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# CONSTRUCTIVISM IN COMPUTER MEDIATED COMMUNICATION – DIGITAL LEARNING, A SOFTWARE ENGINEERING MODULE

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## Abstract

Two distinguishing characteristics of adult learning most frequently advanced by theorists, are firstly the adults autonomy of direction in the act of learning and secondly the use of personal experience as a learning resource. Digital Learning is facilitated by technology, giving the students some element of control of their learning over time, place and pace. Computer-mediated communication can be defined as human communication that is maintained or altered through machines. By exploring computer-mediated communication in a digital learning environment, this project undertook a key challenge for educators teaching students to engineer software in globally dispersed teams for our adult learners.

The current workplace emphasis on teamwork, technology and globalization make these core learning concepts, and none more so than in the software development industry. Organizations have increased their reliance on technology as a mode of communication. Software engineering development in virtual teams, across international boundaries, is common-place in industry, however this is seldom obtainable to students within educational institutions.

This paper describes the constructivist approach, supported by computer-mediated communication theory in teaching Software Engineering. The project involved three international institutes of higher educational teaching Software Engineering to computing students. The paper contribution presents a comprehensive course design that accelerates team and group theory beyond the traditional face-to-face team application. It covveys the potential for growth in online pedagogies and explicates the value of technology in course design and delivery with today's millennial student-learners.

## Introduction

In order to inspire students to learn software development and software engineering, teachers can apply the theory of constructivism (Piaget, 1952; Piaget, 1959).

Constructivism emerged, in part, in reaction to the “overselling” of the computer as a metaphor for learning (Bredo, 1994), and the perceived transmission-of-knowledge focus of information-processing theory (Marshall, 1996). The movement currently is prominently featured in academic and practitioner journals and books (e.g., Brooks & Brooks, 1993; Richardson, 1997), and it has played an influential role in policy formation (e.g., National Council of Teachers of Mathematics, 1989). However, with only a few exceptions (e.g., Brown & Campione, 1994; Palincsar & Brown, 1984), empirical research on constructivist classrooms has yet to be conducted. Several educational texts have described the basic tenets of constructivism (Driscoll, 1994), approaches (Marshall, 1996; Prawat & Floden, 1994), and reported anecdotal classroom observations (Cobb & Bowers, 1999; Cobb & Yackel, 1996). The constructivist perspective can trace the development of concepts in computing from concrete to abstract (Beetham, 2007) and underlines the approach taken in designing this module.

According to the basic constructivist theory, students learn most when they are given the opportunity to explore and create knowledge that is of personal interest to them (Papert, 1993). It is agreed that constructivism is a valuable perspective because once students are

engaged in what they are doing they are more motivated to learn. The approach can be particularly valuable to students who may have found the traditional instruction-based setting challenging. The constructivist method of teaching allows a learner build their knowledge (construct) as a result of experiences and reflection.

Constructivism suggests that learners construct their own understanding, key principles of which involve situated learning, social knowledge and collaboration –core concepts to articulate to computing students. As with any theory, constructivism doesn't provide a complete picture of learning. Attention, perception, metacognition and the limitations of working memory all influence learning, as does modelling and judiciously applied reinforces. These concepts come from information processing, social cognitive theory and behaviourism. Effective educators and educational programmes draw from such theories to promote as much learning as possible.

### **Constructivism incorporated in the design of a Software Engineering Project**

In applying constructivism to higher education, one must prove the instructional assistance necessary to promote learning and development. Bruner used the term 'scaffolding' to refer to ways that learning is supported by adults who build on existing competence in order to accomplish next-stage tasks (Bruner, 1975). Although Bruner used this idea in relation to very young children, it has been applied to classroom teaching (Edwards & Mercer, 1987) and is a useful concept to apply to adult learning in higher education. The lecturer, being more experienced, can organise activities that allow learners structure the learning experience, thus allowing them move beyond their current levels of performance. Research on problem-solving has highlighted the key role the teacher has in leading students to apply learning acquired in one context to another (Perkins & Salomon, 1988). Problem solving is a key component in software development and software engineering. Research into mathematical problem-solving, for example, suggests that for skills to be transferred, the students usually need to be helped to identify common features of the old and new problems or situations, looking especially for similarities in the underlying structure of the two. In other words, the teacher has to make very explicit the link between previous and new learning, or the student may not realise that the two problems or exercises are connected. In addition, the new learning needs to be pitched at a similar level of complexity to that already covered (Reed et al., 1985).

Teaching based on constructivism emphasizes examples and representations of content, high levels of student interaction and content connected to the real world. Teachers who ground their teaching in constructivism recognise that lecturing and explaining often fail to promote deep understanding in learners. Teaching that most effectively applies constructivism in an educational setting emphasizes both students answers and how students arrived at those answers. Effective teaching makes students thinking open and visible. Guided discovery, inquiry, discussions and cooperative learning, can each involve students in knowledge construction and make their thinking visible. Lecturers and teachers using guided discovery present students with information and guide them to find patterns in the data/assignment. Inquiry begins with a problem, followed with hypothesis that offers tentative solutions to the problem and ends with the solution. Discussions involve students in activities in which their interpersonal skills are developed and reconstruction of understanding can occur. These key constructivist components underpin the Computer Mediated Communication Software Engineering project undertaken.

The instruments of knowledge construction are cognitive structures that are either innate or which are themselves the product of developmental constructivism. Piaget believed that the latter was the case (Noddings, 1990) "Piaget ... [described] cognitive structures as products of development rather than innate structure" (p.8). Cognitive structures are activated in the process of constructivism. It is these cognitive structures that are present in the process of continual development (Sinclair, 1985)

*“The fundamental constructivist view thus postulates changes in the relation between the subject and object; and the movement towards better – though never perfect – knowledge of the object has as its concomitant another movement whereby the subject obtains better knowledge of his own actions or thought processes” (p.56)*

Therefore, constructivism is not only a mechanism for the development of knowledge; the cognitive structures, which are activated during the process of constructivism, are also under continual development and therefore ideal to underpin the module and project structure.

## **Computer Mediated Communication and Digital Learning**

As described, Computer Mediated Communication (CMC) can be defined as the study of how human behaviours are maintained or altered by exchange of information through machines (December, 1996). It can be defined as communicative transactions occurring through the use of two or more networked computers (McQuail, 2005). CMC is a form of communication transaction, executed using computer networking infrastructure, which has rapidly become popular in social interaction (Ang et al., 2015; Sheldon et al., 2011; Walther, 1992). Researchers have investigated Internet-based social networking supported by social software, including instant messaging, YouTube, e-mail, social networking sites (SNS) and Internet forums (Chen et al., 2008; Haridakis & Hanson, 2009; Hunt et al., 2012; Ou & Davison, 2011; Papacharissi & Rubin, 2000; St. Amant, 2002; Sun, 2008; Sun et al., 2009). Interpersonal motives for using the Internet include interpersonal utility (Papacharissi & Rubin, 2000), social utility (Kaye & Johnson, 2002), social or interpersonal interaction (Ebersole, 2000; Wolfradt & Doll, 2001), and chatting (Sjoberg, 1999). In our teaching and research, we focus on text-based interaction, since the fact remains that text-based communication is still dominating the interaction on the internet and text-based technologies are the most interactive. Social information processing theory and the hyper-personal perspective of computer-mediated communication are discussed next.

The social information processing theory of computer-mediated communication assumes that communicators are motivated to reduce interpersonal uncertainty, form impressions, and develop affinity in virtual collaboration just like they are in face-to-face situations (Walther, 1992). Since they do not have the same cues available in on-line settings as in face-to-face interaction, people use the means available through computer-mediated communication for impression management and relationship building. Therefore the theory of social information processing posits that in an electronic interaction social information is exchanged through content, style, and timing of verbal messages on-line (Walther, 1992; Walther & Parks, 2002).

The hyper-personal perspective of computer-mediated communication explains the phenomenon that on-line interaction cannot only be as personal as face-to-face communication but actually even more personal, thus hyper-personal. It has been shown that communicators can achieve levels of sociality and cohesiveness online, which could not – or not as rapidly – be achieved in a face-to-face situation. Walther (Walther, 1996; Walther & Parks, 2002) explains these observations by showing the effects virtuality has on sender, receiver, channel and feedback in computer-mediated communication. Additionally, recognizing that media sometimes facilitate communication that surpasses normal interpersonal levels, a new perspective on *hyper-personal* communication is introduced in CMC. Sub-processes are discussed pertaining to receivers, senders, channels, and feedback elements in computer-mediated communication that may enhance impressions and interpersonal relations (Walther, 1996).

## **Teaching Software Engineering Students to Work in Virtual Teams**

The inter-institutional project to teach computer-mediated communication between the University of Heilbronn, Germany, Dundalk Institute of Technology, Ireland and the University

Transilvania of Brasov, Romania has been in operation for more than three years (Kasperek & Marsden, 2007).

Students actively work individually and in teams through electronic partnerships. The international teams work on a software project which prepares students to work in and manage virtual software development. Benefits to the students include developing and improving group skills. The students also learn to work as virtual teams and develop project management skills. They gain experience in remote software development and develop their computer-mediated communication skills.

The coordination and structure of the project across the three institutes is organised at the start of semester. A designated lab time is scheduled when all students are timetabled to be on-line at the same time. However students were required to organise additional on-line meetings. The open source, groupware platform PHProjekt is used for the class work, where all activities are logged. Active participation on the platform is a pre-requisite to pass. Teams of four to six students are established, with each team consisting of students from Germany, Romania and Ireland. All on-line communication is in English.

PHProjekt is a modular application for the coordination of group activities and to share information and documents via the web. Components of PHProjekt include a group calendar, project management, time card system, file management, contact manager, mail client and many other modules. The benefit to such a system is for the academics involved to monitor communication and participation of students.

The structure of the lab work is so that teams given some reading and discussion exercises for the first two or three weeks. These assignments initiated communication between in the international students and started conversations. These early exercises also introduced the students to CMC and working with others in a virtual environment, discussing a topic, agreeing on a decision and completing a task.

The second part of the project involved giving the students a larger project to complete, where they had six weeks to complete the task. During this assignment students had project management responsibilities and development work to complete. The teams are assessed and grades were accumulated. Students received an individual grade for constructive participation and a grade for the overall team project.

## **Embedding Constructivism in our Project design**

Piaget suggested that development is an orderly process occurring in stages.

Our module was structured and well defined from the start, with all students understanding their responsibilities with regard to participation. The quality of experience in the physical and social world, together with the drive for equilibrium, combines to influence development and the social virtual PHProjekt platform for our project supported the students.

Piaget postulated that mental structures determine how data and new information are perceived. If the new data makes sense to the existing mental structure, then the new information is incorporated into the structure (accommodation in Piaget's terms). The process of accommodation allows for minor changes in the structure to incorporate the new data (*figuratively, stretching, bending and twisting* but not breaking). If the data is very different from the existing mental structures, it therefore does not make any sense to incorporate it into the structure and the new information is either rejected or the information is assimilated or transferred so that it will fit into the structure. Again, the module breakdown between the reading/discussion assignments and then the large project enabled the accommodation of new knowledge along with the accommodation of the new learning environment. Intellectually developing people organise their experiences into schemas that help them understand the world. Compatible experiences are assimilated into existing

schemas; incongruent experiences require an accommodation of these schemas to re-established equilibrium.

Lev Vygotsky offered an alternative view of development (Vygotsky, 1962). His theory focuses heavily on language and social interaction, and the role they play in helping learners acquire an understanding of the culture in which they live. Vygotsky's work exerts influence in classrooms when teachers are encouraged to engage students in meaningful learning tasks that involve language and social interaction. Learners who can benefit from assistance are in what Vygotsky called the zone of proximal development. Learners within this zone can profit from instructional scaffolding in the form of modelling, questions, prompts and cues. The accessibility to the PHProjekt by the lecturing staff to monitor and assist the students scaffolded the learning. The assignments were meaningful, real-world software development scenarios the students would at some point encounter in their careers.

Through interactions students develop an understanding that they wouldn't have been able to acquire on their own. Piaget and Vygotsky both agreed that active learners and social interactions are important for development, but they differed in their reasons why. Piaget focused on manipulation of objects and ideas, together with the validation of schemes; Vygotsky on the other-hand emphasised participation in verbal cultural exchange.

## Conclusion

In higher education, the development of intellectual ability and cognition can be defined as the orderly durable changes that occur resulting from the interaction of the environment and culture. The two distinguished psychologists in the area Piaget and Vygotsky offered varying explanation on intellectual development, and their theories underpin this project and module design. The feedback from students, emphasise the learning which had taken place:

*"I thought it was a good learning experience. It was an interesting to see how a software program could be designed and developed between groups of people from different countries." Student2;*

*"I understand the importance and the dangers of a virtual team. I have seen the big difference between our team and a team well organised. If I had to start again, I would try to manage the team from the beginning and be more active." Student4;*

*"From experience in the workplace I have noticed how people working on projects in different countries can sometimes work to your advantage or cause alot of panic.... Overall the project is worthwhile as it teaches students about working as a group while managing time and version control better." Student7*

Working on an assignment in a virtual team environment accelerated the team and group theory far beyond the traditional face-to-face application. Computer-mediated communication differs substantially from face-to-face communication. Our experience was that the students realized that because of the different timing in online communication (Walther & Parks, 2002), they were much less effective than they would be in a face-to-face meeting. Using asynchronous communication-systems did not come naturally to them and this had to be built into the structure of the course, ensuring that they experienced the benefit of it.

The potential for growth in online pedagogies, interaction between institutions and the value of technology in course design and delivery, underpins this work and helps our learners.

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