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Analytics of communities of inquiry: Effects of learning technology use on cognitive presence in asynchronous online discussions

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ABSTRACT

This paper describes a study that looked at the effects of different technology-use profiles on educational experience within communities of inquiry, and how they are related to the students' levels of cognitive presence in asynchronous online discussions. Through clustering of students (N = 81) in a graduate distance education engineering course, we identified six different profiles: 1) task-focused users, 2) content-focused no-users, 3) no-users, 4) highly intensive users, 5) content-focused intensive users, and 6) socially-focused intensive users. Identified profiles significantly differ in terms of their use of learning platform and their levels of cognitive presence, with large effect sizes of 0.54 and 0.19 multivariate η^2, respectively. Given that several profiles are associated with higher levels of cognitive presence, our results suggest multiple ways for students to be successful within communities of inquiry. Our results also emphasize a need for a different instructional support and pedagogical interventions for different technology-use profiles.

1. Introduction

The importance of social interaction for reaching higher levels of learning is widely acknowledged in contemporary education (Anderson & Dron, 2010). Educational research offers many accounts of the benefits of social interaction on the development of skills such as critical thinking, creativity, and argumentation (Dawson, Tan, & McWilliam, 2011; Garrison, Cleveland-Innes, & Fung, 2010; Sawyer, 2006). Affordances of the modern (educational) technology enable for effective social interaction, information seeking, and knowledge building. More importantly, educational research offered approaches that can help design, facilitate, and direct an effective educational experience in communities and/or networks of learners. The Community of Inquiry (CoI) model (Garrison, 2011; Garrison, Anderson, & Archer, 1999; Garrison & Arbaugh, 2007) is a well-known framework in this context. By using qualitative and quantitative research methods, the research centered around the CoI model offered a remarkable amount of empirical evidence that explains an interplay of teaching, cognition, and socialization in communities of inquiry (Garrison, Cleveland-Innes, et al., 2010).

Although heavily dependent on educational technology, our review of the CoI literature revealed rather limited research that studied the relationships between learners' use of educational technology and the dimensions of the CoI model. The only study found in our literature review that focused on this issue was by Rubin, Fernandes, and Avgerinou (2013), and it investigated the association of learners' perceived value of educational technology affordances and perceived value of the core dimensions of the CoI model. However, the study of Rubin et al. used self-reports to gather students' perceived value of educational technology. In this paper, we propose that *learning analytics* (Buckingham Shum & Ferguson, 2012; Siemens & Gasevic, 2012) can: i) offer methods to advance understanding of the CoI model, especially in relation to learners' knowledge construction process and agency, ii) reveal how learners interact with educational technology in communities of inquiry, and iii) drive the development of new instructional approaches that can enhance educational experience for diverse subpopulations of learners that can emerge in communities of inquiry. More specifically, in this paper we report on the results of a study in which we:

1. Propose a *method* for identification of learner profiles – reflective of learners' agency about decisions making when selecting tools to study – based on trace data about their online learning activities performed in learning management systems.
2. Investigate the *effect* of the identified learner profiles on the development of cognitive presence – one of the three main dimensions of the CoI model – extracted from online discussion transcripts of a community of inquiry.
3. *Interpret* results in relation to instructional practice and existing theories on metacognition, motivation, and conceptions of and approaches to learning.

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2. Theoretical background

2.1. The Community of Inquiry model

Built upon the social constructivist perspective to learning, the Community of Inquiry model is recognized by some as the most important model of e-learning today (Garrison & Arbaugh, 2007). The CoI model defines a community of inquiry as "*a group of individuals who collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding*" (Garrison, 2011, p. 2). The model describes a community of inquiry through the three interdependent dimensions, also known as *presences* (Garrison, 2007; Garrison, Anderson, & Archer, 2010; Kanuka, 2011):

1) *Cognitive presence* is a central dimension of the model that describes the learning phases from the initial practical inquiry to the eventual knowledge construction and problem solution (Garrison, Anderson, & Archer, 2001).
2) *Social presence* explains important social relationships among the members of the learning community and the social climate that contributes to the success of learning and attainment of the learning objectives (Rourke, Anderson, Garrison, & Archer, 1999).
3) *Teaching presence* is focused on the role of instructors in course design, organization, and delivery, and instructions that guide social and cognitive processes to desired learning outcomes (Anderson, Rourke, Garrison, & Archer, 2001).

This paper focuses on the study of cognitive presence which is defined as "*the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication*" (Garrison et al., 1999, p. 89). Cognitive presence proved to be a suitable instrument to assess critical thinking (Garrison et al., 2001), given that oral and textual communication (e.g., via discussion forums) have been shown to stimulate development of critical thinking skills. In essence, cognitive presence is a process model describing the development of higher-order thinking rather than individual learning outcomes (Akyol & Garrison, 2011b; Akyol et al., 2009). It is rooted in Dewey's (1910) social-constructivist views of learning and is operationalized through the practical inquiry model (Garrison et al., 2001) that defines four phases of inquiry learning cycle:

1) *Triggering event*: In this phase, a learning cycle is initiated by a problem or dilemma, which is in the formal educational setting typically introduced by the instructor.
2) *Exploration*: This phase is characterized by exploration, brainstorming, and other activities in which students gather information relevant to the problem or task at hand.
3) *Integration*: In this phase, after gathering an appropriate body of information, students synthesize and integrate different bits of information, while being selective and filtering out all irrelevant information.
4) *Resolution*: The last phase is the resolution of the original problem which is – in the context of formal education – typically achieved through vicarious actions and hypothesis testing. Very often resolution of the original problem initiates a new learning cycle with a new triggering event.

The research methods related to the community of inquiry include both: i) *qualitative methods* — primarily based on the use of quantitative content analysis of discussion transcripts and different coding schemes for the assessment of the three dimensions of the CoI model (Rourke & Anderson, 2004) and, ii) *quantitative methods* — primarily based on the CoI survey instrument, which was developed for measuring self-reported values of each of the three CoI dimensions (Garrison, Cleveland-Innes, et al., 2010). Both coding schemes (i.e., high inter-rater reliability) and the survey instrument (i.e., consistency and factor loadings) have been validated in a number of studies (Arbaugh et al., 2008; Gorsky, Caspi, Blau, Vine, & Billet, 2011; Rourke & Anderson, 2004).

Recent studies of the CoI model (Akyol & Garrison, 2011a; Garrison & Akyol, 2013; Shea & Bidjerano, 2010) highlight self-regulated learning (SRL) – a major theory of learning in contemporary educational psychology focusing on the role of metacognition in the learning processes (Bjork, Dunlosky, & Kornell, 2013) – as central for understanding the CoI model. As cognitive presence includes both self-reflection and collaborative knowledge co-construction (Garrison et al., 2001), "*metacognition mediates between reflection and action*" (Akyol & Garrison, 2011a, p. 186). In order to develop cognitive presence, students need to exercise critical thinking skills, which are primarily meta-cognitive in nature and require communicating one's thinking with others (Akyol & Garrison, 2011a). Garrison and Akyol's research showed that metacognition in a CoI could be characterized as "*complementary self- and co-regulation that integrates individual and shared regulation*" (Garrison & Akyol, 2013, p. 84). That is, participation in a community of inquiry affects their meta-cognitive monitoring and control. This is particularly done through the role of teaching presence whereby instructional design, facilitation, and direct instruction along with peer guidance are intrinsic components of metacognition in a community of inquiry.

2.2. Educational technology use and self-regulated learning

One of the central ideas in the modern educational psychology is that learners *do not acquire, but instead construct new knowledge* (Bjork et al., 2013; Winne, 2006; Winne & Hadwin, 1998). One of the major models which conceptually describes this process is self-regulated learning (SRL) (Bjork et al., 2013). It views knowledge construction as being developed through the use of different cognitive, physical, and digital tools to operate on raw materials to create the products of cognition. These products of cognition are evaluated with respect to standards that can be internal (e.g., efforts budgeted to online discussions) and external (e.g., grading policy for online discussions). Moreover, learners are viewed as human *agents* who constantly meta-cognitively: i) control their learning operations by evaluating their study tools, including decisions as to whether tools should be used and how to use the tools (Azevedo, 2005), and ii) monitor their learning progress by comparing the products of their learning with the predetermined learning goals.

As suggested by Winne (1982, 2006) and Perkins (1985), the knowledge construction and agency perspectives to learning have several important implications regarding the learners' use of tools. Typically, learning environments are designed to promote personalization and adaptiveness to the learners' needs (Azevedo, 2005). Still, studies indicate that many students do not make use of the available tools and resources in a way which will maximize benefits to the learning (Ellis, Marcus, & Taylor, 2005; Lust, Elen, & Clarebout, 2013a; Lust, Vandewaetere, Ceulemans, Elen, & Clarebout, 2011). Most of the available tools are underused by the majority of the students indicating the lack of awareness, knowledge, or motivation to use the available tools (Lust et al., 2013a). This is shown to be especially important in the complex, fully online environments given the self-directed nature of learning and the limited opportunities for the physical interactions among the students (Shen, Cho, Tsai, & Marra, 2013). Lust, Juarez Collazo, Elen, and Clarebout (2012) and Clarebout, Elen, Collazo, Lust, and Jiang (2013) indicate that for successful learning in the modern, complex learning environments learners:

1) need to be able to *recognize the opportunities* (e.g., tools or study tactics) that are available in the learning environment. Not all students have the needed meta-cognitive knowledge to recognize the provided learning opportunities (Clarebout et al., 2013) — e.g., the use of asynchronous online discussions for problem solving.
2) need to be able to *draw a connection* between the opportunity and their task at hand — e.g., that participation in the asynchronous