mental models about the affordances of technology, and the connections among technology, content, pedagogy, and learners. The idea that learners will develop these mental models by themselves can only be characterized as wishful thinking.

Consequently, Technological Pedagogical Content Knowledge (TPCK) was introduced (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Niess, 2005) as a theoretical framework of how to effectively integrade technological tools and their technical affordances in education.. In the literature, there are two dominant theoretical models about the conceptualization of TPCK - the integrative model (Koehler & Mishra, 2005) and the transformative model (Angeli & Valanides, 2005). Both models view TPCK as an extension of Shulman's (1986, 1987) pedagogical content knowledge (PCK). PCK identifies the distinctive bodies of knowledge for teaching, and highlights a special amalgam of content, pedagogy, learners, and context (Shulman, 1986). Shulman's (1987) conceptualization of PCK goes beyond teachers' knowledge of subject matter and pedagogy per se, and encompasses the dimension of how to teach and transform content into forms or representations comprehensible to learners, taking always into consideration learners' content-related difficulties. Despite having PCK as their common theoretical basis, the two models are based on different epistemological stances regarding the nature of TPCK.

Angeli and Valanides (2009) also proposed Technology Mapping (TM), as an approach for mapping tool affordances onto content and pedagogy in powerful and transformative ways, and as an approach for developing TPCK that is rooted in Shulman's transformative nature of PCK, and the differing nature between technical and educational (pedagogical) affordances. TM enables teachers to develop complex and interrelated ideas between the affordances of technology and their pedagogical content knowledge. TM can engage learners in a process of developing technological solutions to pedagogical problems by aligning teachers' PCK with knowledge about the affordances and constraints of various computer-based technologies. Mapping refers to the process of establishing connections or linkages among the affordances of a tool, content, and pedagogy in relation to learners' content-related difficulties, and consequently transform tools affordances into educational (pedagogical) affordances.

TM is also a dynamic, situated and personal design process, because teachers' instructional design decisions are guided by a body of knowledge that is highly situated in the context

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of their real classroom experiences (Kagan & Tippins, 1992; Moallem, 1998). Evidently, the process of designing technology-enhanced learning is influenced by certain context-related factors, such as, teachers' beliefs about how students learn, teachers' practical experiences about what can and what cannot work in a real classroom, teachers' views about the role of technology in teaching and learning, their adopted instructional practices, school's vision and educational goals.

These context-related factors influence teachers' thinking about how technology is integrated in the classroom (Niess, 2005; Abbitt, 2011). For example, if a teacher has deep-rooted beliefs in teacher-centered learning, then technology integration will most likely be teacher-directed (i.e., the teacher uses the technology to deliver information to students) and not learner-directed (i.e., the students use the technology as a cognitive tool to construct/represent meaning about something). Furthermore, TM allows teachers to bring experiences from their classrooms into the design process, and, specifically, experiences that are related to teachers' PCK, that is, teachers' understandings of their students' alternative conceptions and learning difficulties in relation to certain curriculum topics, as well as teachers' understandings of their own difficulties in making a specific content teachable and easily learnable for their students.

TM is about making the educational affordances of the tools explicit within the context of authentic design tasks, while, at the same time, students also learn how to use the technology itself. Angeli and Valanides (2013) proposed furthermore interesting and helpfulr instructional design guidelines to facilitate the enactment of the TM and scaffold the.process. These TM guidelines promote a spiral approach to learning how to use a computer tool. The spiral approach is a method where first the basic facts of a subject are learned, and gradually as learning progresses, more and more details are introduced while, at the same time, the basics are revisited (Bruner, 1960). Respectively, the TM guidelines promote teaching the basic functions of a tool first, followed by the more complex, but. it is not the aim of TM to exhaustively teach all technical functions of a tool in one particular course.

In general, the TM guidelines reflect a holistic approach to developing all competencies teachers need to teach with technology. A holistic design approach is successful in preventing compartmentalization and fragmentation (van Merrienboer & Kirshcner, 2007). Compartmentalization refers to the separation of a whole into distinct parts and leads to a piecemeal approach of aquiring knowledge, seriously limiting one's ability to develop an integrated body of knowledge which includes skills, facts, procedures, principles, attitudes, beliefs, and dispositions. Fragmentation is the process of breaking something into small or isolated parts (van Merrienboer, Clark, & de Croock, 2002). The implications of such an approach is that learning objectives are taught in isolation, one at a time, and not in coordination with each other, leading to a highly fragmented body of knowledge.

In particular, the TM guidelines represent an instructional design model that is rooted in van Merrienboers' four-component instructional design theory (van Merrienboer, 1997), which can be described as consisting of: learning tasks, supportive information, procedural information, and part-task practice. Learning tasks are in this case design tasks that aim at integrating design skills, knowledge of content, pedagogy, technology, and learners, and beliefs about the role of technology in teaching and learning. These design tasks are organized in easy-to-difficult task classes and have diminishing support in each task class. This is realized by presenting students with design tasks, ranging from worked-out design tasks to semi-completed design tasks and to new design tasks. Supportive information is specified for each design-task class and is related to the instructional design of each task contigent upon a particular technology affordance. Then, for the routine aspects of each design task, procedural information is provided when needed, to specify exactly how to perform the routine aspects of the task. Part-task (practice) items are provided to help learners reach a high level of automaticity for selected routine aspects of a design task, such as, for example, practicing a set of technology functions pertinent to a particular design task.

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In conclusion, these ideas have theoretical significance related to the enactment of the TM approach, and consequently the development of TPCK as a unique and transformative body of knowledge. The transformative model of TPCK in conjuction with TM focus exclusively on Shulman's PCK and take into consideration not the tools per se, but how to use them for educational (pedagogical) purposes in ways that manifest how to transform the techinal affordances of tools into educational affordances, by exemplifying the added value of technology in teaching/learning environments. The TM approach can also provide empirical data about the effectiveness of TM, and thus can contribute to the ongoing discussions about how TPCK can be developed.

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