Externally-facilitated Regulation Scaffolding and Role Assignment to develop Cognitive Presence in Asynchronous Online Discussions

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Abstract

This paper describes a study that looked at the effects of different teaching presence approaches in communities of inquiry, and ways in which student-student online discussions with high levels of cognitive presence can be designed. Specifically, this paper proposes that high-levels of cognitive presence can be facilitated in online courses, based on the community of inquiry model, by building upon existing research in *i)* self-regulated learning through externally-facilitated regulation scaffolding and *ii)* computer-supported collaborative learning through role assignment. We conducted a quasi-experimental study in a fully-online course (*N*=82) using six offerings of the course. After performing a quantitative content analysis of online discussion transcripts, a multilevel linear modeling analysis showed the significant positive effects of both externally-facilitated regulation scaffolding and role assignment on the level of cognitive presence. Specifically, the results showed that externally-facilitated regulation scaffolding had a higher effect on cognitive presence than extrinsically induced motivation through grades. The results showed the effectiveness of role assignment to facilitate a high-level of cognitive presence. More importantly, the results showed a significant effect of the interaction between externally-facilitated regulation scaffolding and role assignment on cognitive presence. The paper concludes with a discussion of practical and theoretical implications.

1   Introduction

Benefits of social interaction are well-documented in educational research. With the development of (educational) technology, especially computer-mediated communication, many benefits of social interaction are demonstrated in online education such as increased sense of community (Dawson, 2008), creative potential (Dawson, Tan, & McWilliam, 2011), critical thinking (Garrison, Anderson, & Archer, 2001), and integration into learning communities (Haythornthwaite, 2002). The community of inquiry model is one of the best studied theoretical frameworks in online education. Aiming to promote the ideals of higher education (Garrison, Anderson, & Archer, 1999; Garrison & Arbaugh, 2007), the model inspired many researchers to conduct studies and produce empirical evidence about the effectiveness of the model (e.g., for development of critical thinking and problem solving skills). Most of the existing studies focused on investigating effects of different instructional strategies to promote desirable learning outcomes – referred to as cognitive presence in the community of inquiry model – through engagement in asynchronous online discussions. However, limited research is available that investigated the effects of different instructional strategies on the knowledge construction of every individual student involved in a community of inquiry. Thus, the question arises about the equitable learning opportunities for all students in a community of inquiry (Rovai, 2007). Likewise, most of the studies emphasized the importance of leadership role of instructors and direct instruction in order to facilitate high-level learning outcomes

through asynchronous online discussions (Garrison & Cleveland-Innes, 2005). While instructional involvement is important for an educational experience, research evidence shows that student-student discussions lead to deeper learning than instructor-centered discussions (Schrire, 2006). Cost effectiveness and scalability of classes is another important concern attributed to direct involvement of instructors in online discussions (Anderson & Dron, 2011).

This paper proposes that the consideration of self-regulated learning and computer-supported collaborative learning (CSCL) research can offer important insights in order to address the above concerns related to the community of inquiry model. For the self-regulated learning perspective, it is important to recognize the lack of learners' skills to self-regulate own learning (Bjork, Dunlosky, & Kornell, 2013). In particular, this study investigates the effects of *externally-facilitated regulation scaffolds* that are already shown as effective in Web-based learning (Azevedo, Moos, Greene, Winters, & Cromley, 2008). From the perspective of the CSCL research, the emerging script theory of guidance (Fischer, Kollar, Stegmann, & Wecker, 2013) indicates that student-student discussions can be facilitated and high-level of knowledge construction can be achieved through scripting[1] and assigning roles to students (De Wever, Keer, Schellens, & Valcke, 2010; Schellens, Keer, Wever, & Valcke, 2007). To empirically validate this proposition, the paper reports on the results of a study in which the effects of externally-facilitated regulation scaffolding and role assignments were investigated in a fully-online master's level course throughout its six consecutive offerings from 2008 to 2011.

2 Background

2.1 Community of Inquiry Model

Being social constructivist in nature, the community of inquiry model is concerned with higher-order learning – an ideal of higher education – through computer-mediated interaction of learners and educators (Garrison et al., 1999, 2001; Garrison & Arbaugh, 2007). According to Garrison, Anderson, and Archer (2001, p. 7), a community of inquiry "involves (re)constructing experience and knowledge through the critical analysis of subject matter, questioning, and the challenging of assumptions (Dewey, 1959; Lipman, 2003)." An effective educational experience in such a community is facilitated through the interaction of the three cornerstones of the model: *cognitive presence*, *social presence*, and *teaching presence*. Focused on higher-order thinking rather than an individual learning outcome, cognitive presence 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 is explained through the model of critical thinking, i.e., practical inquiry model (PIM) (Garrison et al., 1999). Similar to the work of Duffy, Dueber, and Hawley (1998), PIM distinguishes the four phases of cognitive presence (Garrison et al., 2001): i) triggering event – the initiation of a critical inquiry; ii) exploration – a move from the private world of an individual to the shared world of social exploration in critical inquiry; iii) integration – a construction of meaning based on the information shared in the exploration phase; and iv) resolution – a solution to the idea/dilemma through a direct or vicarious action. Indicators of each of the four phases of cognitive presence were identified by Garrison et al. (2001).

Social presence is a necessary antecedent of an effective educational experience in a community of inquiry (Garrison & Arbaugh, 2007; Garrison, Cleveland-Innes, & Fung, 2010). Social presence of learners is established by providing learners with opportunities to develop "the ability to project their personal characteristics into the community of inquiry, thereby presenting themselves as 'real people' (Garrison et al., 1999, p. 4)". By establishing social presence, the participants of a community of inquiry create a safe environment in which they can be engaged in a practical inquiry with the members of the community. For example, Rovai (2002) showed that a strong sense of community increased cognitive

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[1] Collaboration scripts are recognized as the key scaffolding approach in CSCL, whereby a script can be defined as "a more detailed and more explicit didactic contract between the teacher and the group of students regarding to their mode of collaboration (Dillenbourg, 2002, sec. Introduction, para. 3)."

learning, while a positive causal relationship between perceived measures of social and cognitive presence was empirically confirmed by Garrison et al. (2010).

2.2   Establishing and Maintaining Cognitive Presence in Online Discussions
Importance of teaching presence for "establishing and sustaining an online learning environment and realizing intended learning outcomes" (Garrison et al., 2010, p. 35) is confirmed in numerous studies (Garrison & Arbaugh, 2007; Garrison & Cleveland-Innes, 2005; Garrison, 2011; McKenzie & Murphy, 2000; Meyer, 2003; Pawan, Paulus, Yalcin, & Chang, 2003; Rovai, 2007). Moreover, Garrison et al. (2010) confirmed a causal relationship from teaching presence to both social and cognitive presence, and thus, reinforced the hypothesis that social presence is a mediating variable between teaching and cognitive presence. Consistent with this, early studies of online discussions observed that the students without explicit guidance would engage in "one-way interaction (serial monologues)" (Pawan et al., 2003, p. 135) and only exchanging commentaries without responses to peers' posts (McKenzie & Murphy, 2000). Cognitive presence in such discussions was reported as low with the great majority of posts remaining in the triggering and exploration phases (Kanuka, 2011; Pawan et al., 2003). Thus, the inquiry process of a community would not lead to the desirable learning outcomes and higher order thinking.

Teaching presence is theorized to consist of three components (Anderson, Rourke, Garrison, & Archer, 2001): instructional design, facilitation, and direct instruction. Arbaugh and Hwang (2006) reported the result of a study that confirmed the validity of this construct and its concomitant components. The positive effect of these three dimensions for reaching higher levels of cognitive presence is reported in numerous studies (Garrison & Cleveland-Innes, 2004, 2005; Pawan et al., 2003; Rovai, 2007; Young, 2006). However, developmental factors can make it difficult for some populations of learners (e.g., undergrads vs. graduate students) to distinguish between facilitation and direct instruction (Garrison et al., 2010). For example, Shea, Sau Li, and Pickett (2006) showed that teaching presence is best described by two factors of teaching presence – instructional design and directed facilitation (a combination of facilitation and direct instruction). Integrating the findings of several studies about facilitation of cognitive presence in online discussions, Garrison and Cleveland-Innes (2005) identified instructional design (create structured and cohesive discussions) and clearly defined roles (leadership of instructors in particular) as critical.

2.3   Research Questions
Our literature review revealed the following two research gaps, which motivated the formulation of our research questions. First, most of the present studies report frequency distribution of the four phases of cognitive presence for entire groups involved in the studies. Those studies were mainly done through quantitative content analysis by coding online discussion transcripts with the four phases of cognitive presence (Garrison et al., 2001; Pawan et al., 2003; Richardson & Ice, 2010). However, our research did not reveal a study, in which the effects of specific instructional strategies were analyzed for each individual student. Although group learning and problem solving is important and students can have learning benefits through so-called vicarious participation (Sutton, 2001), it is at least equally important for each individual student to be deeply involved in the knowledge construction process and highly active cognitive processing operations (Bjork et al., 2013; Schellens & Valcke, 2005). This is especially important in situations in which students are provided with the benefits of social construction, while working on personalized problems that are assessed individually.

Second, the leadership role of instructors, their high participation in discussions, and in general facilitation and instruction as critical components of teaching presence for engaging students in deep learning and high cognitive presence (Garrison & Arbaugh, 2007; Garrison & Cleveland-Innes, 2005). While effective, such an approach to facilitating discussions might not be scalable (Anderson & Dron, 2011). However, student-led discussions and student-student interactions can offer important education benefits (Johnson, 1981) as illustrated through the following findings (a) effect size of student-student interaction on achievement was found to be higher than those of student-instructor and student-content in

a meta-analysis of interaction types in distance education (Bernard et al., 2009); (b) cognitive presence of students in student-student discussion threads was found to be higher than in student-instructor discussion threads (Schrire, 2006); and (c) stronger integration of students in learning communities can increase the level of student retention in classes (Tinto, 1997). Unfortunately, a recent study showed that only 1% of faculty members incorporate these strategies into the design of their courses (Lynch, Kearsley, & Thompson, 2011).

We posit that student-student online discussions with a high level of cognitive presence can be achieved through an effective instructional design, which can compensate for the other two components of teaching presence – facilitation and direct instruction. Such instructional design should promote a high level of cognitive presence of individual members of a community and the community as a whole. This proposition can be considered in terms of interaction types – a well-established construct in distance and online education initially proposed by Moore (1989) and extended by Anderson (2003) – whereby facilitation and direct instruction can be considered student-instructor interaction types. As suggested by Anderson (2003), the advancement of (learning) technologies affords replacing student-instructor interactions with student-content interactions, which is consistent with our claim. To support our claim, we build upon research on self-regulated learning (Winne & Hadwin, 1998) and scaffolding in computer-supported collaborative learning (CSCL) (Kobbe et al., 2007) and investigate the following two research questions.

2.3.1   RQ1: What is the effect of external motivation and external regulation standards on the development of cognitive presence?

Models of self-regulated learning deem learners are agents (Bjork et al., 2013). Learners decide which information or learning activity is relevant and induce how it supports their goals. Learners set their goals based on *external* (e.g., course grading policy or task requirements) and *internal* (e.g., knowledge of collaborative learning and intrinsic motivation to learn) *conditions*. The goals are modeled as a set of *standards* for cognition, e.g., extent to which ideas from multiple sources should be integrated. These standards are used for the *evaluation* of the effectiveness of learning through: i) metacognitive control of learning activities they perform while studying, and ii) metacognitive monitoring of their learning by evaluating their learning products against the learning goals in order to inform their decisions about own learning. However, research indicates that many learners are not skilled at self-regulated learning (Bjork et al., 2013). In particular, weaknesses are reflected by the use of inaccurate standards in metacognitive monitoring (e.g., quality of their discussion contributions or time budgeted for collaborative activities) and ineffective tactics they apply while learning (e.g., approaches to seeking, integrating, and sharing information in their inquiry process) (Bjork et al., 2013).

Self-regulation and metacognition are gaining more attention in the research about the community of inquiry model and CSCL (Akyol & Garrison, 2011; Cho & Kim, 2013; Garrison & Akyol, 2013; Shea & Bidjerano, 2010). Shea and Bidjerano (2010) empirically validated associations between key constructs of self-regulated learning (e.g., self-efficacy and effort regulation) with the three components of the community of inquiry model. The emphasis on motivation of Shea and Bidjerano's findings is consistent with several previous studies highlighting the importance of including grading of student participation in online discussions (Conaway, Easton, & Schmidt, 2005; Davies & Graff, 2005; Gilbert & Dabbagh, 2005; Palmer, Holt, & Bray, 2008; Rovai, 2007). However, grading of participation in online discussions is insufficient if only quantitative standards are defined (Palmer et al., 2008) and requires additional support for students to help them regulate their learning in a community of inquiry (Cho & Kim, 2013).

Metacognition in the community of inquiry model is a complex construct that "integrates individual and shared regulation (Garrison & Akyol, 2013, p. 84)." That is, in addition to the weaknesses in self-regulated learning indicated above, shared regulation should also be considered when designing effective participation requirements. Consistent with this, the script theory of guidance in CSCL distinguishes between *internal* (i.e., knowledge of collaborative learning) and *external* (i.e., instructional scaffolds for collaborate learning) *scripts* (Fischer et al., 2013; Kollar, Fischer, & Slotta, 2007). The lack of knowledge

of effective learning strategies and weaknesses in judgment of own learning is well-documented in research of self-regulated learning (Bjork et al., 2013). Learners have similar weaknesses in regulation of collaborative learning and require external instructional scaffolds[2]. A recent study showed that instructional scaffolds were the most important factor that predicts students' regulation of interaction with others (Cho & Kim, 2013). This finding only reinforced the consistency with the research about self-regulated learning and interaction of learners with content, i.e., *externally-facilitated regulated learning* was shown to be more effective than self-regulated learning in Web-based learning (Azevedo et al., 2008; Kauffman, Zhao, & Yang, 2011).

To establish a high level of cognitive presence in asynchronous online discussions, the design component of teaching presence needs to provide *students with externally-facilitated regulation scaffolding for participation in online discussions. Scaffolding should guide the students to progress to the level of cognitive presence expected in the course objectives. Externally-facilitated regulation scaffolds should be designed with the special care for students' motivation to participate in online discussions.*

In the study reported in this paper, we focus on standards as a mean to operationalize externally-facilitated regulated learning. Specifically, we looked at the effects of the improved clarity of the task condition to promote standards that learners use in their inquiry process through online discussion and guide them to higher levels of cognitive presence. Moreover, the study assumed standards for motivation, as part of conditions consistent with the Winne and Hadwin model (1998), by setting expectations for students to participate in the discussions as part of the course grading scheme.

2.3.2   RQ2: Can we build effective student-led discussions through role assignment?

Research in CSCL starts from the same premise, deeply recognized in the community of inquiry model (Garrison et al., 2010), that learners do not engage in deep collaborative learning without instructional guidance (Weinberger, Stegmann, Fischer, & Mandl, 2007). CSCL recognizes importance of scaffolding of collaborative learning as knowledge construction though social negotiation (Woo & Reeves, 2007). Collaborative scripts – a key scaffolding approach in CSCL – are used to define, sequence, and assign roles in collaborative learning activities (Kobbe et al., 2007).

Role assignment is a type of collaboration script that has attracted much research attention in CSCL research over the past decade. Strijbos and Weinberger (2010) define roles as "more or less stated functions or responsibilities that guide individual behaviour and regulate group interaction (2010, p. 491)," while scripted roles are purposefully "designed to improve both learning processes and outcomes (2010, p. 492)." Role assignment has been empirically tested in CSCL research as an effective approach to increasing the level of knowledge construction, cognitive processing, and argumentation (De Wever et al., 2010; De Wever, Van Keer, Schellens, & Valcke, 2009; Hare, 1994; Schellens, Keer, & Valcke, 2005; Schellens et al., 2007; Strijbos & Weinberger, 2010). These studies identify certain role types as particularly effective for knowledge construction, especially if those roles were assigned timely (De Wever et al., 2010). For example, Schellens et al. (2007) showed that the role of summarizer had a statistically significant positive effect on knowledge construction in a study in which online discussion transcripts were coded with the knowledge construction levels proposed by Gunawardena, Lowe, and Anderson (1997). The summarizer role was found to have had a considerably higher effect on the level of knowledge construction over no role assignment condition.

Role assignment is a promising approach to increasing the level of cognitive presence in communities of inquiry. Although some studies have implicitly used instructional strategies, which had specifically

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[2] In the field of CSCL, these external instructional scaffolds are commonly referred to as external scripts (Fischer, Kollar, Stegmann, & Wecker, 2013). The major reason for the use of the term "script" lies in the nature of the scaffolds used in CSCL where role assignment is the most commonly used type of instructional scaffolding. Each role in such collaborative learning context is assigned to students through the scripts describing how they should play the role assigned.

designated roles for students (e.g., WebQuest (Kanuka, 2005)), no study investigated an effect of individual roles on cognitive presence in the community of inquiry model. In order to scaffold knowledge construction in a community of inquiry and help all students move up to the higher levels of cognitive presence (integration and resolution), design and assignment of roles with a single duty does not seem promising, especially in situations when students are requested to work on personalized problems that are assessed individually, which is a common case in junior and senior undergraduate and especially graduate courses. *Therefore, we propose designing roles that will include multiple duties and that will scaffold students' progression throughout the phases of PIM to the highest levels of cognitive presence.* These duties should include opportunities for the initiation of a new inquiry, sharing information and brainstorming, hypothesizing new solutions, and (vicariously) testing the hypothesized solutions. For such roles to be effective, *the specification of the roles should be aligned with externally-facilitated regulation scaffolds that guide students how to contribute to online discussions, as studied in RQ1.*

3 Method

3.1 Study Design

The study reported followed the design-based research method (Design-Based Research Collective, 2003) whichis commonly used for studying knowledge construction through social negotiation in online asynchronous discussions (Gilbert & Dabbagh, 2005; Schellens et al., 2007; Swan, Matthews, Bogle, Boles, & Day, 2012). Design-based research involves at least two main types of intervention – instructional and technological (Brown, 1992). Anderson and Shattuck (2012). The interventions studied in this research were *instructional* – externally-facilitated regulation scaffolding and role assignment. Given the naturalistic context and the interventionist method followed, the study was *quasi-experimental* as the researchers did not have a control over the assignment of the participants to the experimental condition (i.e., the students were assigned to the groups through the course enrollment).

Specifically, our study followed a *quasi-experimental mixed design* (Field & Hole, 2003). The *between groups (i.e., independent samples)* component of the mixed-design looked at the effects of externally-facilitated regulation scaffolding (i.e., research question RQ1). That is, the initial course design related to asynchronous online discussions was used in the first two offerings of a fully online course – *control group*. This initial course design primarily focused on the extrinsic motivation (i.e., grades) and had a limited scaffolding for the quality of discussion participation. This original design was refined and used for structuring of the asynchronous online discussions in the following four course offerings – *treatment group*. The refinement included an externally-facilitated regulation scaffold guiding students to the expected level of cognitive presence, as proposed in research question RQ1. Furthermore, the *within group (i.e., repeated measures)* component of the mixed-design looked at the effects of role assignment and rotation, as proposed in research question RQ2. That is, in both groups (control and treatment), each student was assigned to two different roles as described in Section 3.2. The differences in the numbers of students enrolled into different course offerings, caused by the quasi-experimental nature of the study, led us to have a different number of course offerings per iteration in order to have i) a statistical power necessary for the planned statistical analysis, and ii) the sample sizes in both iterations of the approximately similar size.

3.2 Course Design and Interventions

In our study, we use the data from six offerings of a master's-level research intensive course in software engineering. The course covered selected topics of software engineering related to software requirements, design, implementation, evolution, and process. It was a 13 week long master's level course offered by using the Moodle learning management system. The final grade was based on scores on the four assignments and participation in asynchronous online discussions. In assignment 1 (15% of the final grade), the students were requested to select a peer-reviewed research paper, prepare a presentation of the selected paper, record it in a video format, upload their video recordings to a university-wide software for video sharing and streaming (YouTube-like), and post the URL of their streamed presentation to their

peers on an asynchronous online discussion forum. In assignment 2 (25%), the students were requested to prepare a paper reviewing the peer-reviewed literature on a selected topic in software engineering; the papers were assessed by both two peers (double blind) and the instructor. In assignment 3 (15%), the students were requested to answer six questions based on the course readings with the particular emphasis on the synthesis of course readings and critical analysis of different perspectives of importance to modern software engineering research and practice. Finally, in assignment 4 (30%), the students were requested to work in groups of two on a research project that was solving a practical software engineering problem.

The focus of this study was on the asynchronous online discussions that were organized as part of assignment 1. The discussions were in weeks 3-5 of the course and assigned 10% of the final course mark[3]. Each week, one third of the students enrolled into the course offering were requested to prepare a video-recorded presentation, and the rest of the group was requested to engage into the discussion around the presentations. The guidelines for participation in discussions (RQ1) are available in Appendix A: a) for the control group; and b) for the treatment group (i.e., second iteration). These guidelines were informed by the existing frameworks for facilitating and structuring online discussions (Gilbert & Dabbagh, 2005; Rovai, 2007). As per Rovai's (2007), the guidelines covered the elements of structure. Specifically, the following elements of the structure were included: motivation – by grading student participation in online discussions; expectations – by defining the quality of posts; and task-oriented discussions – by focusing discussions on the particular topics of the presentations and steering discussions towards defining the research problems to be solved in the future assignments. The course revision – treatment group – particularly focused on the expectations component of the guidelines in order to introduce an externally-facilitated regulation scaffold.

Students were assigned two types of roles: *research expert* and *practicing researcher*. Given the complexity of the ill-structured problems students were requested to work on the course (requesting a problem identification and formulation before even starting to work on the solution), need to scaffold the practical inquiry in such a context, and the ineffectiveness of some of the (single-duty) roles reported in the literature (e.g., source searcher), the roles were designed to have multiple functions. In particular, both roles used in our study were built as a composition of existing single-duty roles: *source searcher* – to find relevant information sources in order to propose new ideas, offer counter-point to their peers' posts, express their puzzlement, support their claims (i.e., mostly, to support triggering events and exploration); *theoretician* – to support their claims with the existing body of knowledge in software engineering (i.e., exploration and integration); and *summarizer* – to integrate ideas from different posts of their peers or information sources, hypothesize and test new solutions (i.e., integration and resolution). In addition, expert researchers had an additional two single-duty roles: *moderator* – to facilitate discussions in their discussion threads (i.e., process-oriented role) (Schellens et al., 2007); and *topic leader* – to initiate a new discussion topic and act as an (invited guest) expert on the topic (i.e., support exploration, integration, and resolution) (Kanuka, 2011; Tagg, 1994). During the three weeks scheduled for the discussions, each student played the role of: i) expert researcher in one of the three weeks in a thread they created in relation to their presentation; and ii) practicing research in each of the three weeks in the threads led by their peers. With this script of the roles, we aimed to foster student-student discussions with equitable opportunities for participation in the discussions (Johnson, 1981; Rovai, 2007; Schrire, 2006).

3.3 Participants
The participants (*N*=82) were students enrolled in a master's-level research intensive software engineering course. In particular, the participants from the control group were enrolled into the following

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[3] The students received another 5% of the final course mark on their participation in general discussions in the course. This was created to offer students unstructured opportunities to connect and build their social presence. These discussions are not included in this study. While very important for educational experience, we could not use them for answering the two research questions of this study due to the difference in the context and the lack of the interventions.

course offerings (13-weeks long): Winter 2008 (N=15) and Fall 2008 (N=23). The participants from the treatment group were enrolled into the following course offerings: Summer 2009 (N=10), Fall 2009 (N=7), Winter 2010 (N=14), and Winter 2011 (N=13). Of the total number of students, the sample had 10 females (12.2%), which is a typical gender distribution for computing programs (Zweben, 2012). From the analysis, we excluded data of the students who withdrew from the course before the end of the discussion period (Week 5). The total number of posts submitted to the asynchronous discussion forum by the 82 students used in our analysis was 1,717. The participants were enrolled in to a master's program in information systems offered at a fully-online comprehensive university in Western Canada. The master's program has two student intakes per year and typically caters to part-time students who usually maintain their regular employment. Enrolled students are not requested to follow any predefined course registration; that is, the program does not follow a cohort-based learning model. However, course prerequisites exist and drive the sequence of course completion. As such, all the students had to take one pre-requisite course – survey of computing and information systems – before enrolling into the course under study. An independent t-test did not reveal any significant difference (t(79) = .25, p = .588) in the mean values of the students' grades in the pre-requisite course between the control group (M = 91.85, SD = 5.66) and the treatment group (M = 91.82, SD = 6.31). That is, there were no significant differences between the two groups in the mean values of a proxy of prior-knowledge/ability commonly used in educational research – academic performance in the previous courses.

The first three offerings of the course were instructed by the first author of the paper (Winter 2008, Fall 2008, and Summer 2009). The last three offerings of the course (Fall 2009, Winter 2010 and Winter 2011), included in the study, were taught by an instructor who was not involved in this study, but who completely followed the course design outlined in Section 3.2.

3.4 Quantitative Content Analysis

Media used in asynchronous online discussions forces learners to leave written traces of their communication. Those traces can be used to analyze and interpret knowledge construction developed at the group level and in individual written contributions (Stahl, 2004). Quantitative content analysis is a well-known technique for analysis and interpretation of knowledge construction, cognitive processing, and the three main constructs of the community of inquiry model – teaching, social, and cognitive presence – in asynchronous online discussions (De Wever et al., 2010; Garrison et al., 2001; Gunawardena et al., 1997; Schellens et al., 2007). According to Berelson (1952), quantitative content analysis is "a research technique for the systematic, objective, and quantitative description of the manifest content of communication (p. 18)". Message is the most commonly used unit of analysis in the studies of cognitive presence and knowledge construction (Anderson et al., 2001; De Wever et al., 2010; Schellens et al., 2007).

Specifically, for quantitative content analysis of the discussion messages collected in the study (total 1,747[4]), the four categories of cognitive presence were used. For each category, the indicators outlined in **Error! Reference source not found.** and the specification of their socio-cognitive processes outlined by Garrison (2001) were followed. In addition to the four categories of cognitive presence, an additional category – other – was used to code the messages in which no traces of cognitive presence were found. The quantitative content analysis was performed by the first two authors of the paper – coders. The first author was the instructor in the first three offerings of the course; this author also designed the course and the course revision (i.e., scaffold). To avoid the bias of the first author who directly participated in the course, the second author was involved in the study from the quantitative content analysis stage. Both coders had had experience with the quantitative content analysis technique through its use in other studies. Both coders initially studied the coding scheme, its indicators, social-cognitive processes and

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[4] This number of the total coded messages is higher than the number of the messages used in our analysis, due to the exclusion of the students who withdraw from the course before the end of the discussions, as indicated in Section 3.3.

examples as originally introduced by Garrison et al. (Garrison et al., 2001). A sample thread from the available discussion transcripts was selected randomly, and the coding process was discussed by the coders. Then, the coders coded an additional discussion thread separately, and reconvened to discuss their codes. As a high level of mutual agreement was observed at that time, the coders independently coded messages. Finally, the coders compared their codes and reconciled their coding in the case of an initial disagreement. The overall disagreement was in less than 2% of the analyzed cases (i.e., 32 messages), with high inter-rater reliability (Cohen's kappa of .97).

3.5 Data Analysis

Considering the hierarchical nesting of the data in the study (i.e., individual students are nested into groups created around the course offerings), the revision of the participation guidelines, and the two roles each student was assigned to, mixed-design multilevel linear modeling was used to answer the research questions. Given that the students are grouped based on their enrollment into the six different course offerings, the individual observations – i.e., the students' posts – could not be considered fully independent due to the similarities shared among the individual students enrolled in the same course offering (Hox & Kreft, 1994). According to Hox and Mass (2002), "even if the analysis includes only variables at the lowest level, standard multivariate models are not appropriate. The hierarchical structure of the data creates problems, because the standard assumption of independent and identically distributed observations is generally not valid." The violation of independence assumption in commonly used multivariate methods is often observed in CSCL research. This violation often leads to underestimation of standard errors, and hence, can result in incorrect inferences about statistical significance (Schellens et al., 2007). As a method robust to this violation, multilevel linear modeling has been widely accepted in CSCL research (Cress, 2008; De Wever et al., 2010, 2009; Schellens et al., 2007).

The data analysis in our study was performed using multilevel linear modeling. In particular, the data in our analysis had three levels: 1) individual messages, 2) students; and 3) course offerings (i.e., groups). In our analysis, the mean values of the messages submitted in each of the four phases cognitive presence were used as dependent variables; i.e., for each phase of cognitive presence, we created a separate multilevel linear model (i.e., we had four different models). Given the mixed-design nature of our study, the multilevel linear models had two dummy variables as fixed effects denoting

1. *independent samples*: 0 – the students in the course offerings with the original course design, i.e., control group; and 1 – the students in the course offerings with revised course design that included externally-facilitated regulation scaffold, i.e., treatment group;
2. *repeated measures*: 0 – the discussion contributions of the students posted with the practicing researcher role assignment; 1 – the discussion contributions of the students posted with the expert researcher role assignment.

In addition, the interaction of the two dummy variables was added in order to test for the effects of externally-facilitated regulation scaffolding on the students when assigned to the two different roles analyzed in our study.

The distribution of variables was tested for normality using the Kolmogorov–Smirnov and Shapiro–Walk tests. This was further explored using P-P plots. Non-normally distributed variables were transformed using natural logarithm for statistical analysis (Keene, 1995). As the values of all the four dependent variables were log-transformed, the results of multilevel linear models were estimated as geometric mean values. All the analyses were performed by using SPSS v. 19. The effect sizes were reported as Pearson's *r* (Rosnow, Rosenthal, & Rubin, 2000, Eq. (1)) and interpreted according to Cohen's recommendation (1992) (i.e., .1 – small, .3 – moderate, and .5 – large)

4 Results

Table 1 presents the distribution of the discussion posts based on the level of cognitive presence for both quasi-experimental conditions and role assignments. The total numbers of posts for either role assignment

is very close in both quasi-experimental conditions, which corroborates the study design decision about the number of student groups involved in either experimental condition. In the control group, a great majority (78.3%) of the posts of the students with the practicing researcher role assignment stayed at the lower levels of cognitive presence – triggering event and exploration. The students when assigned to the practicing researcher role had a very marginal number of the resolution posts (2.01%) and a slightly better presence of the integration posts (12.08%). On the other hand, the students when assigned to the role of expert researcher had a much higher level of cognitive presence than practicing researchers in the control group. Although the two lowest levels of cognitive presence – triggering events and exploration – were still predominant (59.4% combined), cognitive presence of the contributions to the asynchronous online discussions at the level of integration was more than double of the proportion of integration posts for the students when assigned to the practicing researcher role (i.e., 25.25% vs. 12.08%). While the proportion of the discussion posts in the resolution phase contributed by the students when assigned to the role of expert researcher was relatively low (6.93%), it was still over three times higher than the proportion of the resolution posts of the students when assigned to the role of practicing researchers (only 2.01%).

In the treatment group, the distribution of the asynchronous online discussion across the four levels of cognitive presence reveals a different trend. The students when assigned to the role of practicing researcher still had around ~50% of the messages in the triggering event and exploration phases. However, this represents a drop of ~28% in the distribution of these two lowest levels of cognitive presence as compared to the control group. The results also show a considerable increase in the distribution of the discussion posts at the upper two phases of cognitive presence, whereby there were over 42% of the discussion posts in the integration and resolution phases combined. That is, the distribution of the integration and resolution posts in the treatment group for the students when assigned to the role of practicing researchers was almost three times of the distribution for the students in the control group with the same role assignments. An increase in the distribution of the discussion posts in the integration and resolution phases is also notable for the students when assigned to the role of expert researcher in the treatment group as compared to the control group (from 32.18% in the control group to 54.45% in the control group). That is, an increase of about 1.7 times. This increase seems to be evenly distributed across both integration and resolution phases. Consequently, the proportion of the messages in the two lowest phases of cognitive presence for the students in the treatment group when assigned to the role of expert researcher decreased. The difference in the distribution of the four levels of cognitive presence between the two role assignments in the treatment group are minor (with the notable exception of resolution) as compared to the differences observed in the control group. Finally, it should be noted that the presence of the messages without traces of the four phases of cognitive presence was at a similar level for both groups and role assignments.

Table 1. The total number of discussion posts and their distribution per cognitive presence phase for both quasi-experimental conditions and role assignments

	Cognitive presence type	Practicing researcher	Expert researcher
Control group	Triggering event	36.47%	9.90%
	Exploration	41.83%	49.50%
	Integration	12.08%	25.25%
	Resolution	2.01%	6.93%
	Other	7.61%	8.42%
	Number of discussion posts	447	404
Treatment group	Triggering event	14.09%	11.14%
	Exploration	35.79%	30.69%
	Integration	38.03%	42.82%

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	Resolution	4.25%	11.63%
	Other	8.50%	6.68%
	Number of discussion posts	450	416

In order to investigate the impact of the externally-facilitated regulation scaffold (research question RQ1) and the assignment of the two different roles (research question RQ2) on the level of cognitive presence in asynchronous online discussions, three-level mixed-design multilevel linear models were estimated. Messages (level 1) were clustered within students (level 2) who participated in the discussions of the groups (level 3) created by the students' course enrollment. The variables used in the models are described in Section 3.5. First, we estimated a random intercept null model for each of the four dependent variables. Then, we estimated the models by entering the two dummy variables and their interaction into the models as fixed effects. All the models are shown in Table 2.

Table 2. The estimated values of the three-level models for the four phases of cognitive presence

Parameter	Triggering event		Exploration	
	Model 0	**Model 1**	**Model 0**	**Model 1**
Intercept	0.759 (0.116)[**]	1.272 (0.185)[**]	1.313 (0.160)[***]	1.484 (0.282)[*]
EFR scaffold		−0.655 (0.232)[*]		−0.184 (0.351)
Role assignment		−0.608 (0.115)[***]		0.102 (0.138)
EFR scaffold * Role assignment		0.668 (0.157)[***]		−0.307 (0.189)
Level 3	0.068 (0.049)	0.055 (0.045)	0.139 (0.098)	0.140 (0.110)
Level 2	-	-	-	-
Level 1	0.294 (0.033)[***]	0.252 (0.029)[***]	0.366 (0.041)[***]	0.363 (0.041)[***]
Parameter	**Integration**		**Resolution**	
	Model 0	**Model 1**	**Model 0**	**Model 1**
Intercept	1.195 (0.163)[**]	0.566 (0.234)	0.345 (0.062)[**]	0.153 (0.116)
EFR scaffold		0.731 (0.293)		0.088 (0.149)
Role assignment		0.602 (0.124)[***]		0.260 (0.097)[**]
EFR scaffold * Role assignment		−0.452 (0.169)[**]		0.020 (0.133)
Level 3	0.144 (0.101)	0.092 (0.080)	0.013 (0.017)	0.015 (0.022)
Level 2	0.003 (0.042)	0.044 (0.038)	0.023 (0.027)	0.039 (0.025)
Level 1	0.374 (0.058)[***]	0.292 (0.046)[***]	0.212 (0.033)[***]	0.180 (0.028)[***]

Legend: [*]p<.05, [**]p<.01, [***]p<.001. All the estimated values are natural logarithms, due to the transformation of the dependent variables by natural logarithm; EFR – externally-facilitated regulation scaffold. The null-models and estimated geometric values are provided in the supplemental material.

The results in Table 2 indicate that the addition of the externally-facilitated regulation scaffold significantly decreased the estimated geometric mean value of triggering events for practicing researchers $(F(1, 5.124) = 8.00, p= .035)$; the decrease was 45.56% (i.e., $|1 - e^{-0.608}|$) with a high effect size $(r = .78)$. The assigned to the role of expert researcher in the control group significantly decreased the estimated geometric mean value of triggering events as compared to practicing researchers in the control group $(F(1, 156.282) = 27.885, p < 0.001)$; the decrease was 48.06% (i.e., $|1 - e^{-0.655}|$) with a moderate effect size $(r = .39)$. Finally, the assignment of the role of expert researcher significantly increased estimated geometric mean value of triggering events in the treatment group as compared to practicing researchers in the control group – i.e. the interaction of the externally-facilitated regulation scaffold and the role

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assignment was also significant (F(1, 156.282) = 18.063, p < 0.001); the increase was about 21.96% (i.e., $|1 - e^{(-0.608 - 0.655 + 0.668)}|$) with a moderate effect size (r = .32). These effects of the two factors and their interaction on the estimated geometric mean values of triggering events are shown in Figure 1a.

Unlike the observed effects for triggering effects, neither externally-facilitated regulation scaffold in the treatment group for practicing researchers (F(1, 4.421) = .276, p = .625, r = .24) nor expert researcher role assignment in the control group (F(1, 155.967) = .541, p = .463, r = .06) were statistically significant (Table 2). Although Figure 1b shows a distinct pattern of the two roles in the two different quasi-experimental conditions, the interaction was also not significant F(1, 155.967) = 2.640, p = .106, r = .13); yet, the value of p = .106 indicates a trend towards statistical significance with the decrease of 32.23% (i.e.,$|1 - e^{(-0.184 + 0.102 - 0.307)}|$) of the exploration posts created by expert researchers in the treatment group, but with a small effect size (r = .13). These effects of the two factors and their interaction on the estimated geometric mean values of exploration posts are shown in Figure 1b.
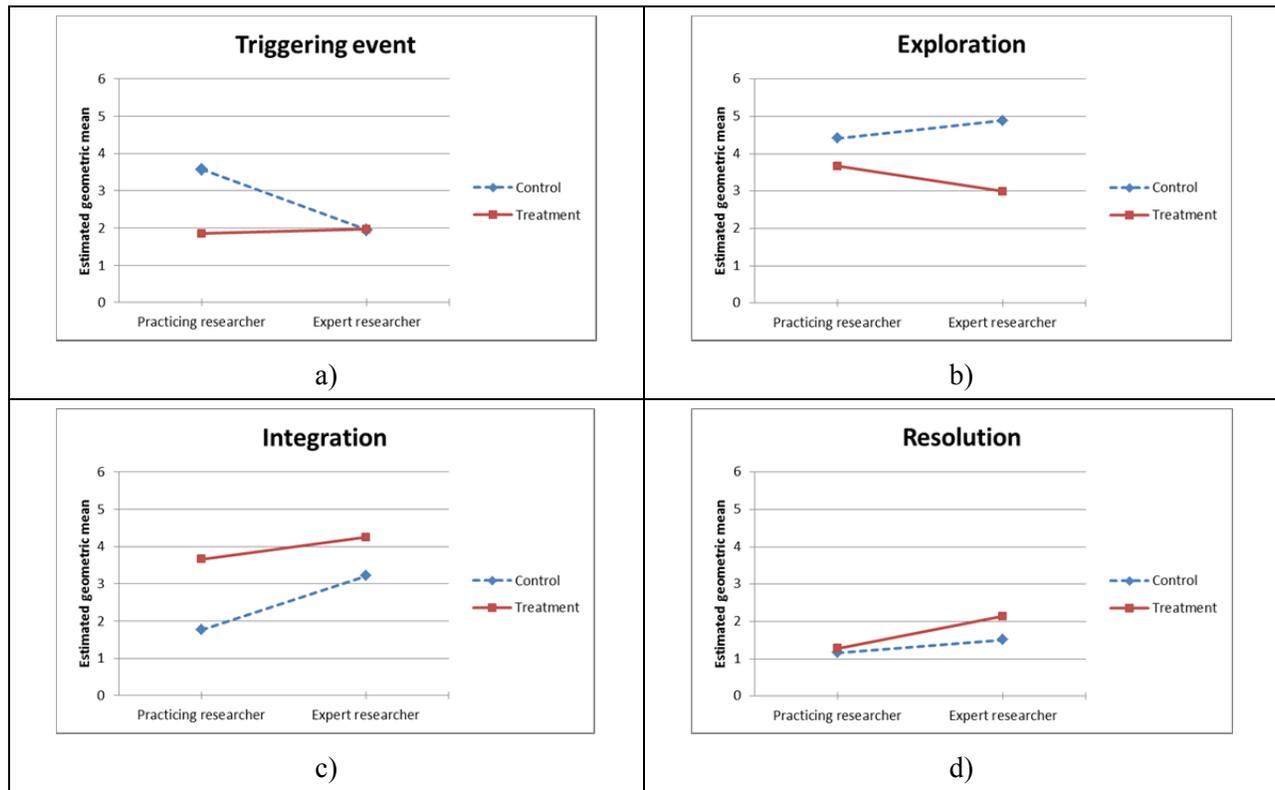
Figure 1. The effects of the interaction of the improved participation guidelines (control vs. treatment group) and the role assignment on the level of cognitive presence

Although the results in Table 2 show that the externally-facilitated regulation scaffold increased for 107.72% (i.e., $|1 - e^{0.731}|$) the estimated geometric mean value of integration posts for practicing researchers, the increase was not statistically signification (F(1, 4.088) = 6.235, p = .066, r = .78). However, the value of p = .066 indicates a clear trend towards statistical significance with a large effect size (r = .78). The assignment to the role of expert researcher in the control group significantly increased the estimated geometric mean value of integration posts as compared to practicing researchers in the control group (F(1, 80.452) = 23.55, p < 0.001, r = .48); the increase was 82.57% (i.e., $|1 - e^{0.602}|$) with marginally large effect size (r = .48). Finally, the assignment of the role of expert researcher significantly increased the estimated geometric mean value of integration posts in the treatment group as compared to practicing researchers in the control group – i.e. the interaction of the externally-facilitated regulation

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scaffold and the role assignment was also significant ($F(1, 80.452) = 7.148$, $p = .009$, $r = .29$); the increase was about 141.33% (i.e., $|1 - e^{(0.731 + 0.602 - 0.452)}|$) with marginally moderate effect size ($r = .29$). These effects of the two factors and their interaction on the estimated geometric mean value of integration posts are shown in Figure 1c.

The positive effect of the assignment of students to the role of expert researchers in the control was statistically significant ($F(1, 81.135) = 7.130$, p $= .009$, $r = .28$) and resulted in the increase of 29.69% (i.e., $|1 - e^{0.260}|$) of the estimated geometric mean value of expert researchers in the control group and with a marginally moderate effect size ($r = .28$), as shown in Table 2. The externally-facilitated regulation scaffold guidelines increased the estimated geometric mean value of resolution posts for 9.20% (i.e., $|1 - e^{0.088}|$) in the treatment group for practicing researchers as compared to the same role assignment in the control group; this increase was not statistically significant ($F(1, 3.549) = .351$, p $= .589$, $r = .30$) though, but the effect size was moderate ($r = .30$). Similarly, the expert researchers in the treatment group had the estimated geometric mean value of the resolution posts for 44.84% (i.e., $|1 - e^{(0.088 + 0.260 + 0.020)}|$) as compared to practicing researchers in the control group; however, this effect of interaction was not statistically significant ($F(1, 81.135) = 0.024$, $p = .878$, $r = .02$) with rather a low effect size ($r = .02$). The effect of the interaction of the two variables is shown in Figure 1.

Finally, to investigate the effect of the group level of cognitive presence, we extracted the temporal dependencies of the messages from the discussion forums used in our study. Table 3 shows the levels of cognitive presence for responses to the messages which were at particular cognitive presence levels.

Table 3. Dynamics of cognitive presence in a community of inquiry: The frequencies of the cognitive presence level of discussion posts contributed as responses to the messages which were at particular cognitive presence levels

Group	Cognitive presence	Triggering event	Exploration	Integration	Resolution	Other
Control group	Triggering event	178	74	25	5	4
	Exploration	40	294	14	2	8
	Integration	6	2	114	1	2
	Resolution	0	1	0	27	1
	Other	17	19	0	1	56
Treatment group	Triggering event	48	56	55	5	11
	Exploration	16	210	69	10	4
	Integration	2	11	212	3	2
	Resolution	0	5	5	53	0
	Other	1	12	14	0	52

5   Discussion

5.1   Discussion of the Results in relation to Research Questions
In research question RQ1, we investigated the effect of external motivation and externally-facilitated regulation scaffolding on the development of cognitive presence. Consistent with the previous research (Gilbert & Dabbagh, 2005; Rovai, 2007), the results showed that grading asynchronous online discussions was not sufficient to help students reach higher levels of cognitive presence if the

participation guidelines were not detailed enough to help students regulate their learning (Appendix A.a). However, the results showed that the introduction of the improved participation guidelines (i.e., externally-facilitated regulation scaffold), produced a desirable effect on cognitive presence. That is, the course design that introduced the externally-facilitated regulation scaffold for participation in asynchronous online discussions, combined with external motivation (i.e., participation grading) resulted in (i) the decrease of the geometric mean values of the posts in the lower levels of cognitive presence (i.e., triggering event and exploration), and (ii) the increase in the upper levels of cognitive presence. Of those, the effect of externally-facilitated regulation scaffold (i.e. treatment) was statistically significant for triggering events only. This effect was so significant by guiding students in the treatment group to produce almost 50% less triggering events. Although not statistically significant (marginally significant, with $p = .066$), the increase of 107.72% in the geometric mean value of integration messages – between practicing researchers in the control and treatment conditions – had a very strong practical significance and a large effect size ($r = .78$).

In research question RQ2, we investigated the effects of role assignment and rotation on cognitive presence. As it was important to support the inquiry process described in PIM, we designed two specific role types – practicing researcher and expert researcher. The results showed desirable effects of the expert researcher role (in the control group) on the level of cognitive presence. The effects of the assignment of this role were similar to those of the improved course guidelines promoting externally-facilitated regulation of online participation: (i) the decrease in the estimated geometric mean values of the lower levels of cognitive presence (i.e., triggering events and exploration) and (ii) the increase in the estimated geometric mean values of the upper levels of cognitive presence. Specifically, the assignment of the expert researcher role compared to the practicing research role resulted in statistically significant effects on the three out of the four phases of cognitive presence, including (i) the decrease of triggering events (48.06%) and (ii) the increase in integration (82.57%) and resolution posts (29.69%).

The most significant finding is that the combined use of the two scaffolding types investigated in the study – role assignment and externally-facilitated regulation – produced the most desirable outcomes – i.e., highest level of cognitive presence. Contrary to our proposition about the importance of designing roles with multiple duties, the results of the study are consistent with previous research on single-function roles (De Wever et al., 2010, 2009; Schellens et al., 2007), which showed that some roles alone were an effective method to promote knowledge construction (i.e., experts researcher), while others were much less so (i.e., practicing researcher). The effectiveness of scripted roles is typically attributed to an explicit specification of the duties a particular student is requested to carry out in a CSCL task (Strijbos & Weinberger, 2010). However, our results show that the design of some of the roles should (i) go beyond the design of collaboration duties only and (ii) recognize the social knowledge construction process through the zone of proximal development, as suggested by Woo and Reeves (2007) and stressed in the emerging script theory of CSCL (Fischer et al., 2013). Therefore, the effective role scripts should be accompanied with the participation guidance that are grounded in principles of instructional scaffolding for externally-facilitated regulation (Azevedo & Hadwin, 2005; Cho & Kim, 2013) and recognize the importance of human agency in (social) knowledge construction (Winne, 2005).

Understanding the relation between factors underlying self-regulated learning is of paramount importance for designing effective discussions in communities of inquiry. Dillenbourg, Järvelä, and Fischer (2009) highlighted the importance of studying cognitive and motivational aspects of self-regulated learning in CSCL research. The results of our study offer some evidence that motivation – whether externally induced through grades or internally driven (e.g., by a wish to interact with peers) – was a necessary but not a sufficient factor to establish a high level of cognitive presence. Previous studies showed that a great majority of students would not create more posts to an online discussions forum than it was set in the course expectations (Palmer et al., 2008). On the other hand, our study showed that the students in the treatment group in the role of practicing researchers contributed on average almost two additional integration and resolution messages (i.e., integration $M = 3.659$ and resolution $M = 1.273$) than expected

in the course requirements[5]. The interpretation commonly used in self-regulated learning research is that students are capable of self-regulating their own learning, but often forget to do so (Kauffman et al., 2011). Therefore, the combined effect of the externally-facilitated regulation scaffold for participation in discussions with externally-induced motivation through grades had a positive effect on cognitive presence. This offers an important direction for future studies that should investigate different configurations of motivation and externally-facilitated regulation scaffolds on building and maintaining cognitive presence in communities of inquiry.

Ineffectiveness of some scripted roles – such as practicing researcher – was more likely due to the weaknesses in metacognitive monitoring and control, rather than students' unwillingness to leave from their comfort zone, as previously interpreted in research about the community of inquiry model (Richardson & Ice, 2010; Shea & Bidjerano, 2010). Consideration of metacognitive monitoring and control is especially significant in the situations when students are working on ill-structured problems, which as it was the case in our study. As our results indicate, some role scripts already promote the standards the students can use in their metacognition. Given the strong grounding of the students in the work they presented when assigned to the role of expert researchers, they probably accumulated more background knowledge on a particular topic; that allowed them to establish a much higher level of cognitive presence than when they were assigned to the role of practicing researchers in the control group. On the other hand, externally-facilitated regulation scaffolding was necessary for the students when assigned to the role of practicing researchers to establish a high level of cognitive presence. A possible interpretation is that the students, when assigned to the role of practicing researchers, needed more scaffolding on how to integrate their own ideas with those presented by their peers. Thus, practicing researchers achieved a much higher cognitive presence in the treatment group. This is consistent with the finding of Cho and Kim (2013) about instructional scaffolds as the most significant factor for self-regulation of interaction with others, which had previously also been shown to be the case in the research of learning with hypermedia (Azevedo et al., 2008).

The significant effects of the interaction of the two interventions – externally-facilitated regulation and role assignment – in the multilevel linear models further corroborate the above interpretation about the connection between self-regulated learning and role scripting. The interactions indicate that the externally-facilitated regulation scaffold had significant effects in different directions for the two role assignments. Specifically, triggering events for practicing researchers were considerably decreased (almost double) in the treatment group as compared to the control group, while the externally-facilitated regulation scaffolding hardly resulted in any change in expert researchers. Integration posts for the practicing researchers increased dramatically (107.72%), while the increase for expert researchers was present but not so high between the control and treatment groups. On the other hand, the increase in the number of resolution posts was higher with expert researchers than practicing researchers between the control and treatment groups. Finally, although the interaction effect on the exploration posts was not significant, the diagram in Figure 1b demonstrates a clear tendency towards significance of the interaction (with $p = .106$, although with a low effect size of $r = .13$). That is, expert researchers had a considerably higher decrease of the exploration posts as compared to practicing researchers between the control and treatment groups.

More equitable knowledge construction opportunities – that promote a balanced cognitive presence for all the students throughout the entire discussion time period regardless of the role assignments – is a significant effect of the interaction of the scripted roles and the externally-facilitated regulation scaffold. Although expert researchers remained to have higher estimated geometric mean values of the posts in the integration and resolution phases than practicing researchers, this difference was considerably reduced in the integration phase between the two role types. The difference however was increased in the number of

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[5] The expectation set in the course was three such posts – two synthesis and one innovation posts as outlined in Appendix A.b

resolution posts. This seems to be reasonable to happen; an expert researcher would initiate a topic and other students (practicing researchers) were requested to integrate their own topics with the topic presented by the expert researcher. Thus, the practicing researchers likely had to put a considerable higher amount of efforts to reach to the resolution phase than the expert researcher who was paying the role of an expert on the presented topic.

The improved cognitive presence of practicing researchers possibly had a positive effect on the cognitive presence of expert researchers in addition to the externally-facilitated regulation scaffold. The enhanced knowledge construction level of a scripted role was already shown to have a positive effect on students who might not even have a role assignment. For example, De Wever et al. (2010) showed that the students without role assignments reached higher levels of knowledge constructions in the groups in which some students had roles assigned as compared to the groups without role assignments. While the positive effect on the expert researchers could be observed in the treatment group, the opposite could not be inferred from the control group and the impact of high cognitive presence of expert researchers on practicing researchers. A possible explanation could be found in the duties assigned to the expert researcher role. Those duties did not include peer-tutoring and a responsibility to help other students to achieve higher levels of cognitive presence. Rather, their role assignment was to act as experts invited to be responsible for a particular topic. As shown by Kanuka (2011), the invited guest instructional strategy was not most effective to facilitation of higher levels of cognitive presence of entire groups of students. Although the results of the control group confirmed that for practicing researchers, our study showed that the students – at least at the master's level of studies – can effectively assume the duties of invited experts through the expert researcher role. Moreover, when assigned to the role of expert researchers (i.e., invited experts) they reached high levels of cognitive presence.

The results of the temporal dependencies of the messages (see Table 3) showed that in the control group, triggering events typically led to new triggering events (178), and then to exploration (74), integration, and resolution (5) posts. Furthermore, the results in the diagonal of the table for the both quasi-experimental groups, indicate a clear trend that the responses were most likely to be at the same level of cognitive presence as the message to which they replied. The most notable expectation to this trend is triggering events in the treatment group, where the exploration and integration messages were more probable responses to triggering events than new triggering events. It seems that breaking the "vicious" cycle of triggering events was the critical effect that the externally-facilitated regulation scaffold for participation in discussions played in increasing the overall level of cognitive presence. Of course, this finding requires confirmation in future studies, which will study group dynamics in different settings.

5.2 Implications and Significance

The results of this study offer new evidence about the importance of studying self-regulated learning and metacognition in communities of inquiry. The positive effects of externally-facilitated regulation corroborate findings of Garrison & Akyol (2013) who defined metacognition as "complementary self and co-regulation that integrates individual and shared regulation". By integrating externally-facilitated regulation scaffolds into the design component of teaching presence, we provided students with the opportunities to co-regulate their learning by following the external standards – provided by "capable others" (Hadwin & Oshige, 2011, p. 247) – the students could use for metacognition of their cognitive presence in communities of inquiry. As such, this study is one of the first attempts that looked into the practical aspects of instructional scaffolding for self-regulated learning in the social knowledge construction process (Järvelä & Hadwin, 2013). In the future research, we plan to look at the implications of scaffolding of more specific phases of self-regulated learning on cognitive presence. Of special importance would be investigation of externally-facilitated regulation scaffolds for different types of roles that might be assigned to students to play in asynchronous online discussions.

Establishing asynchronous online discussions through the instructional design and organization component has significant practical implications. First, it showed that the discussions with a high level of cognitive presence could be organized without a high involvement of instructors into the discussions.

Namely, the data collected from the LMS used in the course for the particular discussion form dedicated to the discussions analyzed in this study, indicate that instructor 1 had the following number of discussion contributions in Winter 2008 – 3, Fall 2008 – 4, Summer 2009 – 2; while the number of contributions by instructor 2 was in Fall 2009 – 0, Winter 2010 – 0, Fall 2011 – 2. Second, instructors' workload should necessarily not be increased if the meaningful discussions were to be organized. For this to happen, the course design should apply strategies that will involve students into meaningful discussions. In the case of the study reported in this paper, this was accomplished through externally induced motivation, externally-facilitated regulation scaffolds, and role scripting and assignment. Although the findings of the study indicate the scalability concerns of the communities of inquiry to course of 30-40 students might be overcome (Anderson & Dron, 2011), future studies with larger groups of students should be conducted to validate this scalability hypothesis. In that process, organization of students into groups (of 8-12 students) seems a reasonable strategy, which was already found effective in CSCL research in social knowledge construction activities with role scripting (De Wever et al., 2010, 2009; Schellens et al., 2007).

Integration messages were the most common cognitive presence level observed as the outcomes of the externally-facilitated regulation scaffold and role assignment in this study. The proportion of resolution messages was much lower, which is reported as common in the previous research (Garrison et al., 2001; Kanuka, 2011; Richardson & Ice, 2010). There are several reasons for this:

i) the stage of the course in which the discussions happened was too early to expect many resolutions. The course itself was research-oriented, and as such, the students worked on ill-structured problems. During the stage of the course in which the discussions were organized (Weeks 3-5), the students were still working on the identification of a problem for their course projects, which had the completion deadline in the end of the course. Therefore, the higher number of integration messages was desirable, as it allowed students to hypothesize new solutions that were grounded in the research literature and experience of their peers. In the future research, it would be important to study the effect of follow up discussions in the final periods (last 4-5 weeks) of a course (subject of our current study), in which students would discuss their research proposals and the results of their final projects.

ii) the externally-facilitated regulation scaffold did not lead the students to the resolution phase. Consistent with the stage of the course under study described under i), both the upper types of posts outlined in the scaffold used in our study (i.e., synthesis and integration posts in Appendix A.b) could be mapped to the integration phase; i.e., the following two indicators given in **Error! Reference source not found.**: connecting ideas, synthesis and creating solutions. That is, the scaffold itself guided the students to the integration phase of cognitive presence. In future research, it would be important to investigate if externally-facilitated regulation scaffolds can be designed in such a way to guide students to reach to the resolution phase of cognitive presence more often than it was the case in our study. Effects of such scaffolds should be studied in different stages of courses in parallel with the study of the issues outlined under i).

The time when a student was assigned to play a particular role – expert researcher or practicing researcher – may have an impact on the cognitive presence of the students. As shown by De Wever et al. (2010), an early assignment of students to particular roles had a strong positive effect on knowledge construction. In future research, it would be important to study the differential effects of the time when a role was assigned and whether the time of role assignment interacts with externally-facilitated regulation scaffolds for participation in discussions. Along those lines, it also seems important to study the effect of fading away instructional scaffolds – including both externally-facilitated regulation scaffolds and role scripting. To test the premise made about the scaffolding for social knowledge construction defined as a zone of proximal development (Woo & Reeves, 2007), future research studies should investigate when and under what conditions the two types of scaffolds can be faded away without affecting the level of cognitive presence of students. The effects of motivation in that process warrant a special attention.

The proportion of the four phases of cognitive presence in asynchronous online discussions requires future research. A recent study reported by Richardson and Ice (2010) showed that undergraduate

students generated almost 81% of integration messages in discussions when a case-based instructional strategy was followed. That result contradicts with the findings reported in this and most of other previous studies (Garrison et al., 2001; Pawan et al., 2003). The reasons for such a difference should be studied in future research. The potential reasons could be found in the types of problems the students in a community of inquiry were solving. If working on a well-structured problem, then it is more likely that students would be reaching the integration phase more often. However, if students are working on ill-structured problems, it does not seem reasonable to expect that the students would directly be able to (i) hypothesize solutions or agree/converge in their discussions before first recognizing (i.e., triggering event) and exploring a problem, (ii) and then, being able to propose solutions by integrating different propositions generated by the community or acquired from the available information sources, so that (iii) they can finally test those solutions. Providing learning opportunities for students and communities to go through all these phases in their inquiry seems very important if the problems are ill-structured with the degree of complexity typical for the graduate level of education, as investigated in the study reported in this paper.

It should be noted that the investigation of the effects of external standards is one possible scaffolding approach to externally-facilitated regulated learning (Azevedo et al., 2008). Future studies should investigate the effects of other types of scaffolds on the level of cognitive presence in communities of inquiry. Of special interest would be dynamic scaffolds that will offer feedback particularly for each individual student. However, such scaffolds could be expensive if they are offered by human instructors, and thus, reduce scalability of the approach studied in this paper. Rather, future research should examine the use of software agents that will be able to automatically analyze online discussion transcripts (Kovanović, Joksimović, Gašević, & Hatala, 2014), gauge the level of cognitive presence, and provide personalized feedback for each individual student.

5.3   Limitations

As common for design-based research, this study has potential limitations. First, it is the context in which study was conducted, including, the specific subject area (i.e., software engineering), mode of course delivery (fully online course), the academic level of the course (i.e., master's level), and researchers' bias through the direct involvement in the course teaching and data analysis. While considering these limitations, the following accounts should be taken into consideration. The previous research about communities of inquiry showed the subject area of studies may affect the perceived level of cognitive presence (Arbaugh, Bangert, & Cleveland-Innes, 2010). The community of inquiry model has been successfully tested in both blended and fully-online learning modes (Vaughan & Garrison, 2005). The previous research reported significant differences in perceived cognitive presence between graduate and undergraduate students (Garrison et al., 2010). Therefore, to generalize the findings about the effect of role assignment and externally-facilitated regulation scaffolding on cognitive presence, future studies should be organized in courses from different subject domains, in blended learning settings, and with undergraduate students. Regarding the potential bias induced by the researcher involvement in the course teaching, this was mitigated by having two different instructors, one of whom was not involved in this study as a researcher. Both course instructors followed the same instructional design, which was confirmed by the analysis of trace data about their activity in LMS that was used in the course. Potential bias in data analysis was mitigated by involving additional researchers – second, third, and fourth authors – in data analysis, interpretation of the results, and writing the paper. Neither of them was part of the original course design. Finally, it should be noted that this study did not collect data about individual differences (e.g., prior knowledge, motivation, cognitive load, and self-regulated learning) and perceived value of the students about the course and teaching and the three dimensions of the community of inquiry model. To be able to triangulate the findings and draw inferences about the effects of the proposed externally-facilitated regulation scaffold and role scripting, future studies should collect these data types (Rourke & Anderson, 2004) and study their effect as covariates in the statistical models.

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Appendix A

a. Participation guidance for the control group
For the participation mark (10% of the final course grade), you are expected to participate actively in the presentations of your peers. Participation in a peer's presentation will not be considered just posting a general comment (e.g., "how great the presentation was" or "how you could not understand the voice due to recording"). To develop a constructive discussion around the presented topics, please, make sure that you understand the paper presented by your peers, provide your peers with feedback about their presentation, and post questions related to your peers' presentation and connected ideas on which you can build your research in the following course assignments.

b. Participation guidance for the treatment group
For the participation mark (10% of the final course grade), you are expected to participate actively in the presentations of your peers. Participation in a peer's presentation will not be considered just by posting a general comment (e.g., "how great the presentation was" or "how you could not understand the voice due to the poor audio recording"). Your participation need to be about the content being presenting with the following three levels (from the lowest to the highest quality):

- clarification question – asking about some uncertain parts of the paper being presented;
- synthesis question – asking a question that connects the topics of the presentation at hand with another peer-reviewed paper and its results covered either in the study guide, presentation of another student, or a peer-reviewed research publication;
- innovation question – asking or praoposing a novel research topic by making use of the results presented in the paper at hand to draw ideas that are formulating a research problem/challenge. Preferably, the result of a discussion triggered by such a question might result even in the problem formulation of the research to be done in the final assignment of the course.

Every student is expected to have at least two posts in category 2 and one post in category 3. The reset of the questions can fit into category 1.

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6 Supplement: Null-level models and geometric mean values

The random part of the three-level null model for triggering events (M0 in Table 2) shows that the variance on the level of messages was significantly different from zero, while variances on the group and student levels were not significantly different from zero. Specifically, 82.19% of the variance of triggering events was explained by the differences between messages in the studied conditions (Wald z = 8.896, p < .001). There was no variance attributed to the differences between students within a group. Although not significantly different from zero (Wald z = 1.385, p = .168), the variance arising from the differences between groups was 17.81%. After adding the two dummy variables and their interaction, the model (M1) estimated the mean values of the triggering events as follows: (a) students with the role of practicing researchers in the control group ($M = e^{1.272} = 3.566$), (b) students with the role of expert researchers in the control group ($M = e^{(1.272 - 0.608)} = 1.941$), (c) students with the role of practicing researchers in the treatment group ($M = e^{(1.272 - 0.655)} = 1.853$), and (d) students with the role of expert researchers in the treatment group ($M = e^{(1.272 - 0.608 - 0.655 + 0.668)} = 1.967$).

Regarding the exploration discussion posts, the random part of the three-level null model (M0 in Table 2) shows that the variance on the level of messages was significantly different from zero. The variances on the group and student levels were not significantly different from zero. Total of 72.24% of the variance of exploration posts was explained by the differences between messages in the studied conditions (Wald z = 8.886, p < .001). There was no variance attributed to the differences between students within a group. Although not significantly different from zero (Wald z = 1.414, p = .168), the variance emerging from the differences between groups was 27.76%. After adding the two dummy variables and their interaction, the model (M1) estimated the geometric mean values of the exploration messages as follows: (a) students with the role of practicing researchers in the control group ($M = e^{1.484} = 4.409$), (b) students with the role of expert researchers in the control group ($M = e^{(1.484 + 0.102)} = 4.881$), (c) students with the role of practicing researchers in the treatment group ($M = e^{(1.484 - 0.184)} = 3.667$), and (d) students with the role of expert researchers in the treatment group ($M = e^{(1.484 - 0.184 + 0.102 - 0.307)} = 2.988$).

For integration discussion posts, the random part of the three-level null model (M0 in Table 2) shows that the variance on the level of messages was significantly different from zero. The variances on the group and student levels were not significantly different from zero. Total of 63.11% of the variance of exploration was explained by the differences between messages in the studied conditions (Wald z = 6.438, p < .001). Although not significantly different from zero, the variance emerging from the differences between students within groups was 12.96% (Wald z = 1.414, p = .168) and from the differences between groups was 23.93% (Wald z = 0.063, p = .950). After adding the two dummy variables and their interaction, the model (M1) estimated the geometric mean values of the integration messages as follows: (a) students with the role of practicing researchers in the control group ($M = e^{0.566} = 1.762$), (b) students with the role of expert researchers in the control group ($M = e^{(0.566 + 0.731)} = 3.214$), (c) students with the role of practicing researchers in the treatment group ($M = e^{(0.566 + 0.602)} = 3.659$), and (d) students with the role of expert researchers in the treatment group ($M = e^{(0.566 + 0.731 + 0.602 - 0.452)} = 4.247$).

The random part of the three-level null model (M0 in Table 2) for resolution discussion posts shows that the variance on the level of messages was significantly different from zero. The variances on the group and student levels were not significantly different from zero. Total of 76.92% of the variance of exploration is explained by the differences between messages in the studied conditions (Wald z = 6.438, p < .001). Although not significantly different from zero, the variance emerging from the differences between students within groups was 16.58% (Wald z = .876, p = .381) and from the differences between groups was 6.50% (Wald z = .736, p = 0.462). After adding the two dummy variables and their interaction, the model (M1) estimated the geometric mean values of the integration messages as follows: (a) students with the role of practicing researchers in the control group ($M = e^{0.153} = 1.166$), (b) students with the role of expert researchers in the control group ($M = e^{(0.153 + 0.260)} = 1.512$), (c) students with the role of practicing researchers in the treatment group ($M = e^{(0.153 + 0.088)} = 1.273$), and (d) students with the role of expert researchers in the treatment group ($M = e^{(0.153 + 0.088 + 0.260 + 0.020)} = 2.141$).

Gašević, D., Adesope, O., Joksimović, S., Kovanović, V. (in press). Externally-facilitated Regulation Scaffolding and Role Assignment to develop Cognitive Presence in Asynchronous Online Discussions. *The Internet and Higher Education*.