# Constructing on Constructivism: The Role of Technology

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## Abstract

*A complementary relationship exists between technology and constructivism, the implementation of each one benefiting the other. Constructivism is a doctrine stating that learning takes place in contexts, while technology refers to the designs and environments that engage learners. Recent attempts to integrate technology in the classroom have been within the context of a constructivist framework (e.g., Richards, 1998). The purpose of this paper is to examine the interrelationship between constructivism and technology as revealed by empirical research. The cases include a variety of studies in a variety of settings – teacher education, online learning, and K-12 education; constructivist strategies include collaborative and cooperative learning methods, engaging in critical and reflective thinking, evaluation through electronic portfolios, and a critical look at emerging teacher roles within constructivist paradigms. Success has been reported in the development of constructivist course modules using technology as cognitive tools, benefiting both students and faculty. However, many teachers do not use constructivist practices, and those who do are not judicious in their selection of technology use (Rakes, Flowers, Casey, & Santana, 1999).*

## Introduction

*"Once knowing is no longer understood as the search for an iconic representation of ontological reality, but, instead, as a search for* ***fitting*** *ways of behaving and thinking, the traditional problem disappears. Knowledge can now be seen as something that the organism builds up in the attempt to order the as such amorphous flow of experience…"*

*von Glasersfeld* (1984, p. 39)

The use of computer technology to support learning has been difficult to document and quantify (Clark, 1994; Russell, 1999), leaving the role of computers in the classroom precarious. In the past decade, a sudden resurgence of interest was markedly observed in the classroom use of technological innovations, along with the increased use of the Internet and other digital technologies (Reiser, 2002). The field of Instructional Design and Technology, too, saw the evolution and emergence of alternative approaches, such as cognitive and constructivist theories,

that deviated sharply from traditional practices, such as behavioral models. New emphases, like electronic performance support systems, web-based instruction, and knowledge management systems, not only shook the knowledge base of the field, but also widened its horizon across business and industry, the military, health care and education, worldwide (Reiser, 2002). Initiatives, such as situated learning theory and constructivism presented fresh approaches to bring about reforms in the domains of public education and higher education (Anderson, Reder & Simon, 1996; Brown, Collins & Duguid, 1989; Jonassen, 1999; Reiser, 2002).

To understand the potential of technology implementation in enhancing the teaching-learning process, the impact of constructivism on classroom practices has been studied by many researchers (e.g., Black & McClintock, 1995; Richards, 1998; Brush & Saye, 2000). Other researchers have suggested that constructivist strategies exploit technologies for greatest impact in learning (e.g., Duffy & Cunningham, 1996). A complementary relationship appears to exist between computer technologies and constructivism, the implementation of each one benefiting the other.

*Constructivism*, derived mainly from the works of Piaget (1970), Bruner (1962, 1979), Vygotsky (1962, 1978), and Papert (1980, 1983), is both a philosophical and psychological approach based on social cognitivism that assumes that persons, behaviors and environments interact in reciprocal fashion (Schunk, 2000). Constructivism is a doctrine stating that learning takes place in contexts, and that learners form or construct much of what they learn and understand as a function of their experiences in situation (Schunk, 2000). More recently, researchers (e.g., Lave, 1990; Saxe, Guberman & Gearheart, 1987) have presented more qualitative documentation of learning in context.

*Technology*, according to Jonassen, Peck, and Wilson (1999) refers to "the designs and environments that engage learners" (p. 12). The focus of both constructivism and technology are then on the creation of learning environments. Likewise, Hannfin and Hill (2002) depict these learning environments as contexts:

> in which knowledge-building tools (affordances) and the means to create and manipulate artifacts of understanding are provided, not one in which concepts are explicitly taught… a place where learners work together and support each other as they use a variety of tools and learning resources in their pursuit of learning goals and problem-solving activities (p.77).

The purpose of this paper is to review the research on the integration of technology in the classroom, highlighting the connection between constructivism and technology. The focus is on the constructivist view of learning as an active process of constructing rather than acquiring knowledge, and instruction as a process that supports construction rather than communicating knowledge. The review is followed by a series of case studies, emphasizing constructivism and technology's relationship. Finally, implications for teachers and teacher educators are presented.

## Review of Related Literature

In order to understand learning within a constructivist framework, as an activity in context, the whole learning environment must be examined. However, the wide diversity of constructivist views makes the task very complex and beyond the scope of this paper. These views commonly emphasize the role of the teacher, the student, and the cultural embeddedness of learning (see e.g., Duffy & Cunningham, 1996; Honebein, Duffy, & Fishman, 1993; Simons, 1993). Using these commonalities as guidelines, this review outlines the relationship of constructivism with technology by looking at (a) technology as cognitive tools, (b) constructive

view of the thinking process, and (c) the role of the teacher in technology enhanced environments.

*Technology as Cognitive Tools*

A central assumption of constructivism is that learning is mediated by tools and signs (Duffy & Cunningham, 1996; Ezell & O'Keeffe, 1994). "Culture creates the tool, but the tool changes the culture. Participants in the culture appropriate these tools from their culture to meet their goals, and thereby transform their participation in the culture" (Duffy & Cunningham, 1996, p. 180). The computer is an exemplar of mediational means that has aspects of both tool and sign. The computer's role in education has been largely viewed as an instructional tool and for providing a richer and more exciting learning environment (Duffy & Cunningham, 1996; Jonassen & Reeves, 1996; Taylor, 1980). However, by focusing on the learner, the role of technology can support new understandings and capabilities, thus, offering a cognitive tool to support cognitive and metacognitive processes. For example, an electronic exchange program between students of a class in the U.S. with a similar classroom in Northern Ireland shared multiple cultural perspectives through pictures, stories, letters and multimedia programs (Duffy & Cunningham, 1996). The experience was enriching, increasing their understanding.

Further, clarifying the role of technology in learning, Duffy and Cunningham (1996) state:

> Technology is seen as an integral part of the cognitive activity….This view of distributed cognition significantly impacts how we think of the role of technology in education and training, the focus is not on the individual in isolation and what he or she knows, but on the activity in the environment. It is the activity – focused and contextualized- that is

> central... The process of construction is directed towards creating a world that makes sense to us, that is adequate for our everyday functioning (pp. 187-188).

Thus, the task of the learner is seen as dynamic, and the computer makes available new learning opportunities.

The view of technology as cognitive tools is also shared by other researchers (e.g., Jonassen, 1994; Jonassen & Reeves, 1996; Lajoie, 2000). The traditional view of instructional technologies of instruction as conveyors of information and communicators of knowledge is supplanted with active role the learner plays in learning *with* technology. Technologies, primarily computers, help build knowledge bases, which will "engage the learners more and result in more meaningful and transferable knowledge… Learners function as designers using the technology as tools for analyzing the world, accessing information, interpreting and organizing their personal knowledge, and representing what they know to others" (Jonassen, 1994, p. 2). Technological tools such as spreadsheets, databases, expert systems, video conferencing and others can be used by students to analyze subject matter, develop representative mental models, and then transcribe them into knowledge bases (Jonassen, 1994; Jonassen & Carr, 2000; Jonassen & Reeves, 1996).

An illustration is the development of simulated microworlds and games by children using Logo programming. Logo programming has evolved since the early text-based medium conceived by Seymour Papert and his team at MIT in the 1970's, to a considerably easy, digitized format. Kafai, Ching, and Marshall (1997) gave an introductory training program to fifth and sixth grade students one week before the design projects. The Logo version included support for modern computer features like multimedia, sprite animation, sounds, movies, and paint tools. According to Kafai and her colleagues (1997), the multimedia software proved to be a good context for students to learn through collaboration and project management. The

interaction between team members, the flow of ideas and loud thinking encouraged the children to experiment and find alternative ways for designing and solving problems. For example, the students worked on different characters individually, but then worked together to integrate all the characters, and in debugging (Kafai et al., 1997).

Cognitive tools do not preclude the use of computers to increase productivity for learning. Off-loading repetitive tasks and lower order tasks to cognitive tools frees cognitive resources for deeper thinking (Duffy & Cunningham, 1996; Jonassen, 1999) and reduces errors. According to Swain and Pearson (2001), teachers and students must be educated to use the computer as a productivity tool, as well as a tool for learning, research, networking, collaboration, telecommunications, and problem-solving. Using computers as a productivity tool is one of the six National Educational Technological Standards (NETS) (http://cnets.iste.org/) for teachers which states that teachers will "use technology to enhance their productivity and professional practices" (Morrison, Lowther, & DeMeulle, 1999).

*Constructive view of " Thinking"*

The process of thinking in constructivist paradigms requires higher-order skills, delving deeper and harder into content and context (Black & McClintock, 1995; Jonassen, n.d.; Manzo, 1998; Swain & Pearson, 2001). Traditional schooling, according to Manzo (1998), actually discourages constructive thinking with goals of transmitting existing knowledge that conflicts with any real attempt to generate new understanding. **"**Constructivist thinking combines both the critical and creative intellectual processes. It can be practiced by encouraging critical analysis in activities. Schools, teachers and students can be conditioned to veer away from traditional schooling regimen to encourage constructive thinking" (Manzo, 1998, p. 287). Cognitive tools, along with constructivist learning environments, guide and activate cognitive learning strategies

and critical thinking (Jonassen, 1994). Cognitive tools help in knowledge construction and not knowledge reproduction. The knowledge constructed by the learners reflects their comprehension and conception of the information. To illustrate, when students build knowledge bases with databases, they need to analyze the content domain and engage in critical thinking.

Black and McClintok (1999) stress the importance of *interpretation* as being central to cognition and learning. Their design of Study Supported Environments (SSEs) based on constructivist design principles called Interpretation Construction Design (ICON) focused mainly on the interpretive construction of authentic artifacts in the context of rich background materials, and spanning across different fields of study. Their study showed that in addition to learning specific content, students were able to acquire generalizable interpretation and argumentation skills.

For example, in teaching sixth grade ancient history, a program called *Archaeotype* © was used that presented students with a graphic simulation of an archaeological site. Students who worked collaboratively in groups, had to dig up artifacts through simulation, observe and measure them in simulated laboratories, and finally through a process of interpretation and argumentation, arrived at the understanding of general principles behind what they were doing. In a follow-up evaluation study, it was found that there were significant gains in the interpretative and argumentation skills of students who had participated in the study against a control group (Black & McClintock, 1999).

*Reflective thinking*, that requires careful deliberation, is also encouraged by constructivists (e.g., Kafai et al., 1997; Swain & Pearson, 2001; Walker, 2000). Metacognition, or the self-monitoring and self-control of the learning process, is emphasized. New knowledge which is composed is added to previous representations, modifying them in the process. This

usually requires external scaffolding in the form of people, books, or technologies such as computers. Swain and Pearson (2001) advocate the practice of reflective thinking by teachers to evaluate their technology use. They stress the importance of documentation of reflective thoughts to determine the extent and quality of personal versus instructional uses of technology, organization and implementation of environments and activities. Jonassen (1994) describes technological tools as "intellectual partners" and "powerful catalysts" in the process of learning, "scaffolding the all-important processes of articulation and reflection, which are the foundations of knowledge construction" (p. 5).

*The Role of the Teacher in Technology Enhanced Environments*

The role of the teacher as a *facilitator* is seen as most important in a constructivist context (Witfelt, 2000; Richards, 1998). Within a constructivist classroom, the teacher engenders social and intellectual climates, where collaborative and cooperative learning methods are supported. In parallel, technology-enhanced classrooms tap constructivist strategies (Jonassen, 1999), arranging problem-based projects where students actively construct knowledge, linking knew knowledge with previous knowledge.

In non-traditional classrooms such as the open/global classroom (Walker, 2000; Witfelt, 2000), the role and responsibilities of the teacher have changed. The teacher, as an agent, has to constantly update information and technology for making learning authentic and relevant. For example, while developing a course module for teachers and taxonomy for teacher competencies in the use of educational multimedia, Witfelt (2000) observed that it was important to combine several theories such as constructivism, postmodernism, situated intelligence and multiple intelligences. However, the theoretical framework would be constructivist in nature with the teacher assuming the role of the facilitator, providing an environment for spontaneous research,

understanding the social and collaborative nature of learning, helping children construct knowledge and initiate problem-based, project-oriented work. With this transition in roles and responsibilities, Witfelt (2000) listed new teacher competencies in constructivist contexts that include supervisor qualifications, supporter and facilitator of students' work, advisor and subject-matter expert, inspirer and encourager, arbiter at group discussions, critic in mobilizing greater effort when objectives are not being met, and evaluator to improve general learning capacities of students.

## Case Studies

After examining the literature on technology integration and constructivist principles, a complementary relationship between technology and learning within a constructivist framework seems sound and advantageous to teachers and learners. To illustrate these principles discretely, exemplary cases are presented that reflect the philosophy established above.

Teacher-trainees at Winthrop University in South Carolina undertook a meaningful technology-based activity to accomplish literacy goals (Richards, 1998). They developed an electronic portfolio around a literacy-related topic, including data, reflections and critical responses, which they shared with their peers and other educators. The infusion of technology was helped by implementing constructivist-based activities, such as collaboration and cooperation in a group, engaging in problem solving and constructing potential solutions to societal dilemmas, and communicating the deeper processing of content and the critical development of literacy skills and strategies (Richards, 1998). Student perceptions were determined through formative and summative assessment methods. Students responded positively toward accomplishment of cooperative and collaborative learning, the technology component functions and the relevance of the activities to future careers in schools. However,

they recommended that more time be provided for processing ideas and synthesizing them in the portfolio.

Research conducted at the Open University, U.K. also demonstrated a positive relationship between constructivism and technology integration (Walker, 2000). A distance-learning course was developed keeping in mind the experiential and constructivist perspectives of learning. The purpose was to help students in a distance-learning course learn in better and more effective ways, to be active learners, constructing their own understanding. Assignments and assessments were also oriented towards constructivist goals. Their efforts culminated in a new paradigm of course development. A survey of all the students who completed the course and took the examination revealed that the majority felt that they had improved their learning skills to a considerable extent.

A follow-up survey was undertaken the following year. These findings revealed a high proportion of positive responses to questions regarding the continued use of reflection to improve assignments, based on instructors' feedback and evaluation criteria. However, students were less positive about their use of reflection in general. These students like those described above (Richards, 1998) struggled with maintaining and using reflection effectively.

Students were not the only beneficiaries of the mixture of constructivist strategies with technology tools. According to Richards (1998) and Walker (2000), the development of course modules based on constructivist practices and the integration of technology were also beneficial to the faculty, as they had to plan and retool to integrate technology so that students could be helped to become more capable and mature learners.

## Implications for Practice

These cases have significant implications for teacher educators and teachers. In the area of teacher education, Kim and Sharp (2000) observed that the planning of teachers consistent with constructivist practices was highly variable with most preservice teachers knowing very little about the effective integration of technology in education. Since teachers tend to teach as they were taught, it is essential that both preservice and inservice teachers must be exposed to constructivist-based instruction, which would then facilitate the development of teaching strategies consistent with recent reform movements (Kim & Sharp, 2000). An exposure to constructivist teaching methods and simultaneous multimedia learning experiences influenced the planning of constructivist behaviors and infusion of technology (Kim & Sharp, 2000).

Technology may also influence teacher practice to incorporate constructivist principles. Rakes, Flowers, Casey and Santana (1999) report that as the amount of technology available, the level of technology skills of the teachers, and the use of technology increased, the use of constructivist strategies in the classroom also appeared to increase. "Technology can provide the vehicle for accomplishing constructivist teaching practices" (Rakes et al., 1999, p. 3). So, increasing the skill levels of teachers with regard to computers and providing additional opportunities for teachers to integrate technology into lessons may encourage the use of constructivist behaviors.

Availability, skill level and use may not, however, guarantee purposeful use of technology nor constructivist principles. Rakes et al. (1999) reported many teachers concentrated on the drill and practice type of software, neglecting basic computer skills development, or dealt only with presentation skills and Internet resources. These researchers recommended focusing on staff development and training in technology use and constructivist

practices that moved beyond literacy skills to address more thoroughly application and curriculum integration issues.

When addressing the role of the teacher in constructivist paradigms, there should be no misunderstanding regarding the importance of the teacher. Yet, many teachers feel uncomfortable with the lack of a well-defined content and the shift of locus of control to the learners (Brush & Saye, 2000; Duffy & Cunningham, 1996). Creating suitable contexts is not merely providing learners with resources and letting them discover things for themselves, but organizing resources in such a way to engender cognitive dissonances in the minds of the learners, inspiring them to learn how to learn through a process of collaboration and defensible understandings (Duffy & Cunningham, 1996).

As a facilitator of learning, the teacher is not ineffectual and on the sidelines. On the contrary, the teacher is free to use a variety of constructivist strategies, such as coaching, modeling, and scaffolding, to aid each learner (Collins, Brown & Newman, 1990). Scaffolding may include support from other individuals and artifacts, as well as the cultural context and history that the learners bring to the environment. Scaffolding, however, does not mean guiding and teaching a learner toward some well-defined goal but supporting the growth of the learner through cognitive and metacognitive activities (Hannafin, Hill & Land, 1997). Thus, the teacher assumes the role of a coach and ensures mutual understanding of the views of the learner. In using collaborative and cooperative groups, the teacher must be careful in ensuring that they are not just strategies for learning, but means to promote dialogical interchange and reflexivity (Duffy & Cunningham, 1996).

As Morrison, Lowther, and DeMeulle (1999) aptly suggest, “Technology and a constructivist approach need not be at odds with each other. If we change our view of computers

from merely a means to deliver instruction to one of a tool to solve problems, then the reform movement can influence the use of technology, and technology can influence the reform of education" (p. 5).

## Conclusion

Constructivist views assert that learning is the active process of constructing rather than passively acquiring knowledge, and instruction is the process of supporting the knowledge constructed by the learners rather than the mere communication of knowledge (Duffy & Cunningham, 1996; Honebein, Duffy & Fishman, 1993; Jonassen, 1999;). Truth is determined by the viability of the learners' understanding in the real world, where viability is culturally determined. The constructivist framework seeks to understand multiple perspectives, and challenges the learners' thinking (Duffy & Cunningham, 1996; Jonassen, Mayes & McAleese, 1993). It examines the social origins of constructions, whereby it acknowledges learning as a process of acculturation. Thus, the study of social and cultural processes and artifacts becomes a central issue. Context is a dynamic whole including the individual and sociohistorical aspects (Duffy & Cunningham, 1996; Ezell & O'Keefe, 1994). Thinking is always dialogic, connecting minds, either directly or indirectly. The indirect or semiotic means are the signs and tools appropriated from the sociocultural context (Duffy & Cunningham, 1996).

Within this shift in focus from the objectivist to the constructivist context domain, technology can play an integral part in the learning environment (Duffy & Cunningham, 1996). "The richness of the technology permits us to provide a richer and more exciting (entertaining) learning environment… our concern is the new understandings and new capabilities that are possible through the use of technology" (Duffy & Cunningham, 1996, p. 187). By integrating technology with constructivist methods, such as problem-based learning and project-based

learning, learners are more responsible for and active in the learning process (Grant, 2002). Additionally, everyday applications, such as word processors and spreadsheets, become powerful instruments for authentic learning. Constructivism offers flexibility to teachers to individualize learning for each student while using technology tools to augment cognitive and metacognitive processes.

## Contributors

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Michael M. Grant is an Assistant Professor at the University of Memphis in the Instructional Design and Technology program within the teacher education department. His most recent research has focused on accommodating individual differences and constructionism. He has worked with both preservice and inservice teachers on integrating technology.

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