Communities of Inquiry: Cultivating cognitive development in asynchronous discussions through an adaptable learning analytics visualization tool

by

Maria G. Tzelepi

HELLENIC REPUBLIC
National and Kapodistrian
University of Athens

A thesis submitted for the degree of
Doctor of Philosophy

in the

Department of Psychology

Athens, Greece
March, 2020

Communities of Inquiry: Cultivating cognitive development in asynchronous discussions through an adaptable learning analytics visualization tool

by

Maria G. Tzelepi

SUPERVISOR

Petros Roussos

Associate Professor, Department of Psychology, National and Kapodistrian University of Athens

ADVISORY COMMITTEE

Chronis Kynigos

Professor, Department of Philosophy, Pedagogy and Psychology, National and Kapodistrian University of Athens

Kyparisia Papanikolaou,

Professor, Department of Education, School of Pedagogical and Technological Education, Athens

Petros Roussos

Associate Professor, Department of Psychology, National and Kapodistrian University of Athens

EXAMINATION COMMITTEE

Chryse Hatzichristou

Professor, Department of Psychology, National and Kapodistrian University of Athens

Athanassios Jimoyiannis

Professor, Department of Social and Educational Policy, University of Peloponnese

Chronis Kynigos

Professor, Department of Philosophy, Pedagogy and Psychology, National and Kapodistrian University of Athens

Kyparisia Papanikolaou,

Professor, Department of Education, School of Pedagogical and Technological Education, Athens

Fotini Paraskeva,

Associate Professor, Department of Digital Systems, University of Piraeus

Fotini Polychroni

Associate Professor, Department of Psychology, National and Kapodistrian University of Athens

Petros Roussos

Associate Professor, Department of Psychology, National and Kapodistrian University of Athens

ACKNOWLEDGMENTS

Reaching the end of the line, I want to thank the Holy Trinity for enlightening my soul and offering all these great opportunities that led me to the right path of my life.

I also feel the need to thank those people who so generously contributed to the work presented in this thesis.

My deepest appreciation goes first and foremost to Professor Kyparisia Papanikolaou who has been a truly dedicated mentor. She offered me countless opportunities to evolve as an objective researcher, as an educator and especially as a person, and I warmly thank her for that. Her ethos, selflessness, high ideals, and scientific prestige compose a unique personality that serves as a role model to me. I feel blessed to have met her, proud to have known her and awe her a debt of gratitude which never can be repaid.

Additionally, I would like to express my warmest thanks to Professor Petros Roussos for the confidence he had in me, his precious guidance, and the constant and flawless cooperation we have had.

I also want to thank Professor Chronis Kynigos for his constructive feedback, and kind support that were essential for the work presented in this thesis.

Special thanks to my close friend George for the linguistic editing of the texts. He provided me with great conversations and constant encouragement during this journey.

I am deeply indebted to my mother Calliope who was always my safe haven. She motivated me and equipped me with dreams and determination to face life. Mom, there are no words to say how thankful I am.

My son John and my daughter Calliope grew up and accomplished much more than I did while I was studying for this research. I want you to know that your bright smile and your love provided me unlimited inspiration to continue. I feel the need to apologize for the lost time and I promise to make amends from now onwards.

Most importantly, I am indebted to my dearest husband, George. He encouraged me to start my dissertation, stood by me in every decision, and took on a lot more than his fair share. He provided me with unwavering support, always with compassion and from start to finish. This Ph.D. is his accomplishment as much as mine and I dedicate it to him with all my love and devotion.

George, John and Calliope, I have written the final words and now come back home.

LIST OF PUBLICATIONS

Tzelepi, M., Papanikolaou, K., Roussos P. Enhancing Communities of Inquiry through an adaptable learning analytics visualization tool: the case of ADVICE (*submitted*)

Tzelepi, M., & Papanikolaou, K. (2018, July). Critical Thinking for Personalization in Communities of Inquiry. In *2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT)* (pp. 304-306). IEEE.

Tzelepi M., Papanikolaou K., Roussos P. (2016). Involving Learners in Content Analysis to Empower a Community of Inquiry. In: Li Y. et al. (eds) State-of-the-Art and Future Directions of Smart Learning. Lecture Notes in Educational Technology. Springer, Singapore.

Tzelepi M., Papanikolaou K., Roussos P. (2016). Students' Potential as Active Participants in Peer Content Analysis Through Asynchronous Discussions. In: Spector M., Lockee B., Childress M. (eds) Learning, Design, and Technology. Springer, Cham

Tzelepi, M., Papanikolaou, K., Roussos, P., & Tsakiri, A. (2015, October). Promoting cognitive presence through asynchronous discussions on learning design tasks. In E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (pp. 682-688). Association for the Advancement of Computing in Education (AACE).

Tzelepi, M. (2014, July). Personalizing learning analytics to support collaborative learning design and community building. In 2014 IEEE 14^{th} International Conference on Advanced Learning Technologies for the track of Doctoral Consortium (pp. 771-773).

Summary

Current worldwide conditions focus on collaborative inquiry learning and the cultivation of critical thinking. A well-established process model that supports the development of these skills is the Community of Inquiry (CoI) model. At the same time, a variety of research fields converge to the analysis of big data to optimize the learning process through Learning Analytics.

Aiming to contribute to this line of research, this thesis (a) proposes guidelines for organizing asynchronous discussions that promote cognitive development in the context of a Community of Inquiry and (b) provides the research community with Adaptable Visualizations for CommunitiEs (ADVICE), an innovative tool which integrates two ways to enhance learners in cultivating cognitive presence which, according to the CoI framework, is the main element of critical thinking. The first one is by allowing learners the responsibility of coding messages according to the practical inquiry phases of CoI and the second one is by providing learners with timely feedback through adaptable visualizations of the teachers' and the community's perspective for the cognitive development of the discussion. In this way, the learner can observe, comparatively, different perspectives. The learners, apart from communicating through a forum are also able to share their viewpoint for the cognitive structure of the discussion and, on the side, to self-reflect on the community's perspective not only for the discussion's but also for their own cognitive development. Goy, Petrone, & Picardi (2017) suggest that enabling the learner to relate their personal perspective to the shared ones can "foster the development, recognition and meta-reflection on her own perspective".

To this end, four studies have been conducted, the results of which led to the design principles of ADVICE (Adaptable Visualization for CommunitiEs). Then, ADVICE has been evaluated for its accuracy, usability, and the reflection that it promotes on the learning process.

In particular, the first and the second study propose and evaluate a coding schema for the identification of the cognitive presence of the discussion, by the learners. The third and the fourth study propose and evaluate variables that reflect learners' behavior which is meaningful for the CoI model in order to be integrated into the tool for providing visualization for the cognitive presence of the discussion and the appropriate adaptation variables.

Keywords: Community of Inquiry, Cognitive Presence, Learning Analytics, Adaptability, Content Analysis

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Introduction

1.1. Statement of the Problem

New and emerging technologies are radically changing the educational landscape in terms of connectivity and collaboration. They provide the means to create cohesive communities of learners, regardless of time and space, and offer new opportunities for collaborative knowledge construction (Semple, 2000). As a result, researchers and educators need to properly integrate pedagogical and cognitive theories with learning technologies (Garrison, 2017). In this direction, this thesis sits at the intersection of three disciplines: Psychology, Computer Science, and Learning Sciences, supporting the argument that underlying pedagogical and cognitive theories should affect how learning technologies are used to transform the educational setting and thus bringing all the challenges of interdisciplinarity.

Promoting **collaboration** through asynchronous online discussions has emerged in recent years (Andresen; 2009). There are strong indications that collaborative learning methods encourage knowledge building and deeper comprehension, and promote active learning and in-depth information processing as students are required to invest in a significant cognitive effort. Prominent aims of the collaborative learning approach, is the development of a) critical thinking, b) communication skills, and c) construction of awareness of knowledge-building mechanisms (Gokhale, 2012; Siemens & Baker, 2012; Bodemer et al., 2018).

The emergence of online learning has shown that deep and meaningful learning is not limited to the class experience. A well established and validated learning theory that applies to online learning is the **Community of Inquiry** (CoI) theory (Garrison et al., 2000). The CoI model focuses on the purposeful nature of a community of learners that collaboratively construct meaning. It is argued (Swan et al., 2009) that constructivist approaches, and community are essential for effective critical thinking.

The CoI model guides understanding and designing of e-learning experiences for them to be accessible and collaborative, and transforms information and communication into a challenging learning community. CoI consists of three interdependent elements (teaching, social, and cognitive presence) that shape a deep and meaningful educational experience. Cognitive presence is the central construct in the CoI model (Garrison et al., 1999). It is closely associated with **critical thinking** as it is derived from Dewey's (1933) reflective thinking model, named Practical Inquiry (PI). PI represents a process that begins with the perception of a problem and then proceeds to "exploring for relevant knowledge, constructing a meaningful explanation or a solution, and finally resolving the dissonance through action" (Arbaugh et al., 2008). Thus, cognitive presence is defined by Practical Inquiry that consists of four phases: triggering event, exploration, integration, and resolution.

The CoI model also, provides the means for both **quantitative and qualitative assessment** of the state of a community of inquiry. The CoI questionnaire (Arbaugh et al., 2008), which is validated (Olpak, & Cakmak, 2018; Swan et al., 2008), has been developed for quantitative assessment. Additionally, qualitative assessment indicators have been developed for content analysis of online communities of inquiry (Garrison et al., 2000). The initial research methodology (Hilgenberg & Tolone, 2000; Swan, & Shea, 2005) in CoI focused more on qualitative assessment through content analysis that reveals learners' cognitive development in a continuous way, but the need for a quantitative approach soon emerged to accelerate research results, allowing for large-scale empirical studies.

To emphasize the process of thinking and learning collaboratively, the concept of **metacognition** is shifting from a personal learning path to the acknowledgment of the individual interaction with other members of the learning community (Iiskala et al., 2011). Therefore, the value of collaboration and knowledge sharing for metacognitive awareness is increasingly emphasized (White et al., 2009).

In order to become an effective inquirer, it is essential to develop metacognitive awareness (White et al., 2009). Metacognition process has been mostly defined in terms of monitoring and controlling cognition (Flavell, 1979). The metacognitive monitoring function is associated with the awareness of cognition and is a process of reflection on thinking and learning in a community of inquiry. Garrison (2016) suggests that students need to be aware of their own and others' thinking in order to effectively regulate thinking and learning collaboratively. Their awareness will advance the discussion on the integration and application of new ideas and concepts. This raises the importance of **shared metacognitive awareness** (Garrison & Akyol, 2015). Specifically, for cognitive presence, Garrison highlights that the awareness of PI phases can be useful in understanding and selecting specific strategies and activities in order to progressively move to the resolution of the discussion (Garrison, 2016, Garrison et al, 2001).

Quite recently (Garrison, 2011) it has been suggested to extend the use of CoI so that learners can assess the cognitive presence development they achieve as a metacognitive understanding of all the PI phases of the CoI model. Likewise, learners' self-coding has been suggested (Vaughan et al., 2013) as an activity for improving metacognitive skills and therefore promoting cognitive presence.

Although there has been little research into **coding discussion** contribution (Valcke et al., 2009), positive evidence to its relation to cognitive development has been found. In addition, corresponding research on the CoI model was encouraging in the development of cognitive presence (Chen, 2018). Despite this trend, the effectiveness of learners' involvement in coding the community's cognitive development, as well as the visualization of this process for the stimulation of metacognition have not yet been investigated.

A promising field that could be used in this direction is **Learning Analytics** (LA). At the 1st International Conference on Learning Analytics (LAK 2011), learning analytics has been defined as «the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs»(Siemens & Long, 2011, p.30). Research in Learning Analytics (LA) deals with transformation of discussion raw data into meaningful information (Khan et al., 2012; Ferguson & Buckingham Shum, 2012; De Liddo, & Buckingham Shum, 2010). LA tools have been criticized for their tendency to focus more on quantitative measurement of messages than the quality of learning (Flynn & Polin, 2003). Especially, regarding visualization, LA rarely integrates concepts from learning sciences and the need for a deeper interpretation of students' learning experiences is increasingly highlighted (Viberg et al., 2018; Peña-Ayala, 2018). Even LA that is appropriately designed based on other educational theories they still provide static visualizations rather than personalized ones (Vieira et al., 2018). Recent reviews have also revealed that despite the aforementioned LA definition, which mainly focuses on learners, published studies are still deficient in addressing learner's needs (Viberg et al., 2018; Peña-Ayala, 2018). Specifically, for CoI asynchronous discussions, LA still focuses on the automation of content analysis for researchers rather than learners (Kovanović et al., 2016).

Likewise, although visualization in LA is a prominent field of research, visualization techniques based on the CoI model have not been proposed yet.

The present thesis extends the research in the areas of LA and CoI by exploring how to use LA to enhance CoI through active involvement of learners in coding discussions. To this end, learners are provided with an appropriated coding schema and with personalized visualizations that would stimulate reflection and awareness on the cognitive development of the discussion.

The research presented in this Ph.D. thesis attempts to address the apparent gap in literature related:

a) to the value of learners' involvement in identifying evidence of cognitive presence through asynchronous discussions,

b) to the identification of variables that reflect learner's behavior within the CoI discussion and
c) to the value of visualization of the community's perception for the cognitive presence of the discussion in the community members.

1.2. Methodology

This thesis aims to explore the enhancement of the cognitive presence through the involvement of learners in the coding of the discussion and the enhancement of their awareness of the cognitive development of the discussion. The analysis format considered to be appropriate is content analysis because, as the literature highlights, it is suitable for asynchronous discussion data analysis. Content analysis attempts to evaluate the cognitive quality of the discussion, the cognitive development of the community, and the cognitive contribution of each community member.

In this line of research, the present dissertation proposes and evaluates a learning analytics visualization tool that supports communities of learners in cultivating critical thinking and metacognitive skills through an asynchronous discussion. In particular, this tool aims a) to enable the learner, during an asynchronous problem-solving discussion, to record their perspective in terms of cognitive presence, and b) to provide adaptable visualizations to the learners, through the discussion, according to learners' variables based on the cognitive presence context, for the community's and specific groups' perspectives.

Regarding the cognitive presence's indicators as a process for assessing the nature of critical thinking, it has been stated (Garrison et al, 2001). that this process depends upon the validity of the critical thinking concept and its ability to reflect educational practice. Aligned with this approach, the design of the proposed tool is based on (a) the accuracy of the data it provides to the learners which guarantees its validity and (b) the adaptation of the visualization according to the appropriate learners' variables to stimulate reflection within the CoI.

In the present thesis, initially, the CoI model was used to develop and evaluate a classification schema intended to be used by the learners. The results of the analysis by the learners were compared with those of the teachers and at the same time a qualitative assessment of the learners' experience was carried out through a questionnaire.

The results were used to redesign the discussion classification schema. This schema was examined for its reliability by using appropriate statistical tests but also was examined qualitatively through the in-depth comparison between the classifications that the learners gave, to that of the teachers. The positive results led to the development of a calculating method for resulting in a unique learners’ view of the cognitive development of the discussion. This process was evaluated for its effectiveness in representing the cognitive development of the discussion as well as on its ability to identify participants whose perspectives diverge from that of the community.

Quantitative and qualitative variables were also proposed and investigated regarding their suitability to represent the discussion in the CoI context. Specifically, participation, and cognitive contribution to exploration, integration, and resolution phase were proposed. The positive results led to a second study that proposed and examined the learner’s cognitive contribution to the discussion. This variable integrated the “cognitive contribution to exploration”, “cognitive contribution to integration” and “cognitive contribution to resolution” variables proposed in the previous study. The results have led to the use of (a) the participation variable and (b) the cognitive contribution variable for constructing the visualizations and adaptability variables for the proposed tool.

The results of the above studies were used to develop ADVICE. ADVICE was evaluated for its usability through questionnaires. In addition, it was evaluated for its accuracy and the reflection it promotes during the ADVICE processes.

In order to obtain reliable results, the research methodology has been designed with the following common critical features for all the consecutive studies:

- **Sample**: The sample consists of students at undergraduate or postgraduate level in higher education willing to become teachers, thus considering to be pre-service teachers.
- **Course context**: The research was conducted in technology enhanced learning courses where the students cultivate technological and pedagogical skills, working with learning design environments, developing Web 2.0 learning objects, and collaborating while developing educational scenarios aiming to synthesize technological with pedagogical tools and content.
- **Discussions' design**: The students participated in online discussions, based on CoI principles, in order to collaboratively work out specific assignments that relate to the design of content (learning activities/scenarios) using specific web-based tools/environments.
- **Unit of analysis**: Social, teaching, cognitive presences, and combinations were expected to be identified in the discussions. For the research, the students classified each particular message (unit of analysis) of the discussion.

The research is conducted in three successive phases:

Phase 1: Design of a coding schema for learners.

In the first research phase, a pilot study (Chapter 3) and a main study (Chapter 4) were conducted. A coding schema was designed, validated, and evaluated, based on the cognitive presence's indicators (Garrison et al., 2000). This schema was used by learners to analyze the content of the discussions and to identify elements of the cognitive presence according to the CoI model. The development and evaluation of the proposed coding schema is described in the pilot Study 1.1 in Chapter 3. Specifically, the research questions investigated are:

Study 1.1: Research Question 1. How can a coding schema for students be developed?

Study 1.1: Research Question 2. How did the coding procedure affect students' perception of the discussion enabling the development of metacognitive skills?

In Chapter 4 (Study 1.2) the coding schema was redesigned, according to the results presented in the pilot study. Then, a measure that calculates a unique coding for each message by all the codings of the community members and reflects the community's perspective was evaluated for its reliability. The research question of this study is:

Study 1.2: Research Question. Can the proposed coding schema reflect a reliable community perception for the cognitive presence of the discussion?

Phase 2: Learners' variables as sources for adaptability and visualization

Since the coding schema is designed to be used by learners, the next step is to visualize the learner's codings to the learners themselves in order to cultivate reflection. It is generally agreed that reflection needs awareness and critical thinking to examine presented information, consider experiences, question information validity, and come to critical conclusions (Hoyrup & Elkjær, 2006). But what information could be selected to raise the learner's reflection on the learning process of the CoI? Variables related to the cognitive evidence of the discussion were examined as learners' variables to be used for the visualization. Information that was proposed to be visualized is (a) learners' codings and (b) each learner's cognitive contribution Besides, specific learners' variables related to the cognitive evidence of the discussion were proposed for adaptability variables and the adaptability of the visualization.

Adaptability requires the user to explicitly specify how they want the system to be different.

Study 2.1 and Study 2.2. Research Question: Which variables represent the learner's behavior within a CoI discussion?

To answer this question and personalize the tool, specific learners' variables for community grouping were examined. These variables include among others: learners' participation and cognitive contribution to the discussion. The design of the tool's adaptability focuses mainly on the CoI model.

For this, the relation of participation and cognitive contribution to the cognitive development of the discussion was explored in Study 2.1, (Chapter 5) and Study 2.2. (Chapter 6). Specifically, in Study 2.2, the cognitive contribution variable was further investigated for its relation to the learners' ability to identify the cognitive evidence of the discussion.

Phase 3: Development and evaluation of ADVICE

According to the coding schema proposed in phase 1 and the variables proposed in phase 2, an adaptable visualization learning analytics tool was developed and evaluated for accuracy, usability, acceptance by the learners, and ability to promote reflection and, therefore, cognitive development (Chapter 7). The research questions of this study are:

Study 3. Research Question 1: What is the accuracy of ADVICE?

Study 3. Research Question 2: To what extent did students consider ADVICE usable?

Study 3. Research Question 3: To what extent did students consider that ADVICE promoted reflection during the discussion activity?

Study 3. Research Question 4: Is the reflection promoted by ADVICE related to the students' performance through the discussion?

1.3. Thesis Structure

This dissertation consists of 8 Chapters. The introduction presents the theoretical framework through which the research questions arise and, in the next Chapters, the constituent studies are presented in detail.

In particular, **Chapter 2** presents the two pillars of the theoretical background of the thesis a) Community of Inquiry and b) Learning Analytics. The starting point of the literature review is the CoI model and the cognitive presence as one of its three constituent elements, cognitive presence's functionality through the

PI cycle, the metacognition within CoI, and the process of classification for promoting community.

The review highlights the issues to be taken into consideration for designing the coding schema proposed in the present study. For this, it focuses on the Cognitive Presence in the context of asynchronous discussion, its quantitative assessment through the CoI questionnaire, and its qualitative assessment through content analysis. The presentation of critical components of the content analysis method such as reliability, analysis unit, latent and manifest content, and coder's training is then followed. Regarding LA, the various LA definitions and the LA frameworks are presented.

Finally the literature review focuses on a) the ways to enhance cognitive presence, b) the LA tools used in the asynchronous discussions are presented. and c) the LA techniques that have been used for the semi-automated content analysis based on the Communities of Inquiry, are presented. This overview presents the context in which the proposed tool belongs and identifies the research gap that the tool attempts to fill. Chapter 2 concludes with the motivation analysis of the dissertation, which stems from the theoretical field considerations.

Chapter 3 presents the first of the two studies (Chapter 3 and 4) of Phase 1, that propose a coding schema designed to be used by learners in order to promote the discussion. The coding schema, proposed in the first study, is designed based on the Cognitive Presence indicators of the Practical Inquiry phases. It also investigates how learners can be involved in content analysis during an asynchronous discussion and the benefits of this process for building a CoI by using the proposed coding schema. During the discussion, learners were asked to classify their own and their peers' messages. This way, learners' classification data were captured and analyzed to evaluate the way they classify messages compared to the researchers' coding. The development of metacognitive skills was also evaluated based on questionnaires that students completed reflecting on this experience. The findings of this study were positive for the development of metacognitive skills through the proposed procedure, and led the research in this direction. Also, the results highlighted the need to expand the coding options of the schema and this led to the redesign of the coding schema and its further assessment with both qualitative research and quantitative research of its reliability.

The second study of Phase 1 is presented in **Chapter 4**. It proposes a redesigned coding schema based on the findings of the first pilot study which is presented in Chapter 3. The study assesses the reliability of the proposed coding schema that reflects cognitive presence. This schema was provided to learners/participants after a discussion, to characterize their peers' messages. According to LA, a main aim is to organize all this data/coding by the learners to present the information through meaningful visualizations integrated into an educational theory. For this, a measure was proposed for a unique cognitive presence classification for every message of the discussion, according to the classifications of all the learners, in order to be used as a source for visualization. The measure proposed reflects the community's perception of the cognitive presence of the discussion. The results of this measure represent the main tendency of the community for the practical inquiry phase of every message of the discussion. Statistical analysis has been conducted for assuring a) the reliability of the schema by testing the agreement of each student's coding with the researchers' final coding (which is considered to represent the objective perspective), and b) the capability of the proposed measure to accurately represent the cognitive development of the community. The evaluation had positive results and confirmed the community's ability (the learners who participate in the discussion) to adequately represent the cognitive development of the discussion without the intervention of the teachers. This way the proposed measure can also be used to also calculate the cognitive contribution of each participant in this discussion. For this, it was decided that the community's perspective, calculated by this measure, to be visualized back to the learners as the cognitive presence of the discussion. Moreover, the learners whose perspective deviates from the objective perspective could be identified. This potentiality paves the way for calculating variables that correspond to each participant and are meaningful in the context of CoI and leads the research to the second Phase in Chapters 5 and 6.

Chapter 5 presents the first of the two Phase 2 studies (Chapters 5 and 6) which propose and evaluate four variables to be related to the cognitive presence for visualization and personalization. In the study of Chapter 5 the learner's participation and their cognitive contribution to a) the exploration phase, b) the integration phase and c) the resolution phase of the discussion are proposed and evaluated. Learner's participation is a quantitative variable that derives from log data while learner's cognitive contribution in each phase is a qualitative variable that derives from the measure proposed in Chapter 4. The research aims to study to what extent these variables reflect the individual behavior of the community members within the cognitive presence.

Chapter 6 presents the second study of Phase 2 that focuses on exploring further the "cognitive contribution" variable concerning the learner's awareness of the cognitive development of the discussion. In this study, the "cognitive contribution" variable consists of the three qualitative variables proposed in chapter 5 and reflects the learner's cognitive contribution to the last three phases of Practical Inquiry. As the "cognitive contribution" variable represents the individual's performance in the discussion according to the cognitive presence it is further investigated as an adaptability variable.

The two studies of Phase 2 aim to explore participation and cognitive contribution variables for integrating them in an adaptable learning analytics visualization tool and as adaptability variables in order to enhance personalized interaction.

The research presented in Chapters 3, 4, 5, and 6 lays the foundation of the proposed learning analytics visualization tool presented in Chapter 7.

Chapter 7 presents ADVICE which is a learning analytics visualization tool for asynchronous discussions based on the CoI theory. ADVICE involves learners in classifying discussion messages based on the CoI framework thus supporting them in acknowledging the discussion's cognitive development. It also provides learners with adaptable visualizations of their contribution and cognitive development during asynchronous discussions. In particular, the tool aims to stimulate the learners' reflection on their personal cognitive development by allowing them to compare themselves to the community and specific community subgroups that learners can choose during the discussion. This study also evaluates the accuracy of the data visualized, the tool's usability, its acceptance by the learners, and the degree of cultivation of metacognitive skills to learners.

In particular, the integration of the coding schema is presented into the asynchronous discussion environment, the utilization of variables in building adaptability features, and the visualization of the student's position in the community. Also, a method for calculating a unique **community's perspective** of the cognitive development of the discussion is proposed. This perspective emerges from the classification of the messages of each member of the community. The method is evaluated for its accuracy and a second method is proposed for calculating a unique **teachers' perspective** of the cognitive development of the community resulting from the characterization of messages by two teachers. Additionally, the visualizations and personalization options provided by ADVICE are presented.

The **8th Chapter** presents the conclusions for the research questions of the dissertation. Also, directions are given for future research.

Figure 1 presents the individual Chapters according to the Phases of the thesis.

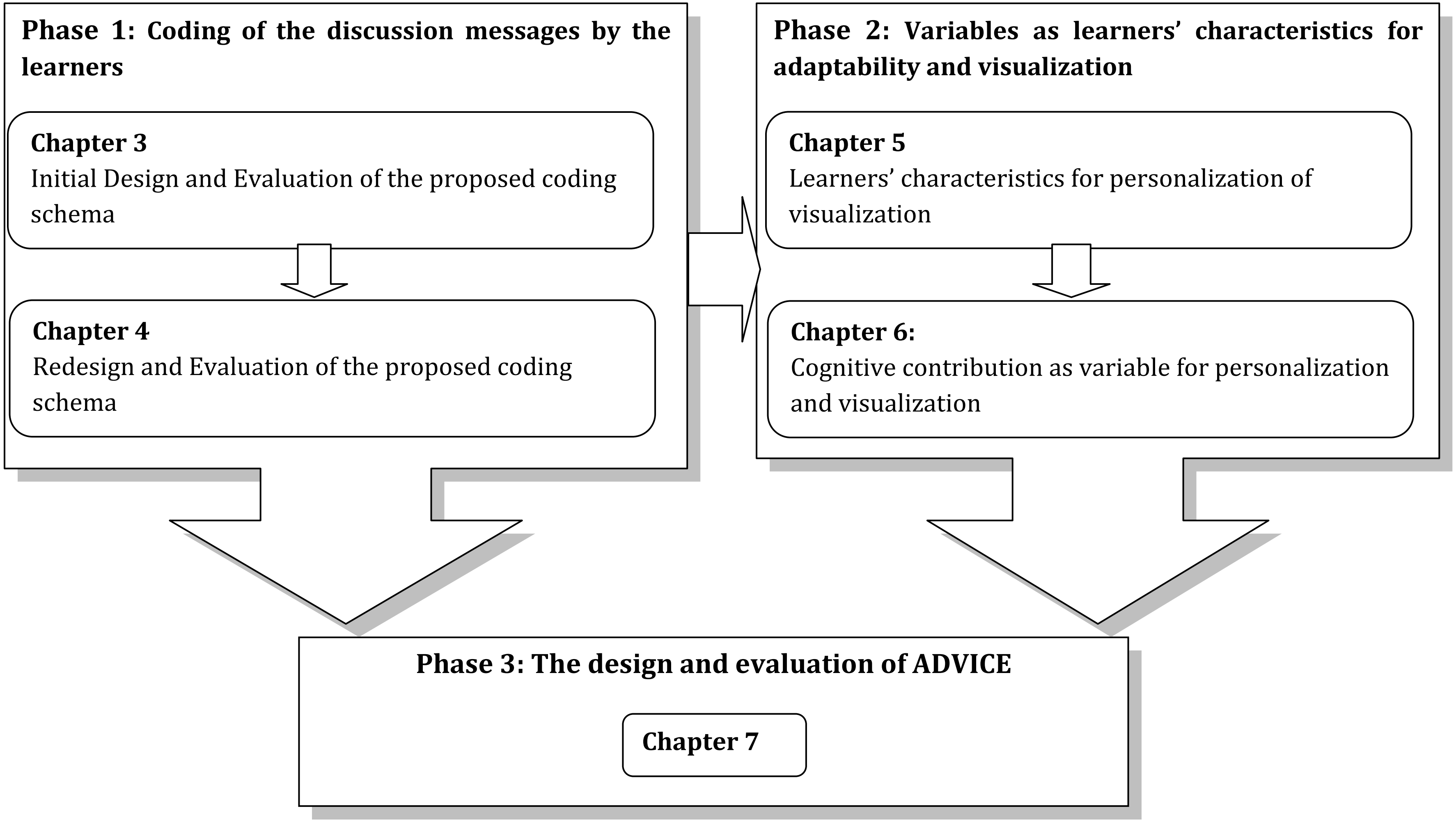

Figure 1. *Overview of the research Phases along with the thesis structure*

2. THEORETICAL BACKGROUND

Chapter Overview

This Chapter is a review of a) the existing literature on Communities of Inquiry and more specifically on cognitive presence, b) the process of content analysis for cultivating metacognition, and c) the learning analytics field regarding the cognitive presence.

The goal of this review is to develop a clear understanding of the content analysis practice based on the cognitive presence schema as well as the Learning Analytics approach to cognitive presence until now. Thus, the research gap leading to this study emerges.

2.1. Community of Inquiry

Community of Inquiry (CoI) (Garrison et al., 2000) is a well-formulated theoretical framework that describes and promotes collaboratively constructing meaning through critical reflection and discourse (see Fig.2). It emerged from the context of asynchronous text-based group discussion. In the past two decades, CoI has been validated by many studies (e.g., Arbaugh & Hwang, 2006; Shea & Bidjerano, 2009). A study that investigated the current trends of the seven leading online and distance learning journals (Bozkurt et al., 2015), revealed that the theoretical perspective most commonly used was the CoI theory for constructing knowledge.

Unlike the traditional perspective of online learning that requires students to work independently from each other, CoI emphasizes inquiry within a community (Garrison & Anderson, 2003). In this community higher-order learning is expected to be achieved through critical thinking, meaning negotiation, idea creation, and knowledge construction (Garrison & Anderson, 2003).

CoI addresses the online interaction as a meaningful blend of three interdependent presences – social presence (Rourke et al., 1999), cognitive presence (Garrison et al., 2001), and teaching presence (Anderson et al., 2001).

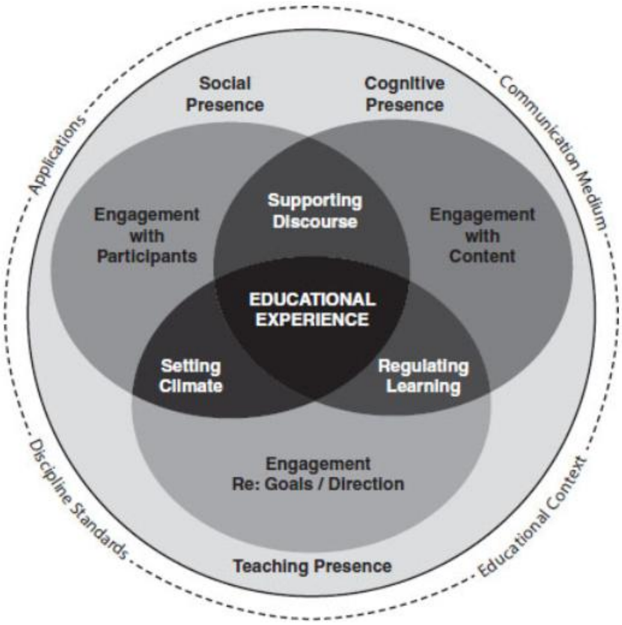

Figure 2. *Community of Inquiry framework (Garrison et al., 2000)*

Teaching presence in the CoI framework is defined as '*the design, facilitation and direction of cognitive and social processes for the purpose of* realizing *personally meaningful and educationally worthwhile learning outcomes*' (Anderson, et al., 2001, p.5).

Social presence is defined as '*the ability of participants to identify with the community (e.g., course of study), communicate* purposefully *in a trusting environment, and develop inter-personal relationships by way of projecting their individual personalities*' (Garrison, 2009).

Cognitive presence is defined as '*the extent to which learners are able to construct and confirm meaning through sustained discourse in a critical community of inquiry*' (Garrison et al., 2001, p.5).

Prior research has also shown that social, teaching and cognitive presence are highly correlated. Additionally both teaching and social presence appear to be influential predictors of cognitive presence (Archibald, 2010; Shea & Bidjerano, 2009b).

2.1.1. Cognitive Presence in Communities of Inquiry

In the CoI model, cognitive presence is operationalized as a tool to assess critical discourse and reflection. The four phases of the practical inquiry approach, their descriptors and indicators of cognitive presence have considerable potential to assess the inquiry process. Practical Inquiry (PI) is grounded on the work of Dewey (1933) and operationalizes cognitive presence (see Fig. 3). PI process consists of four phases (Garrison et al., 2001):

1) Triggering event, as an initiation phase, initiates a dialogue about a particular issue. A problem emerging from experience is identified and recognized.

2) The second phase is exploration. Participants move between private reflection and social exploration as they strive to perceive and grasp the nature of the problem, and then move to a fuller exploration of relevant information being selective to what is relevant to the problem. This phase is characterized by brainstorming, questioning, and exchange of information.

3) Integration is the third phase. Participants begin to construct meaning from the ideas generated in the previous phase. The applicability of ideas is assessed in terms of how well they interconnect and describe the issue at hand.

4) Resolution involves a vicarious test of the adequacy of the proposed solutions.

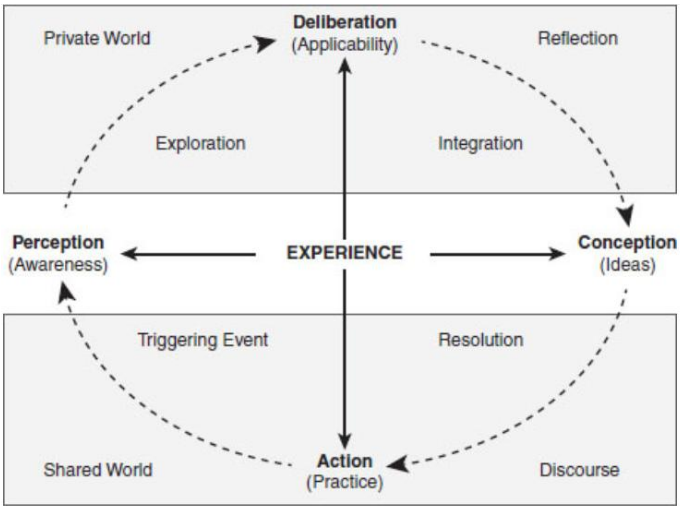

Figure 3. *Practical Inquiry Model (Garrison et al., 2001)*

Guiding a discussion through the above phases, while at the same time aiming to cultivate learners' awareness of these phases, can be useful for them in configuring and selecting specific strategies and activities (Garrison, 2011).

Several researchers argue that later phases reflect a higher level of PI (e.g., Kalelioglu & Gülbahar, 2014; Shea & Bidjerano, 2009b; Stein et al, 2013). In addition, several studies have consistently shown that the critical reflection of the discussion rarely moves beyond the exploration phase (Garrison et al., 2000; Vaughn & Garrison, 2005; McKlin et al., 2002; Meyer, 2003; Meyer, 2004; Murphy, 2004; Celentin, 2007).

2.1.2. Metacognition in Communities of Inquiry

Flavell originally used the term metacognition to mean "cognition about cognitive phenomena," or more simply "thinking for thinking" (Flavell, 1979, p. 906).

Decisions made through metacognition are based on the representation of cognition, and it is therefore worthwhile the model of cognition to be accurate (Efklides, 2009).

Metacognition is an emerging research field, and various versions of definitions, processes, and elements of it are still proposed. Recent definitions aim at metacognitive awareness. According to Hennessey (1999, p. 3) metacognition is defined as “Awareness of one’s own thinking, awareness of the content of one’s conceptions, an active monitoring of one’s cognitive processes, an attempt to regulate one’s cognitive processes in relation to further learning, and an application of a set of heuristics as an effective device for helping people organize their methods of attack on problems in general” and according to Kuhn & Dean (2004, p. 270) metacognition is defined as “Awareness and management of one’s own thought”.

Metacognitive awareness is strongly related to learners’ success in cognitive activities such as attention focusing, comprehension, and problem-solving (Flavell, 1979; Whitebread et al., 2009).

Observation and awareness support the learner in the reflection and analysis of a) their internal state, b) behavior, c) and actions, and their results. Observation and awareness also allow the learner to convey the content of their reflection to others, draw conclusions, make judgments about their relationship between their inner state and observable behavior, and compare it with that of the other co-learners. This approach leads to the construction of a socially shared knowledge model (Newell, 1990).

Regarding CoI, Akyol and Garrison (2011, p.184) refer to metacognitive awareness as “the awareness and willingness to reflect upon the learning process”, which is achieved through learners’ understanding and self-assessment of their progress and efforts in learning. Akyol and Garrison (2001) suggest that ‘metacognition in an online learning community is defined as the set of higher knowledge and skills to monitor and regulate manifest cognitive processes of self and others’ (p.184). Also, Garrison (2016) leans on the approach that metacognition should be thought to originate from the interaction between individuals and between individuals and their environment rather than an isolated process (Iiskala et al., 2011). Thus, Vaughan, Cleveland-Innes, and Garrison (2013) state that individual and shared metacognitive monitoring has to be considered.

The CoI model has the potential to support shared metacognition through discussion based on critical thinking. Garrison argues that for the discussion to evolve beyond the exploration phase, students should be aware of their and their peers' critical thinking emphasizing the importance of shared metacognitive awareness (Garrison & Akyol, 2015).

Regarding metacognition, it is critical to support students to understand their own cognitive processes. Garrison (2016) suggests that encouraging students to collaboratively monitor and manage their learning increases shared metacognitive awareness which consequently gives students a better understanding of critical thinking and the inquiry process. He also suggests introducing to learners the CoI framework and PI model before engaging them in discourse so that it will increase the awareness of inquiry and shared metacognition.

Metacognitive strategy refers to methods used to enhance learners' metacognitive awareness of their learning and thinking process. A technique proposed for cultivating metacognitive awareness and regulation is to encourage students to think about their online contributions by classifying their messages according to the phases of the PI model (Pawan et al., 2003) and thus performing the content analysis process.

Schellens et al. (2009) have also concluded that coding discussion contributions encourages students to contribute with more in-depth messages and relates to a higher level of critical thinking. Besides, according to Valcke et al. (2009), coding discussion messages were found to attain a higher level of cognitive development.

Garrison (2016) also, proposes the discussion coding as it has value in understanding and promoting shared metacognition and reflection. Garrison (2003) suggested that sharing the PI model and the concept of cognitive presence with students is a promising practice that can promote the development of cognitive presence. In the research that De Leng et al. (2009) conducted, they applied the practice of post-coding to highlight the metacognitive awareness of learners. The students had to code the message they aimed to send to the discussion based on a menu of the PI phases. The results of this study provided empirical evidence supporting the effectiveness of coding posts based on the cognitive presence in facilitating students' critical thinking in the discussion.

In light of the foregoing, this thesis examines the coding of the discussion by learners based on the cognitive presence as a means for cultivating metacognitive skills.

2.1.3. Assessment of Cognitive Presence in Asynchronous Discussions

Two main approaches have been mainly applied to collect and analyze empirical data based on the CoI framework: a) a survey procedure and b) content analysis of the discussion messages.

2.1.3.1. *The Community of Inquiry Survey Instrument*

The CoI Survey is a 34-item instrument (Arbaugh et al., 2008), with items designed to document responses of participants in a community, to describe the teaching, social, and cognitive presences they experienced through their participation. Concretely, the survey includes teaching presence perception (13 items), social presence perception (9 items), and cognitive presence perception (12 items). The questions are measured on a Likert scale with a scale of 1-5 (1=Strongly Disagree, 5=Strongly Agree).

The survey has been validated in several different learning environment contexts (Swan et al, 2008; Bangert, 2009; Carlon et al., 2012; Díaz et al., 2010; Kozan & Richardson, 2014; Shea & Bidjerano, 2009a) and shown to provide a reliable measurement of the relative presences described by the CoI model.

The survey has also been translated and tested in several other languages: Turkish (Horzum & Uyanik, 2015), Korean (Yu & Richardson, 2015), Chinese (Ma et al., 2017), and Portuguese (Moreira et al., 2013).

According to the review of the CoI survey by Stenbom (2018) the structural relationship between the presences indicates that "*teaching presence predicts student perceptions of cognitive presence with social presence as a partial mediator*".

According to the literature, the studies based on the CoI survey are increasing compared to the studies that use the CoI coding schema for content analysis. Garrison (2016) interprets this observation by arguing that the application of the CoI survey is easier than the time-consuming manual content analysis.

2.1.3.2. *Content Analysis of Asynchronous Online Discussions*

A significant number of researchers have proposed coding schemes for content analysis as a way of measuring evidence of critical thinking in asynchronous online discussions (Henri, 1992; Gunawardena et al., 1997; Newman et al., 1995; Garrison et al., 2000; Hara et al., 2000).

Rife, Lacy, and Fico (1998), define content analysis as "the systematic assignment of communication content to categories according to rules and the analysis of relationships involving these categories using statistical methods" (p. 2).

More generally, Krippendorff defines content analysis as "a research technique for making replicable and valid inferences" (2018, p.18).

As a technique, content analysis involves specific procedures. Coding is one of the processes included in the content analysis. Specifically, according to Krippendorff, "Coding is the transcribing, recording, categorizing, or interpreting of given units of analysis into the terms of a data language so that they can be compared and analyzed" (2018, p.220).

In the CoI model, the primary approach for assessing the three presences through an asynchronous discussion is qualitative content analysis. For assessing the levels of cognitive presence, the CoI model uses a specific coding schema with a list of descriptors and indicators of the four phases of PI (Garrison et al., 2001). The indicators consist of the occurrence of phrases or certain keywords and, in this way, they guide the content analysis process (see Fig. 4). The coding schema has been used in a significant number of studies (Shea et al., 2010; Naranjo et al., 2012)

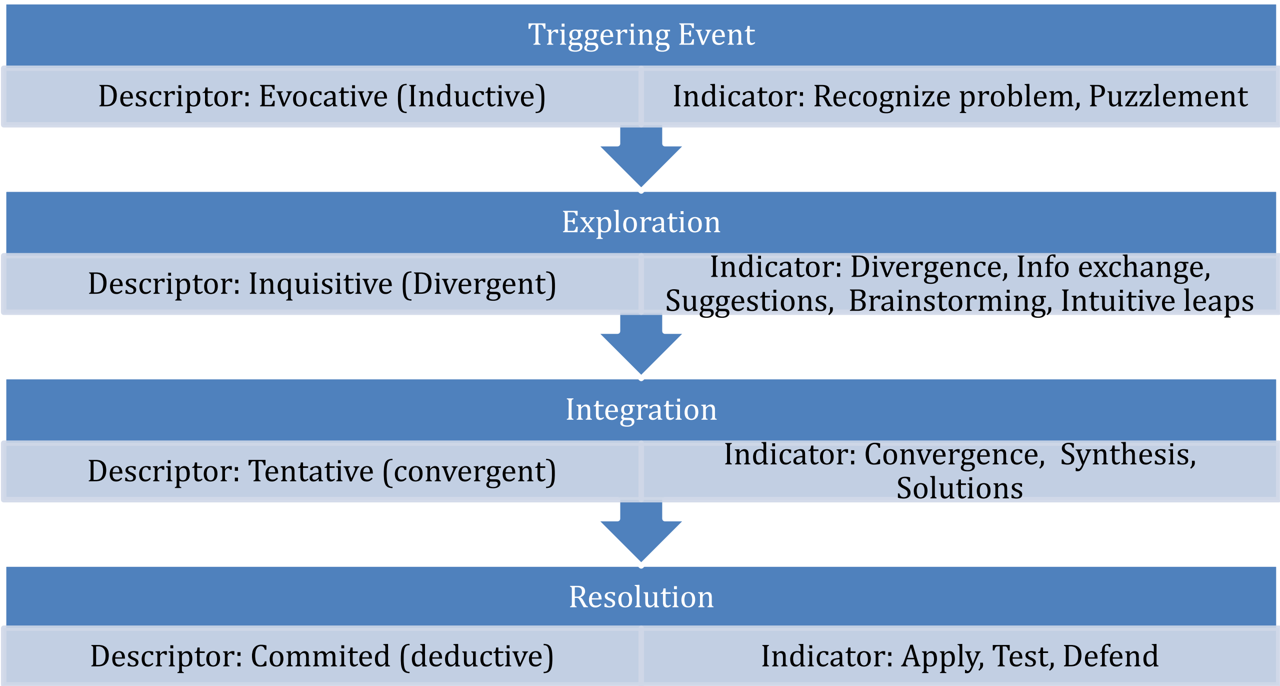

Figure 4. *Practical Inquiry Descriptors and Indicators*

According to Rife, Lacy, and Fico (1998) the steps for performing content analysis are a) definition of the unit of analysis, b) definition of the construct that will be measured, c) training of the coders, and d) reliability test to calculate the agreement between the coders.

Reliability

Krippendorff's aforementioned definition (2018) for the content analysis technique places particular emphasis on the issue of reliability.

The research process is reliable when it responds to the same data in the same way regardless of the conditions in which it is applied. This is the base of the reliability measurement theory. Inter-rater reliability is the primary test of objectivity in content studies. Regarding the content analysis process, reliability is "the degree to which members of a designated community agree on the readings, interpretations, responses to, or uses of given texts or data" (Krippendorff, 2004, p.212). Specifically, Rourke et al. (2001) refer to reliability as the extent to which different coders, each coding the same content, come to the same coding decisions.

Regarding reliability data, Potter & Levine-Donnerstein (1999) suggest to the researchers to be highly cautious in applying research findings when the findings cannot demonstrate strong reliability. Garrison et al. (2006) also emphasize the importance of reliability as a criterion for content analysis research (p. 20). Neuendorf (2005) even states that the results of the content analysis are useless if the reliability is not high enough. However, many researchers have been criticized for the lack of full statistical tests (Rourke et al., 2001) for calculating the reliability of the content analysis technique, raising questions about credibility.

Rourke et al. (2001) provide an excellent summary of influential content analysis studies that have been published between 1992 and 2006. According to this summary, 6 of the 17 studies do not report any reliability value that strengthens their findings. In addition, 8 studies report the percentage agreement for estimating the reliability and 3 studies used the Cohen's κ coefficient. But what statistical test reassures the reliability of a content analysis study is a question that remains.

Various statistical tests have been proposed for measuring content analysis reliability.

➢ <u>Percentage Agreement</u>

The most popular statistical test of reliability is the percentage of agreement among all coders' decisions in coding the same units of data (Neuendorf, 2005). It is easy to calculate and it can be applied to more than two coders (Wang, 2011).

The indices of the measure range from .00 (no agreement) to 1.00 (perfect agreement). The formula of Percentage Agreement is the following:

$$PAo = A/n$$

where:

- PAo represents an observed proportion of agreement,
- A represents the number of agreements between the coders and
- n represents the total number of decisions the two coders have made.

➢ <u>Holsti's coefficient</u>

Holsti's method (1969) is a variation of percentage agreement. Compared to the percentage agreement, Holsti's method (1969) is applicable to situations in which two coders code different units of the same sample. The formula of Holsti's agreement is:

$$\mathrm{PAo} = 2\mathrm{A}/(\mathrm{n1} + \mathrm{n2})$$

where

- A is the number of agreements between all coders and
- n1 and n2 represent the number of coding values recorded by each individual coder.

➢ <u>Kendall's τ coefficient</u>

Kendall's τ coefficient (1938) (after the Greek letter τ), is proposed for measuring inter-rater reliability as it calculates the ordinal association between two measured quantities. In other words, it tests for the difference between the probability that ranking in the data is similar between the judges and that it is dissimilar. The Kendall τ coefficient between two judges will be high when the data have a similar rank in each observation between the two judges, and low when observations have a dissimilar rank between the two judges. It has been used as a measure of agreement between multiple judges.

There are three scenarios for the observations that will be explained in terms of a content analysis research for an asynchronous discussion which is coded according to ranking categories.

- Tied pairs: Both coders agree for every message. That means that each message has the same ranking for both coders.
- Concordant pairs: Both coders rank each message in the same order but not necessarily giving the same rank. E.g., the first coder codes the first message in the 1st category while the second coder codes the same message in the 2nd category and the first coder codes the second message in the 3rd category while the second coder codes the same message in the 4th category. The 1st and 2nd messages are concordant because the 2nd message was ranked consistently higher than the 1st message.
- Discordant pairs: When two messages are ranked in opposite directions then these messages are discordant.

The Kendall τ coefficient is defined as:

$$\tau = \frac{(\text{number of concordant pairs}) - (\text{number of discordant pairs})}{n(n-1)/2}$$

where: n= the number of observations

If the agreement between the coders is perfect (i.e., the codings are the same) the coefficient has value 1. If the disagreement between the two coders is perfect (i.e., one coding is the reverse of the other) the coefficient has value −1. If the two coders are independent, then it would be expected the coefficient to be approximately zero.

➢ Cohen's kappa

Cohen's kappa is a chance-corrected measure of inter-rater reliability that assumes two coders, n cases, and m mutually exclusive and exhaustive nominal categories (Capozzoli et al., 1999). It is generally thought to be a more robust measure than simple percent agreement calculation, as κ takes into account the possibility of the agreement occurring by chance. The formula for calculating kappa is:

$$\kappa = \frac{\mathrm{p_0} - \mathrm{p_e}}{1 - \mathrm{p_0}}$$

where:

p_0= the relative observed agreement among coders

p_e= the hypothetical probability of chance agreement, using the observed data to calculate the probabilities of each coder randomly seeing each category.

If the agreement between the two coders is perfect (i.e., the codings are the same) the coefficient has value 1. If there is no agreement among the raters other than what would be expected by chance (as given by pe) the coefficient has a value near 0. It is also possible for the statistic to be negative which means that the agreement is worse than random.

Although kappa is a powerful measure of inter-rater reliability, some authors have argued that it is excessively conservative (Potter & Levine-Donnerstein, 1999). It is therefore customary to provide another reliability statistical test such as the Holsti's Coefficient for better estimation of the reliability agreement. This is particularly true with coding protocols that include several categories, thereby making the possibility of an agreement by chance negligible.

For content analysis, the exact level of reliability to be achieved has not been documented. Regarding Cohen's kappa, Capozzoli, McSweeney, and Sinha (1999, p.6) have stated that "...values greater than 0.75 or so may be taken to represent excellent agreement beyond chance, values below 0.40 or so may be taken to represent poor agreement beyond chance, and values between 0.40 and 0.75 may be taken to represent fair to good agreement beyond chance".

Specifically, for manual content analysis in Communities of Inquiry, in most studies, sufficient agreement has been reached with Cohen's Kappa> 0.7.

Unit of Analysis

Part of conducting a content analysis involves identifying the segments of the transcript that will be recorded and categorized. For this, an important issue of content analysis is the unit of analysis.

Many researchers propose thematic unit to be their unit of analysis. (Henri, 1992; Newman et al., 1995; Rourke et al., 1999). This way, the content is divided into units according to their theme. However, this is a latent, complex construct that increases the chances for subjective ratings and low reliability (Krippendorff, 2004). In a typical way, the thematic unit analyses do not provide reliability values (Henri, 1992). The size of the unit also affects the reliability and effectiveness of the analysis.

On the other hand, the syntactical unit is based on the size of the analyzed content. The larger syntactical unit used is the paragraph (Hara, Bonk, and Angeli, 2000). However, as the unit size expands the possibility that the unit reflects multiple categories increases. Another thematic unit that has also been proposed and used is the sentence (Fahy, 2001, 2002; Poscente & Fahy; 2003). Aviv, Erlich, Ravid, and Geva (2003), Gorsky (2011), Ahern, Peck, and Laycock (1992) and Garrison, Anderson, and Archer (2000) used the entire message as a unit of analysis.

The message as an analysis unit has also been used to analyze asynchronous discussion content based on the CoI model. This unit carries significant benefits. First, it is objectively recognizable, because unlike other analysis units a discussion message is clearly defined by many different coders. In addition, through this selection, the number of cases to be analyzed is easily manageable. Finally, the message is a unit specified by the composer of the message.

Nature of Content

According to Rourke et al. (2001), manifest content is “content that resides on the surface of communication and is therefore easily observable”. Manifest content in an asynchronous discussion could be the appearance of a particular word or an emoticon in a discussion message. The coding of manifest content imposes little interpretive burden upon coders (Hagelin, 1999) and therefore it achieves high reliability. For this coding makes it attractive for content analysis.

Specifically for educational dialogues, this growth attracted the interest of researchers for quantitative studies that focus on manifest data elements such as the number, origin, and length of messages or time spent online (Muzio, 1989). These studies impose little ‘interpretive burden’ on researchers because coding choice was not dependent on observer inference (Rourke et al., 2003).

On the other hand, the latent content focuses on the meaning of observing elements underlying the surface of a message (Babbie, 1992). It has been supported that the most interesting research questions are answered by focusing on the latent content of the discussion (Rourke et al., 2001)

A clear distinction has been proposed between two types of latent content (Potter & Levine-Donnerstein, 1999) The first type focuses on patterns in the content itself (latent pattern variables), while the second type focuses more on coders’ interpretations of the meaning of the content (latent projective variables). In the first type the content analysis designer focuses more on the content aiming to reveal objective patterns while in the second type the researcher has to interpret the meaning of the content based on their own judgment and the coding schema. Coding schemas for latent pattern variables are more complex than coding schemas for manifest variables. Inter-rated agreement decreases as the list of category indicators increases.

The inter-rated agreement increases when content indicators are limited in number but cover the whole range of the researched subject. In addition, the inter-rated agreement is increased when the coders are adequately trained in the process so that the interpretation they give is coherent.

Regarding latent projective variables, the focus moves to the coders' interpretation. An indicator of social presence includes the indicator "use of humor" in its coding schema and found that reliable coding depended on the intersubjectivity of coders' social and cognitive schemas.

Rourke et al. (2001) have found that cognitive processes were the most commonly investigated latent variable. Experienced content analysts argue that measuring latent content is inherently subjective and interpretative. The implications of this protocol on objectivity and reliability are obvious.

However, even though the CoI proved to be a valid model (Garrison et al., 1999; Rourke et al., 1999) for assessing cognitive development in online learning contexts, the practical issues of applying CoI analysis and its coding scheme remain; it is still a time consuming and manual process. Moreover, the CoI survey is also completed by the students after the end of the course thus not allowing the teacher to intervene during the course to form the dynamics of the community. As a result, neither of the above two methods provide an effective way of assessing students' development of CoI that can facilitate instructional interventions in real-time. Hence, the primary use of both instruments has been for the post hoc analysis of the student learning, primarily for research purposes (Kovanović et al., 2014).

2.2. Learning Analytics

Learning Analytics is at the intersection of technical and social learning theory fields. It attracts many researchers from various fields such as computer science, sociology, learning sciences, machine learning, statistics, and big data. In the present thesis, LA is the second pillar of the theoretical background for the design of the proposed visualization of ADVICE.

2.2.1. Learning Analytics definitions

Learning Analytics is a rapidly evolving research field. This is why there are no well-established definitions of the term “learning analytics”. The most cited definition comes from the International Conference on Learning Analytics (LAK 2011). The Society for Learning Analytics Research defines LA as “the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (Siemens & Long, 2011, p.30). Other representative definitions that have been proposed are the following:

- “*The selection, capture and processing of data that will be helpful for students and instructors at the course or individual level.*” (Elias, 2011, p.5)
- *“(The) interpretation of a wide range of data produced by and gathered on behalf of students in order to assess academic progress, predict future performance, and spot potential issues*”. (Bach, 2010)
- *“(To) enable teachers and schools to tailor educational opportunities to each student’s level of need and ability.”* (Johnson et al.,2011, p.20)
- *“(The) collection and analysis of usage data associated with student learning; (to) observe and understand learning behaviors in order to enable appropriate intervention.”* (Brown, 2011)
- “*Learning analytics is about collecting traces that learners leave behind and using those traces to improve learning*.” (Duval. 2012)

Despite the various aforementioned definitions there is a convergence to the fact that LA includes “the transmission of information in the automatic analysis of educational data to enhance the learning experience” (Chatti et al., 2012).

2.2.2. Learning Analytics Frameworks

The growing number of research events and publications necessitates a meta-analysis of the field in order to establish a solid scientific basis (Greller & Drachsler, 2012). In this context, efforts have been made to describe LA through organized frameworks such as those presented below. The frameworks that will be described have a common aim to encourage a coherent understanding of the basic concepts associated with LAs, each by offering a different approach.

Learning Analytics Model (LAM) (Siemens, 2013)

This model supports the "top-down approach" to data used for institutions supporting learners through LA. It also highlights the need for data management for educational purposes by a group rather than by an individual, as this process requires a combination of skills and knowledge.

Siemens (2013) describes the data analysis as a data loop. LAM includes seven components: collection, storage, data cleaning, integration, analysis, representation and visualization, and action. Each of these components constitutes the cycle of data processing and is further explained in detail in Figure 5.

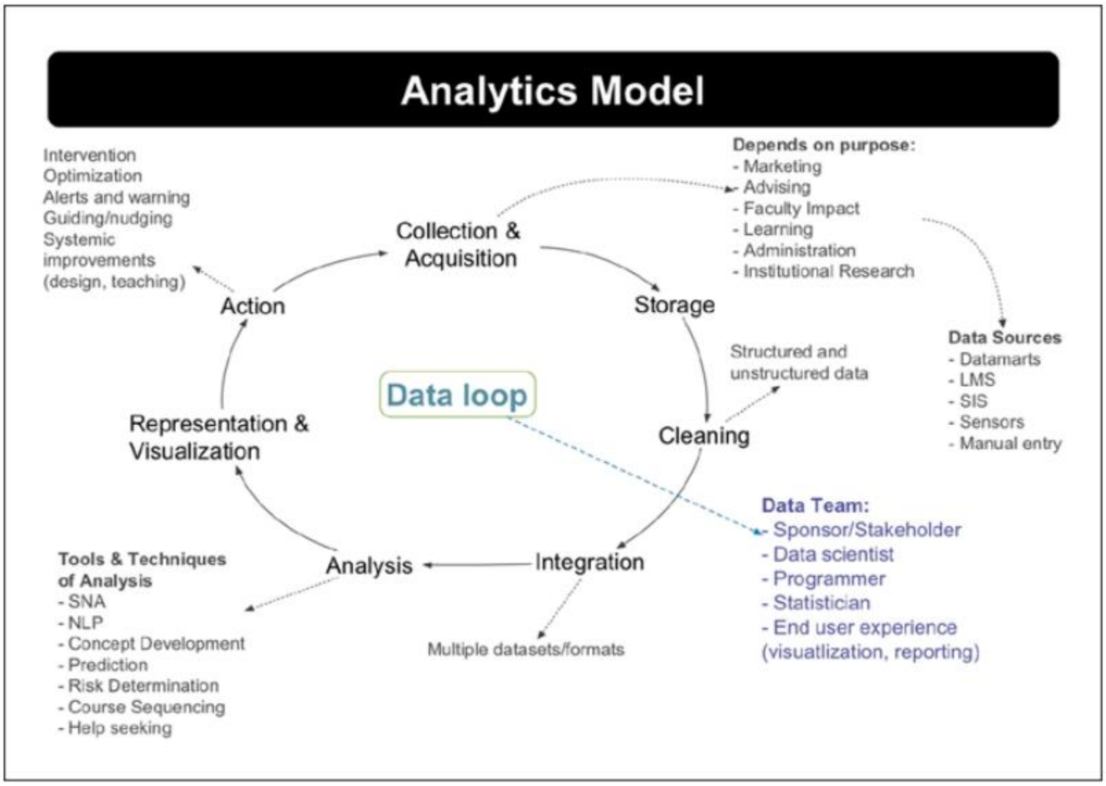

Figure 5. *Learning Analytics Model by Siemens (2013)*

Generic Framework for Learning Analytics (Greller & Drachsler; 2012)

Greller and Drachsler (2012), attempting to focus on ethical issues such as opening and protecting personal data, developed the concept of a conceptual framework incorporating LA's design requirements into their practical application to education. This framework contains six main dimensions, each of which is subdivided into smaller parts. Figure 6 represents this context.

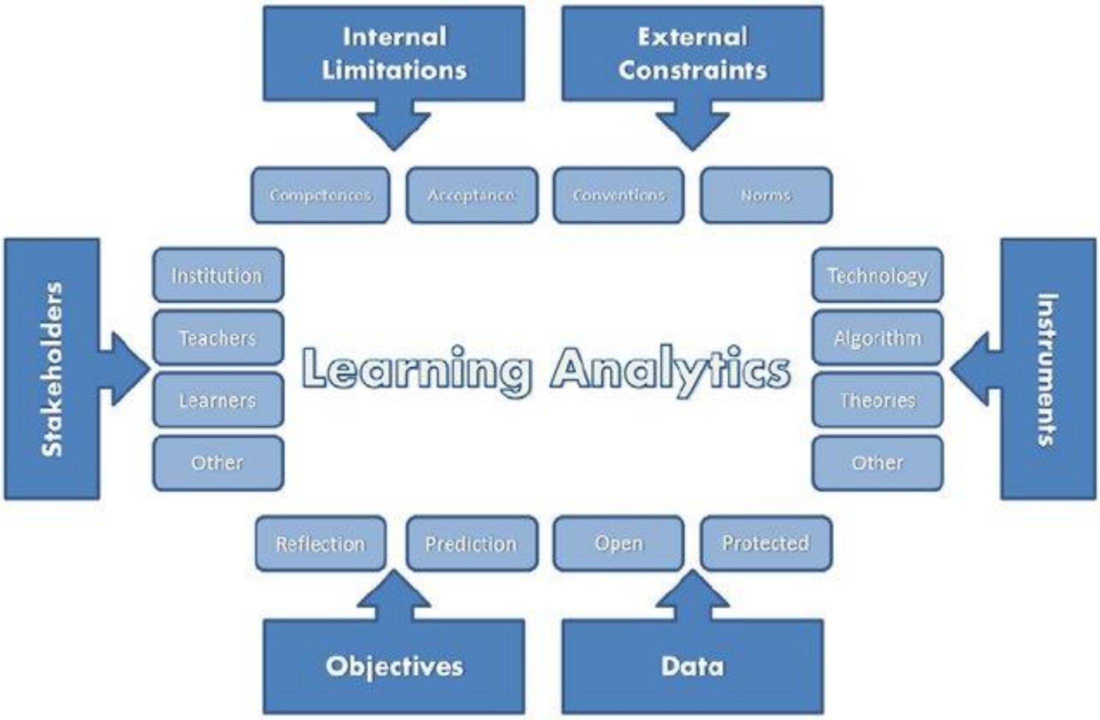

Figure 6. *Critical dimensions of learning analytics*

The dimensions of the framework include the following perspectives: (1) Concerned: data suppliers and beneficiaries of the LA process, (2) Objectives: defined objectives for the stakeholders to succeed, (3) Data: educational data sets and the environment through which they are captured and analyzed (4) Methods: technologies, algorithms, and theories used for data analysis, (5) Restrictions: restrictions or potential limitations for expected benefits, (6) Adequacy: user prerequisites for exploiting the benefits of the LA process.

Learning Analytics Continuous Improvement Cycle (Elias, 2011)

After combining and comparing specific theories: (1) Baker's (2007) "Knowledge Continuum", (2) Hendricks, Plantz and Pritchard's (2008) "Web analytics objective", (3) Oblinger and Campbell's (2007) "The five steps of analytics "and (4) Dron and Anderson's; (2009) the "Collective Application Model", Tanya Elias proposes a LA model which includes seven directly linked LA processes: selection, capture, summation and reference, prediction, use, filtering (refine) and sharing. These processes are integrated into an ongoing pattern of three-phase cycles: data gathering, information processing, and knowledge application.

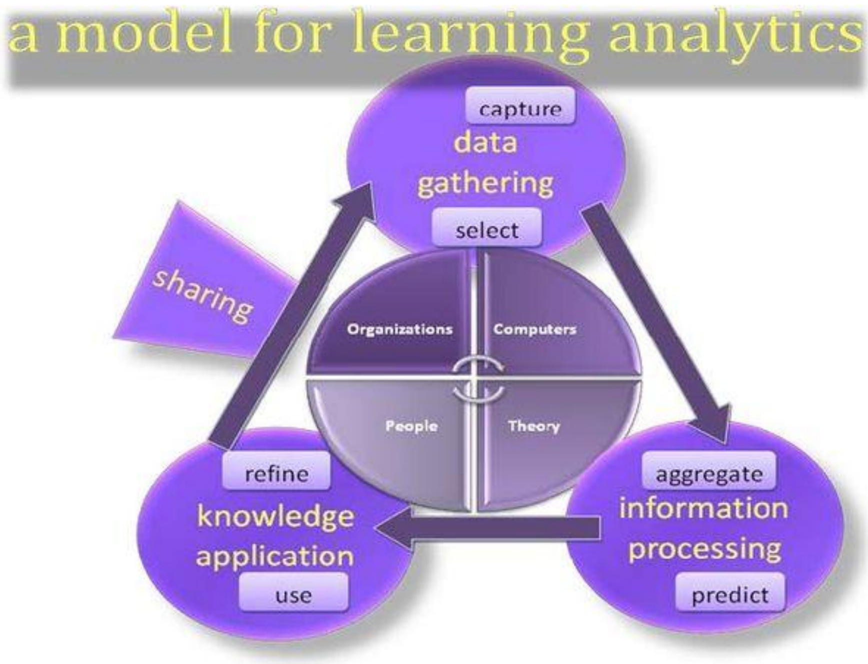

Figure 7. *Learning analytics continuous improvement cycle (Elias, 2011)*

Through the combination of the above theories, continuous improvement of learning and education can be achieved according to Figure 7.

Learning Analytics Process and Reference Model (Chatti et al., 2012)

As shown in Figure 8, according to Chatti et al. (2012), the general LA process is often a repetitive cycle carried out in three general steps: (1) data collection and pre-processing, (2) analytics and action, and (3) post-processing.

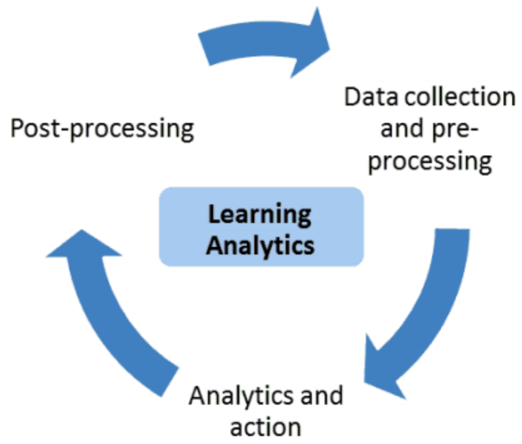

Figure 8. *Learning Analytics Process (Chatti et al., 2012)*

The LA reference model is based on the combination of four dimensions, describes LA as an iterative cycle, and combines a variety of challenges and exploration opportunities in the LA field concerning each dimension.

As shown in Figure 9, the four dimensions of the LA reference model are described by the following questions:

What; What kind of data does the system record, manage, and use to analyze it? (centralized learning environments or distributed learning environments)

Who; Who is the target of the analysis? (student teacher, designer, educational organization, researcher, system designer, etc.)

Why; What is the purpose of the system for analyzing the data collected? (control, analysis, prediction, intervention, counseling, evaluation, feedback, adaptation, personalization, recommendation, and reflection).

How; How does this analysis work? (statistics, information visualization, data mining, and social networking).

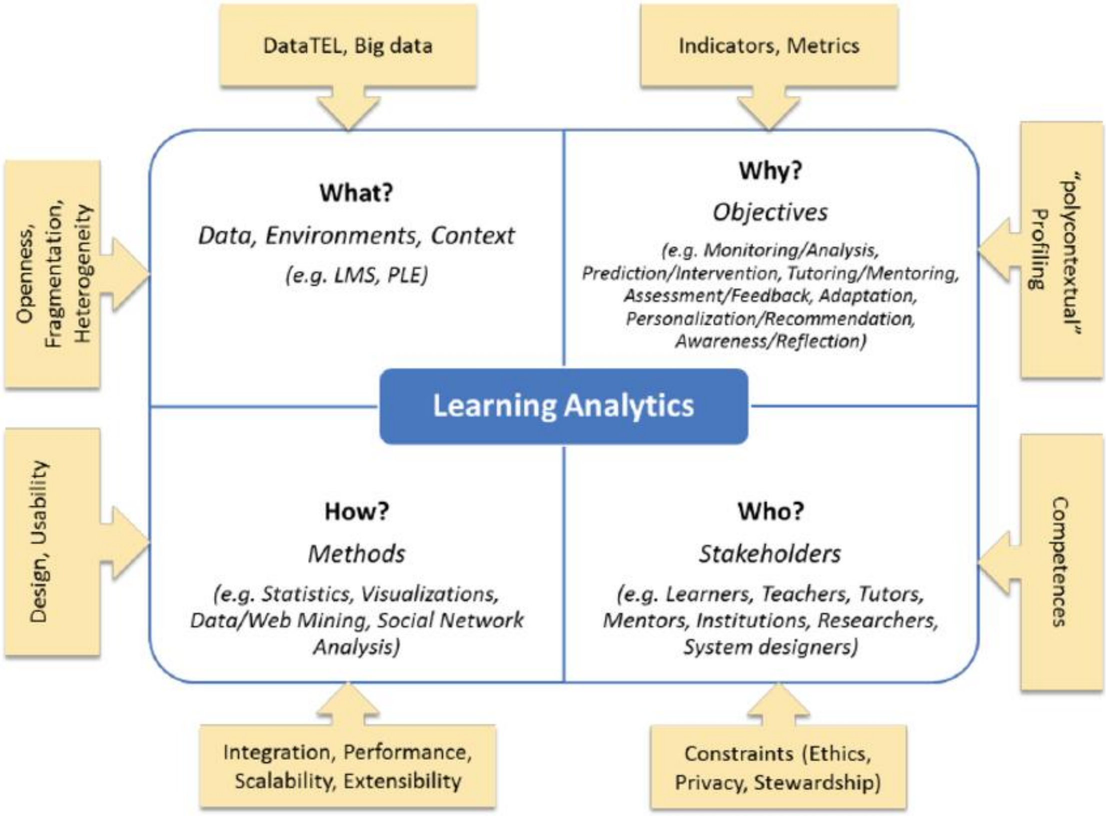

Figure 9. *Reference Model of Learning Analytics*

Greller and Drachsler's innovation lies in describing issues that are referred to as "soft", thus seeking to identify issues arising from assumptions about humans and society such as moral issues. The same differentiation into soft and hard issues has also been made by Dron (2011). Instead of developing a model of processes such as that of Elias (2011), Greller and Drachsler focused on a description framework that would later be able to evolve into the main model.

Elias, approaching LA differently, designed a model by combining pre-existing theories, attempting to cover the LA field and addressing issues such as technical issues, visualization tools, social analytics, LA theory, the human factor, and the educational organization involved (Elias, 2011).

On the other hand, Chatti and his colleagues propose a model that supports communication between researchers seeking to address challenges not necessarily within the narrow boundaries of the model but also others that may arise through the deepening of technical and pedagogical issues associated with LA (Chatti et al., 2012).

The LA reference model is the most cited model that approaches LA both as process and as a field compounded of specific components in comparison with the other models presented above (LAM, Generic Framework for Learning Analytics, Learning Analytics Continuous Improvement Cycle). For this reason, it will be used in the following section to describe the LA tools that belong to the same research field as ADVICE to highlight the gap in research that ADVICE aims to fill.

2.3. Literature Review

The literature review focuses on the recent research that illuminates the enhancement of cognitive presence in online discussions as well as the use of learning analytics in this direction. Consequently, as the thesis stands on the intersection of two emerging research fields, Communities of Inquiry and Learning Analytics tools, the literature review attempts to present the relative research of both approaches. Thus, the review focuses on a) methods adopted to enhance cognitive presence in online discussions, b) LA tools that analyze asynchronous discussions data, and finally c) how LA approach cognitive presence in asynchronous online discussions.

2.3.1. Enhancement of Cognitive Presence

Research on Communities of Inquiry focuses more on engaging communities in online discussions (Makri et al., 2013; Gašević et al., 2015; Akyol et al., 2009b, Oh et al, 2018; Junus & Suhartanto, 2019) and less on other means used for online communication such as blogs (Jimoyiannis & Angelaina, 2012; Angelaina &

Jimoyiannis,2012a; Angelaina & Jimoyiannis, 2012b; Eteokleous-Grigoriou & Ktoridou, 2012) or wikis (Eteokleous et al., 2014; Lambert & Fisher, 2009; Roussinos & Jimoyiannis, 2013). The potential offered by social networks to learners' communication based on CoI has also emerged in recent studies. However, early studies on Facebook (Kazanidis et al., 2018) and Twitter (Solmaz, 2016; Lomicka & Lord, 2012) have so far focused on social and teaching rather than cognitive presence. Through proper instructional design, CoI presences were also detected in various environments utilized in education such as virtual reality environments (Burgess et al., 2010), MOOCs (Kovanović et al., 2018), and online video games (Voulgari, & Komis, 2010).

Most studies focus mainly on research on the inter-relationships of the three Presences (Dempsey & Zhang, 2019; Garrison et al., 2010; Gutiérrez-Santiuste et al., 2015; Pellas, 2017) or on the development of a specific CoI presence: a) Social (Kovanovic et al., 2014a; Lowenthal & Dunlap, 2014; Swan, 2019), b) Teaching (Wang & Liu, 2019) or c) Cognitive (Galikyan & Admiraal, 2019).

In addition, Shea & Bidjerano (2010, 2012) articulated a new construct within the CoI framework, called "learning presence". This presence represents elements such as self-efficacy and online learner self-regulation constructs. Although learning presence was criticized by Garrison (2017), it nevertheless attracted research interest. Pool et al. (2017) identified self-regulation aspects related to learning presence in a blended learning course and Hayes et al. (2015) proposed strategies to foster regulatory behaviors and outline strategies for teachers to enhance learning presence.

To study the promotion of cognitive presence, different approaches have been explored and recommended on its activation, maintenance, or development. Instructional strategies have been explored such as a) exposure to multiple perspectives (Darabi et al., 2011), b) brainstorming (Kalelioglu & Gülbahar, 2014), c) debate (Kanuka et al., 2007), d) introduction with stories/cases (Richardson & Ice, 2010), e) role assignment (Gašević et al., 2015; Olesova, 2016) and f) students' question guidance (Gašević at al., 2015). In addition, for the enhancement of cognitive presence, arrangements on e-learning context features are proposed: a) a specific and sufficient amount of time for discussion at each of the cognitive presence phases (de Leng et al., 2009), b) providing sufficient total discussion time with immediate feedback (Stein et al., 2013).

Concerning the importance of metacognition in Communities of Inquiry, Gaševic, et al. (2015) demonstrated the positive effects of externally facilitated regulation on cognitive presence. Also, Kramarski and Dudai (2009) highlighted the importance of giving and receiving peer feedback as metacognitive support versus self-explanation strategy.

A technique proposed for cultivating metacognitive awareness and regulation in order to develop cognitive presence is to encourage students to think about their online contributions by labeling their messages according to each of the phases of PI (Pawan, Paulus, Yalcin & Chang, 2003). Schellens et al. (2009) have also concluded that labeling discussion contributions encourages students to contribute with more in–depth messages and it relates with higher level of critical thinking. Also, according to Valcke et al. (2009), labeling discussion messages was found to contribute a higher level of cognitive development. Garrison (2017) proposes this technique as it promotes understanding, shared metacognition and reflection. He also (2017) argues that students should be given the opportunity to reflect on their contributions and the inquiry process. Students' peer messages could be used as a basis for reflection on learning activities (Davie, 1989; Paulsen, 1995).

2.3.2. Learning Analytics tools for Asynchronous Discussions

In recent years, an increasing number of LA tools has appeared. These tools collect and analyze data from asynchronous discussions, recognizing that they can be associated with learning indicators (De Liddo et al., 2011; Mercer, 2004; Adraoui et al., 2017).

Most of the LA tools that use asynchronous discussion data are of general purpose, meaning that they provide visualizations and information around various types of data for a more holistic overview of course activities (Moclog, LOOP). On the other hand, a few LA tools focus particularly on discussion activities (SNAPP (Social Network Adapting Pedagogical Practice), INSIGHT). The tools presented in Table 1 were selected to give an overview of the range of possibilities opened up by LA for asynchronous discussions.

The review of tools in Table 1 is based on the Reference Model approach proposed by Chatti et al. (2012) for framing and assessing the potential impact of the LA tools on asynchronous discussion learning. These tools have been presented in articles, published after 2011, when the LA field was officially defined, and they use LA techniques as well as data from online discussions. Actually, most LA reference models aim at the classification of the literature on LA and they are based on or extend the “Who” (stakeholders), “What” (data), “Why” (purpose) and “How” (techniques) questions (Chatti et al., 2012; Knight & Shum, 2017; Klerkx et al., 2017).

Accordingly based on Chatti et al. (2012), the four dimensions of LA are: (a) who? (is targeted by the analysis), (b) what? (data are gathered, managed, and used for the analysis), (c) why? (the collected data are analyzed), and (d) how? (the collected data are performed).

WHO?

The LA tools analyze and make sense of asynchronous discussion data in order to provide intelligent scaffolding and insights to various *stakeholders (who)*. At a macro level, administrators and policymakers have the opportunity to use LA to make programmatic or legislative decisions. In contrast, at a micro-level, learners and educators have the opportunity to use LA to make more local decisions about the current learning event they are involved in (Wise et al., 2013). For example, Moclog provides numeric and graphic feedback for students, teachers, study program managers, and administrators. Through this tool, teachers can view data for all of their students whilst the students can only see their own data. Also, TrAVis (Tracking Data Analysis and Visualization Tools) provides data to both students and teachers.

In the LA research field, special reference has been made to the value of using LA by the learners themselves (Drachsler and Greller 2012; Durall & Gros, 2014; Ferguson & Shum, 2012; Santos et al., 2012). It is often argued that providing visualizations of their own learning process to learners, may promote the development of cognitive and metacognitive skills (Vieira et al., 2018). Extending this trend Wise, Zhao, & Hausknecht (2013) have maintained that in terms of pedagogical design, the intervention of LA tools consists not only in providing analytics to learners but also in framing their interpretation as an integrated activity associated with educational goals. Nevertheless, LA tools focus on learners (INSIGHT) to a much lesser extent compared to LA tools that apply to teachers. Most LA tools support teachers in gaining a better overview of the discussion activity (LAe-R (Learning Analytics Enriched Rubric), LOOP, Topic Visualization Dashboard) or to monitor the social interactions (SNAPP) through the discussion in order to enable them to proceed to pedagogical actions when necessary (Van Leeuwen et al., 2014).

WHAT?

The question "what?" involves (a) selecting the kind of raw data to be gathered in order to fulfill the particular purpose of the tool and (b) appropriately communicating them to stakeholders. Existing asynchronous discussion tools visualize data such as (a) forum log data (SNAPP, LAe-R, LOOP, TrAVis) that are analyzed to provide as output various visualizations of learners' interactions (see Table 1, SNAPP) or provide specific indicators such as collaboration and engagement (see Table 1, LAe-r, Cohere), (b) discussion contents (INSIGHT, Topic Visualization Dashboard, EduMiner) (see Table 1, Topic Visualization Dashboard), (c) other log data such as learner's coding, views, votes (see Table 1, Cohere, Topic Visualization Dashboard).

However, the cognitive structure of the discussion (Cohere, EduMiner) still remains a shortcoming in the research. Topic Visualization Dashboard gathers messages' content data for semantic analysis and also log data such as mouse click, scrolling, buttons clicked, text highlighted, keywords searched, etc. The log data captured in each tool varies according to the tools' purpose. INSIGHT captures the semantic content of the discussion in order to help users browse faster through the various topics of the discussion while TrAVis forum log data such as the number of participants, of messages, of threads, of replies, of messages quoted, etc. mainly for providing monitoring to the course staff.

Consequently, one issue that arises is the shift of focus from big data to meaningful data (Merceron et al., 2016). For example, although the information resulting from log data and social network analysis provide visualizations about the social structure of students' discourse, they reveal little about the cognitive quality of the content of the discussion. Thus, the question emerging is which methods and models may be used to analyze raw data resulting in reliable knowledge (Keim et al., 2008).

Table 1. *A comparison of LA tools in asynchronous discussions including ADVICE*

LA tool	What?		Who? (benefits from the visualization)	Why? (the purpose of the visualization)		How?
	Raw Data	Output				
Cohere (De Liddo & Buckingham Shum; 2010).	Discussion content, forum log data, messages' labels and connections provided by learners,	Semantic network of posts, table including learning indicators	Teacher	Monitoring Reflection	Argumentation Theory	SNA, Visualization
SNAPP (Bakharia, & Dawson, 2011)	Forum log data	Social Network of peers' interaction	Teachers	Monitoring	-	SNA
TrAVis (May, George & Prévot, 2011).	Forum log data	Bars and Spheres reflecting time and access information	Students Teachers	Monitoring Adaptability	-	Visualization
Moclog (Mazza, Bettoni, Faré, & Mazzola, 2012)	Forum log data	Tables and Pies of views (e.g., reading messages) and posts (e.g., writing messages)	Students	Self-monitoring	Theory of eLearning Functions (Reinmann-Rothmeier, 2003; Reinmann, 2006)	Statistics, Visualization
			Course Staff	Monitoring		
LAe-R (Petropoulou, Kasimatis, Dimopoulos, & Retalis; 2014)	Forum log data	Rubric reflecting learners' engagement & collaboration	Teachers	Assessment		Statistics, Visualization
			Students			
Loop (Corrin, Kennedy, De Barba, Bakharia, Lockyer,	Forum log data	Timeline of pies reflecting forum posts	Teachers	Monitoring	Laurillard's (2002) conversational framework	Statistics, visualization

Gašević, & Copeland; 2015)						
INSIGHT (Awasthi & Hsiao, 2015)	Discussion Content, Forum log data	Bubble charts reflecting semantic characteristics of forum posts	Students	Monitoring Adaptability	-	SNA (TFM)
Topic Visualization Dashboard (Atapattu, Falkner & Tarmazdi, 2016**)**	Discussion content, log data	Bubble graphs reflecting amount and weight of posts related to specific topics	Teachers (course staff)	Monitoring, Adaptability	-	Data Mining (Naïve Bayes Classifier), Visualization,
EduMiner (Hsu, Chou & Chang, 2011)	Discussion content	The cognition level of Bloom's Taxonomy of each message	Students	Assessment	Bloom's Cognitive Taxonomy	Data Mining (Text mining : LSA – multiclass SVM classifier)
			Teachers			
ADVICE	Forum log data, learners' coding messages	Scattergram reflecting the cognitive phase of each message according to the perspective of various groups of learners Radar chart that reflects the cognitive contribution of each learner to the discussion	Students	Reflection Adaptability	CoI	Code messages, Visualization
			Teachers			Visualization, Reference file

WHY?

The “Why” question is the most essential aspect of the LA design rationale. The purpose for which a tool is designed, determines the target audience, the data it intends to visualize, and how it does so. The LA tools’ purposes, listed in this review in Table 1, Column ‘Why’, are: (a) adaptation (e.g., INSIGHT, Topic Visualization Dashboard, TrAVis), (b) assessment (LAe-R, EduMiner), (c) monitoring (e.g., SNAPP, Moclog, LOOP, Cohere) and (d) reflection (Cohere).

Adaptation is usually focused on the learner (Klašnja-Milićević et al., 2017) appearing in two forms of adaptation (a) adaptivity and (b) adaptability. Through adaptivity, the learning process is guided by the system triggered by the user’s actions, while, through adaptability, the user changes and decides on the learning process (Khemaja and Taamaallah 2016). Adaptability emphasizes learner’s self-direction, self-organization and self-control (Chatti et al., 2012). An adaptable visualization is not viewed as a representation of analyzed data but is instead offered so as to help learners explore and discover the possible relationships among data by assisting them in searching specific meaningful patterns. Regarding adaptability, in TrAVis, the users may select visualization parameters e.g., the period of time for a specific indicator’s values, the type of the indicators, etc. In this way, TrAVis provides multiple forms and different scales in the visualizations offered while INSIGHT provides an interactive interface where the user can select between different links, sort, or select tags.

The tools that support monitoring provide users with specific indicators regarding the progress and/or the results of the discussion activity (Muñoz-Cristóbal et al., 2018). Learners can monitor themselves (Moclog) or learners can be monitored by other stakeholders such as teachers or course staff (Loop, Moclog, SNAPP). On the other hand, assessment targets on learner’s outcomes providing objective information concerning a specific learning goal (Baker & O’Neil, 2002).

Reflection requires awareness of one’s experiences in order to examine presented information and draw accordingly critical conclusions (Hoyrup & Elkjær,

2006) in order to foster further learning. There is a widely documented argument that reflection enhances learning and practice since the learner is involved in processes that explore experiences as means of deepening understanding (Boud et al., 2013; Linn & Eylon, 2011). To this end, Cohere attempts to promote learners' reflection by asking them to code and link the forum messages based on the argumentation theory without providing the learners with any feedback on this process. On the other hand, EduMiner provides an assessment by a visualization of the cognitive level of the learners' posts according to text mining analysis but it does not actively involve them in the process.

HOW?

According to Chatti et al. (2012), the "how" dimension refers to the LA techniques applied. Statistical analysis (LAe-R, LOOP, Cohere, TrAVis) appears to be the most common technique. Also, the following techniques appear: Latent Semantic Analysis (INSIGHT), Social Network Analysis (SNAPP, Cohere), and Data Mining Techniques (Topic Visualization Dashboard). INSIGHT models the discussion based on the Topic Facet Model algorithm for forum posts semantics while Cohere applies Social Network Analysis (SNA) for representing the typology of the network of the discussion forum and also applies statistics for revealing information such as the most popular link or node type, etc. SNAPP applies SNA for monitoring users' interactions in order to evaluate the effectiveness of implemented learning designs. In addition, Topic Visualization Dashboard applies the latent Dirichlet allocation algorithm for coding the topics of the discussion and naïve Bayes classifier for obtaining the most suitable labels for each topic cluster.

Most tools use visualization techniques to facilitate the interpretation of data instead of reports and tables of data (LAe-R, SNAPP, Moclog, Loop, INSIGHT, Topic Visualization Dashboard, Cohere, TrAVis). To achieve this, however, it is not enough just to provide the information to the users but to appropriately design visualizations that reflect a learning theory promoting at the same time theoretical informed interpretations by users (Clow, 2012).

It has been claimed that existing visualizations offer limited interactivity for the user, and they are not framed by learning theories (Dawson, 2010; Ritsos & Roberts, 2014). Indeed, there is a research gap in the LA literature, as most tools have been developed based rather on empirical approaches than on specific educational theoretical frameworks (Nistor et al., 2015). In this line, Sedrakyan, Järvelä, and Kirschner (2016) suggest that the feedback provided by the LA visualization tools presented in the literature lacks theoretical background grounded in the learning sciences.

Concretely, the integration of such a theoretical background is important for data analysis because it enhances the choice of appropriate variables to analyze, the appropriate selection of data to be presented or explored and the appropriate interpretation of the resulting visualizations (Wise & Shaffer, 2015; Wilson et al., 2017; Stewart, 2017).

Therefore, researchers continuously highlight that one of the key challenges in LA field is LA to be connected to learning science (Stewart, 2017; Gašević et al., 2014; Koh et al., 2016; Knight et al., 2014; Ferguson, 2012; Avella et al., 2016; Marzouk et al., 2016).

A primary observation regarding the existing tools is that almost all of them lack providing theoretical support to learners. Consequently, the main tendency for learners is to monitor evidence of a 'practical' focus in using asynchronous discussion (e.g., for course management or information) rather than to identify collaborative construction of knowledge in asynchronous forums, and looking for evidence of community amongst learners. Bratitsis and Dimitracopoulou (2008) state that discussion analysis indicators enhance students' activity and this might lead to more effective discussions and critical thinking.

Aiming to contribute to this line of research, ADVICE integrates two ways to enhance learners in cultivating cognitive presence which, according to the CoI framework, is the main element of critical thinking. The first one is by allowing learners the responsibility of coding messages according to the cognitive presence phases of PI and the second one is by providing learners with timely feedback through adaptable visualizations of the teachers' and the community's perspective for the cognitive development of the discussion. Goy, Petrone, and Picardi (2017) suggest that enabling the learner to relate their personal perspective to the shared ones can "foster the development, recognition and meta-reflection on her own perspective".

2.3.3. Learning Analytics and Cognitive Presence

Learning Analytics approaches the theory of Communities of Inquiry by aiming to develop systems (Corich et al., 2012; McKlin et al., 2002) and classifiers (Kovanović et al., 2016) for semi-automated content analysis of discussion messages to surpass time-consuming analysis and researchers' manual work.

Mcklin uses artificial neural network to propose a tool for semi-automated content analysis of the discussion based on the PI phases. It attempts to measure the critical thinking of the participative group rather than of individual participants in an asynchronous discussion. The tool aims to provide evaluative feedback to instructors, researchers, and administrators for the facilitation of online learning. This work connects computer-supported collaborative learning, content analysis, and artificial intelligence. This tool has demonstrated two experiments. In the first experiment the reliability agreement Cohen's kappa between the ANN model and the group of human coders was found to be .519 and in the second experiment where the improvement efforts were made to the human content analysis, the Cohen's kappa was found approximately 0.70.

Following the work of McKlin (2004), a study by Corich et al. (2012) presented ACAT, a general classification framework that can support any coding schema besides cognitive presence. Users have to provide a set of examples to train the classification models. The use of the ACAT system is also evaluated on the problem of coding the cognitive presence of the CoI model. Corich et al. (2012), demonstrated reliability agreement 0.71 in their best test case.

However, given that sufficient experimental details such as the classification system and indicators have not been reported so that the experiment could be verified, it is hard to interpret the significance of the results.

Another promising approach is that of Kovanovic et al. (2014b) which used classifiers such as Support Vector Machines for the automation of the cognitive presence coding. In their experiment they achieved a classification accuracy of 0.41 Cohen's Kappa. Trying to improve the classification accuracy, Kovanovic et al. (2016) used LIWC and Coh-Metrix features and they obtained Cohen's value of 0.63.

The above approaches do not ensure high accuracy in providing valid human-like analysis which is their goal. Moreover, they are neither addressed to the students through the learning process by opening the analysis results to them nor used for learning activities.

2.4. Summary

The state of the art presented in this Chapter elicits the main concepts from two diverse fields that are at the leading edge of technology-enhanced learning: Communities of Inquiry and Learning Analytics.

The two above-mentioned fields are examined by focusing on the cognitive presence which is considered to be the main component of the CoI model as it primarily reflects the learner's critical thinking. The analysis reveals that an open research object is the promotion of CoI through the enhancement of the learners' shared metacognitive awareness.

The shared metacognitive awareness is suggested to be enhanced by the awareness of the learners for the cognitive development of the course, but little research has been done in this direction. Moving one step further, it has been attempted for learners to classify discussion messages as a process of cultivating learners' awareness. Although limited research is available, they offer some positive indications in this direction.

A promising field of the above-mentioned practice is LA. In this direction, methods of automated content analysis based on cognitive presence have been explored, but the accuracy of the results that the methods achieve in order to be used in the educational process is questioned.

It appears that exploring the classification of asynchronous discussion messages by the learners themselves for promoting Communities of Inquiry is still in its infancy. Although learning analytics tools that aim at analyzing asynchronous discussions are considered a dynamic field of research, they have not yet embedded relevant processes. There are, therefore, concrete concerns about the implementation of this process in the LA field. In addition, any combination of the two research fields (Communities of Inquiry and Learning Analytics) are moving towards different directions and have not yet offered any comprehensive proposal for use within the classroom.

The main concerns that arise are divided into three main axes:

(i) Lack of a valid process appropriately designed for learners to code messages.

(ii) Lack of appropriate variables based on the Communities of Inquiry that may enhance learners' awareness through the learning process.

(iii) Lack of LA visualization tools for asynchronous discussions that are a) based on an educational theory, b) are learner-oriented and c) support learners' active involvement through personalization.

The three above mentioned concerns formed the basic motives of the dissertation to investigate four experimental studies that lead to the development and evaluation of ADVICE.

Initially, the thesis focuses on the development of a coding schema that, according to the coding of the learners, will lead through appropriate calculations to a reliable representation of the PI phase of the discussion messages. The relevant studies presented in Chapter 2 have therefore been taken into account. The research then focused on variables based on CoI theory and related to cognitive presence. The proposed variables are then integrated into ADVICE, which is specifically designed to address to learners both through coding messages and through the personalized visualization provided. For this reason, these variables are used for both adaptability and visualization.

Figure 10 summarizes the topics reviewed in this Chapter and illustrates the relationships among these topics.

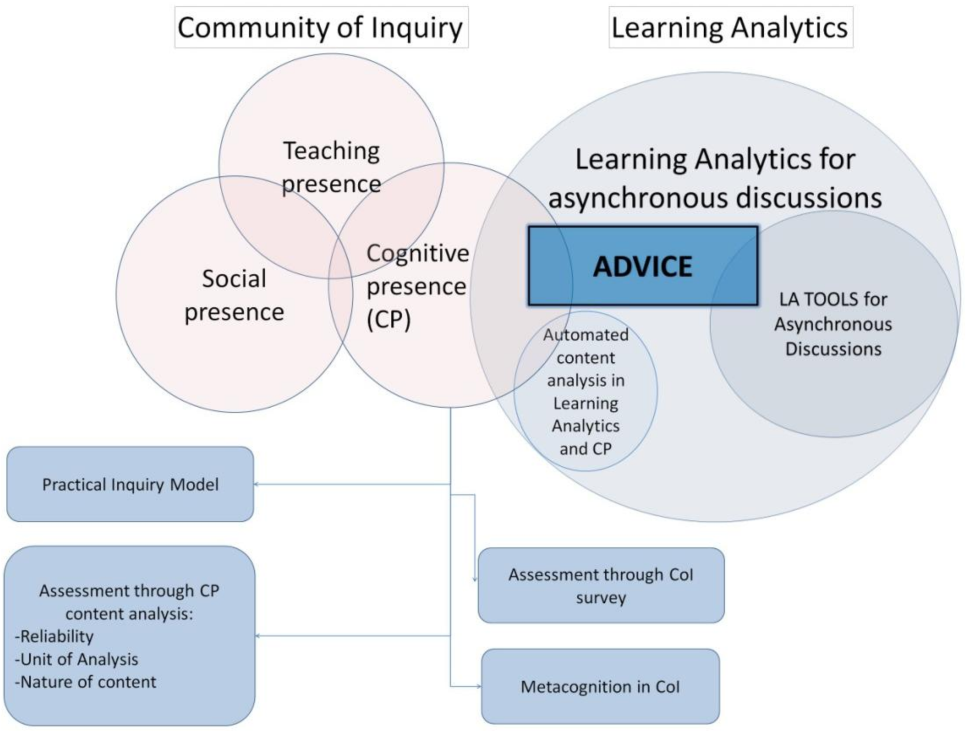

Figure 10. *Summary of the 2nd Chapter*

3. PHASE 1. STUDY 1.1: DESIGN AND EVALUATION OF ADVICE'S CODING SCHEMA

3.1. Introduction- Research Questions

This study proposes the process of self and peers' messages content analysis as a promising way to cultivate metacognitive skills and consequently cognitive presence. For this, a cognitive presence coding schema is designed and proposed for use by the learners.

In this context, the main research questions of this research are:

Research Question 1. How can a coding schema for students be developed?

Research Question 2. How did the coding procedure affect students' perception of the discussion enabling the development of metacognitive skills?

3.1.1. The initial Coding schema (proposal)

The proposed coding schema adopts the message as an analysis unit as it is applied and proposed by other researchers in CoI. It is based on the four phases of PI. Every choice offers a comprehensive description for each phase to encompass all the meaning of the indicators that constitute it. The purpose is for the learner to correctly recognize to which phase each message that they classify, belongs. The learner is aware of the theoretical context of cognitive presence but they are not trained as an experienced analyst-researcher in content analysis.

The selections of the coding schema are rendered in English as follows:

Selection 1: Issue a problem to begin its investigation (triggering event phase)

Selection 2: Exploration of ideas and information regarding the issue, even intuitively (exploration phase)

Selection 3: Constructing solutions or explanations by linking ideas that have value and meaning to solve the issue (integration phase)

Selection 4: Application or testing or defending the final solution (resolution phase)

The discussion forum in INSPIREus has been extended with a classification functionality allowing its users to classify their own and other participants' messages. Thus, through the discussion, the participants can classify their own and their peers' messages by selecting the appropriate category options (see Fig. 11, selection icon for each phase) from a multiple-choice menu containing four options (see Fig. 11, selection icon for the pop-up window). Each option corresponds to a specific PI phase (Garrison, 2011) and is described through the corresponding cognitive presence indicators (see Fig. 11, pop up window with the four PI phases). The students can select only one option of the coding schema for each post and they are free to change their classifications during the discussion. They are also able to see how many users (students and instructors) have chosen each phase for every message (see in Fig. 11, Number of users who had chosen the specific phase for this message). All the students' choices are recorded by the system.

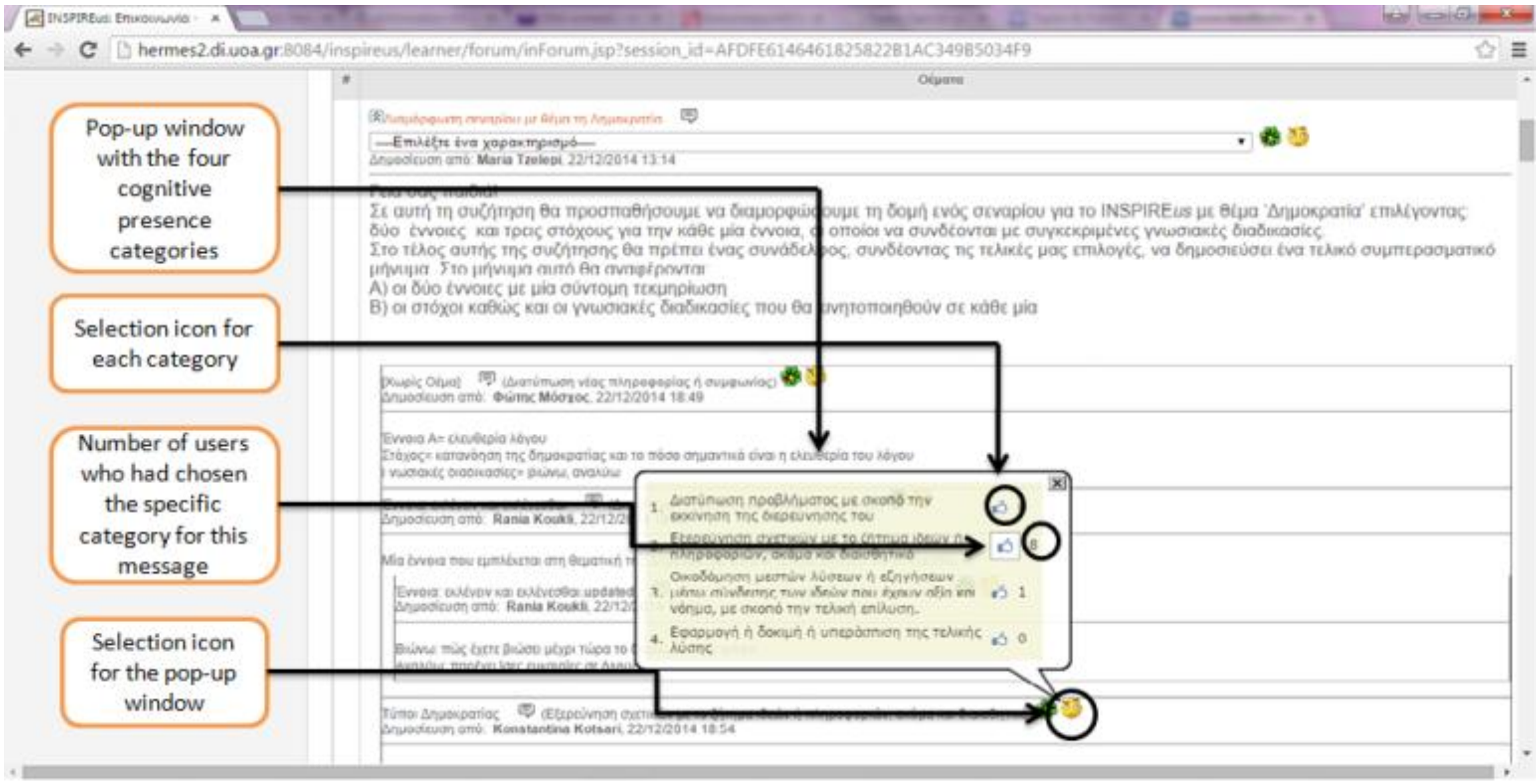

Figure 11. *A screenshot of the forum of INSPIREus presenting the coding functionality*

3.2. Methodology

In this section, the research design, the participants, the data collection process and instruments used, are described.

3.2.1. Participants

This study was performed with 9 MSc students of the University of Athens attending a postgraduate course on digital technologies in distance learning. Through the discussion, the students were involved in self and peers' messages classification through a particular coding schema.

3.2.2. Research Design

The discussion topic was about the design of an educational scenario for the adaptive educational system INSPIREus and particularly about the selection of the main concepts underlying a specific scenario proposed by the researchers. This was a preparatory activity aiming to familiarize students with the instructional design of INSPIREus. Before the discussion activity, two of the researchers presented the CoI framework and discussed with the students the scope of the three presences: Cognitive, Social, and Teaching presence. During the discussion activity, the students were able to classify their peers' messages through the proposed coding schema. After the discussion activity the students completed an evaluation questionnaire designed by the researcher (Appendix A).

3.3. Data Analysis

Aiming to answer research question 1, a content analysis procedure is followed involving experts, whilst for research question 2 students' answers to the evaluation questionnaire were analyzed. The content analysis procedure used the message as the unit of analysis for the asynchronous discussion as a) it has mostly been used for CoI (Garrison et al., 2001; Rourke et al., 1999; Osguthorpe, 2003), b) it is objectively identifiable (Rourke, 2001) and c) "it is a unit whose parameters are determined by the author of the message" (Rourke, 2001) who, in our case, is actually the person who initially coded this message. So, even if a message may contain contradictory meanings that lead to different categories (Henri, 1992), the message's author is most appropriate to state which is the main purpose of the message.

The content analysis procedure has been organized in two phases:

Phase A. The messages were initially analyzed by two expert-coders (one of them participated in the discussion as instructor, whilst the second one was an expert on CoI coding) in order to have a reliable coding to assess students' classification. The analysis was based on the PI descriptors and indicators. In cases of coders' disagreement, the resolution came through discussion to convert to consensus. In this way they resulted in a unique PI phase for each message, ensuring this way the reliability of the coding.

Phase B. Then, Cohen's Kappa coefficient was used in order to test whether the student approaches a reliable coding perspective without this agreement being resulted randomly (Kappa takes into consideration the agreement by chance). This way, students whose disagreement on coding may be derived from a different perspective rather than just guess can be distinguished. In this process various instances of disagreement among students and teachers but agreement among students are also explored.

As for the Research Question 2, the evaluation questionnaire that the students answered after the discussion is analyzed.

3.4. Results

Two of the most popular techniques for calculating the percent agreement of content analysis are Holsti's coefficient of reliability and Cohen's kappa. Inter-rated reliability was chosen due to the coding suggestions of Rourke et al. (2001) as well as the research methodology proposed in Garrison et al. (2001). The inter-rater reliability analysis using the Cohen's κ statistic and Holsti's coefficient reliability was found to be $\kappa = .92$ ($p < .001$) and C.R. = .88.

The discussion consisted of 37 posts, of which 10 were posted by instructors and 27 were posted by the students. All the students' messages belong to cognitive presence categories. The first message of the discussion was the triggering event of the discussion provided by the instructor. In regards to students' messages, 44% were classified in the exploration phase, 52% were classified in the integration phase and one message was in the resolution phase.

Study 1.1. Research Question 1. How can a coding schema for students be developed?

Initially, it was explored at what level the student's classification agrees with the experts' coding. The coding agreement was calculated for each student's classification with the use of Cohen's Kappa statistical measurements, including also percentages of agreement (see Table 2).

Table 2 *Coding agreement between each student's classification and experts' coding*

Students	Agreement (%)	Cohen's Kappa	p
Student 1	85	.726	.000
Student 2	83	.742	.000
Student 3	80	.622	.000
Student 4	80	.688	.000
Student 5	76	.463	.005
Student 6	73	.459	.018
Student 7	58	.401	.000
Student 8	40	.333	.005
Student 9	38	.381	.008

The conventional level of inter-rater reliability is not clearly declared yet (Strijbos et al., 2006). A well-accepted guideline for scale indication describes five different levels of agreement (Landis et al., 1977). For Cohen's kappa, Landis et al. (1977) characterized "values < 0 as indicating no agreement and 0–0.20 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial., and 0.81–1 as almost perfect agreement".

There are three students (Student 7, 8, and 9) whose Kappa values represent fair strength of agreement. The specific students, answering question 5 from part B of the questionnaire (see Appendix), referred to the difficulty of distinguishing between the third and fourth classification. Indeed, from the database log files, above the 90% of "ambiguous" messages belonged to one of these two categories and most of them were the messages that the three students had coded differently than the experts.

Then, based on the cognitive presence coding, the characteristics of the messages of which experts' coding vary from the students' ones were explored. According to the classification data logs:

- There were 19 of the 27 messages been exchanged in the forum to which more than 65% of the students categorized the messages by choosing the same PI phase as the experts' coding and
- In the remaining eight messages, less than 65% of the students had categorized each message by choosing the same phase as the experts' coding.
- Two from these 8 "low agreement" messages had been coded by the experts as belonging to the exploration phase while students have chosen the triggering event phase. These were also the two first messages of the discussion in chronological order (Table 3). An explanation can be given with the responses given to question 4 from part B of the questionnaire (see Appendix), on the difficulties of classifying peers' messages. Most of the students, who had classified differently, messages 1 and 2, answered that at the beginning of the discussion they were confused.

- From the rest six messages, five were coded by the experts' as belonging to the integration phase while most student-coders have chosen the resolution phase. The last message was coded by the experts' as belonging to the resolution phase while most student-coders have chosen the integration phase. Actually, three students, that responded to question 5 from part B of the questionnaire (see Appendix) and claimed that they found it difficult to distinguish the third from the fourth phase in the messages, had coded the specific messages differently than the experts' coding. Indeed, three of these messages had initially been coded differently by both experts. Analyzing the messages' content it was found that these messages could be either coded as belonging to integration or resolution phase. So, these messages could not be reliably coded since the students could select only one phase for each message.

A very interesting issue observed, was that, most students who chose a different categorization from the experts' coding, mostly agreed among themselves on the phase chosen. Actually in Table 3 appear: a) the number of the discussion message according to chronological order (column M), b) message phase according to experts' coding (column MC), c) number of students who coded the message (column NS), d) number of students whose classification differs from the experts' coding (column NDS), e) percentage of the number of students who chose a different phase from the experts' one in relation to the number of students that coded the message (column FDS), f) message phase most often chosen by students who categorized the message differently than the experts' coding (column DC), g) number of students who chose the most often selected message phase that differed from experts' coding, (column NCS) and h) percentage of number of students, who chose the most often selected message phase that differed from experts' coding, in relation to the number of students that coded the message (column FCS).

Table 3. *Students' and experts' coding for the eight messages which, over 65% of students, coded differently than the experts did*

M	MC	NS	NDS	FDS (%)	DC	NCS	FCS (%)
1	2	8	4	50	1	4	50
2	2	8	3	38	1	3	38
15	3	7	6	86	4	5	71
18	3	8	4	50	4	3	38
19	3	7	7	100	4	7	100
24	4	7	3	43	3	3	43
25	3	7	3	43	4	3	43
26	3	6	2	33	4	2	33

For example, a closer examination of message 19 (see Table 3, line 5) shows that from the seven students who coded the message (see Table 3, line 5 - column NS), all disagreed with the initial experts' coding (integration) (see Table 3, line 5 - column NDS) but agreed with each other in a different phase (resolution) (see Table 3, line 5 - column FCS). Reading the content of this message again we realize that this message is the first comprehensive effort in the discussion for a solution, examining all the parts of the initial problem which is the triggering event of the discussion. We can, therefore, only hypothesize that this message could reasonably be interpreted as a resolution phase by the rest of the students.

<u>Study 1.1. Research Question 2. How did the coding classification procedure affect students' perception of the discussion enabling the development of monitoring skills?</u>

Students' answers about the metacognitive benefits of coding peers' posts were positive (Appendix, question 2 of Part A of the questionnaire). In this question 56% of the students answered "Strongly Agree" and the rest of them answered "Agree". There was not observed a certain tendency of students' perception on metacognitive benefits from coding instructors' posts (Appendix, question 1 of Part A of the questionnaire). In this question 50% of the students answered "Agree" and

50% of the students answered: “Disagree”. According to students’ answers to questions 1, 2, and 3 of Part B of the questionnaire, this may be because the students have encountered difficulties with the classification of instructors’ messages and three of them couldn’t distinct teaching categories when coding.

3.5. Discussion - Conclusions

In this study it is proposed a novel content analysis approach involving self and peer assessment, based on the CoI framework. This approach is based on students’ classifying their own and peers’ messages during an asynchronous discussion. Self and peers’ messages coding process involves students in the inquiry process and provides awareness and metacognition, aspects that are central to successful inquiry (Garrison, 2011). This also confronts the issue of time-consuming content analysis that takes place after the completion of the discussion and therefore deprives instructor of valuable feedback.

The results of this research provide evidence about the effectiveness of the proposed content analysis procedure due to the sufficient level of coding agreement between the expert coders and the majority of the students (coders). The majority of students had Cohen’s Kappa values between .73 and .46 (moderate to substantial agreement). For those who were in fair agreement, it was found that they were aware of the coding difficulty by acknowledging specific characteristics of the messages they found more difficult to code and by acknowledging the criteria of the coding choices they had difficulty to distinguish. On the other hand, the messages for which coding showed higher disagreement between students and the experts’ coder revealed that in some cases students agreed with each other in a different coding than the experienced coder. This may happen because of students’ different perspective or as an influence of their peers’ classification choices as they had access to these data. In the next study this information will be hidden, to clarify this issue. In addition, messages with high frequency of low coding agreement between students’ and experts’ coding, revealed that the four given choices of the cognitive presence coding schema are not enough to express all the possible categories that a message can belong to.

In any case, students consider that the content analysis process enabled them to elaborate on their own, peers' and the instructor's messages identifying interesting perspectives that they couldn't otherwise be aware of. Furthermore, the proposed strategy looks promising for cultivating metacognitive skills in a semi-automated content analysis method. The work presented in this study will be continued since the limited number of students of this pilot study prevents the generalization of the findings. Thus, based on the current evidence this study will be redesigned in order to conduct experiments with more students. This way, the impact of this classification method in the learning process as well as functionality and visualization aspects of a tool facilitating online peer content analysis will be examined thoroughly.

4. PHASE 1. STUDY 1.2: REDESIGN AND EVALUATION OF ADVICE'S CODING SCHEMA

4.1. Introduction – Research Question

In this study a redesigned coding schema, based on CoI model, is proposed in order to facilitate students to code their own and peers' messages during a discussion. The design of the proposed coding schema is based on the results of Study 1.1. The data coming from this process could potentially be provided to the participants of the discussion at real-time aiming at (a) promoting students to reflect on their own and their peers' cognitive development to the discussion, (b) support instructors' adequate and timely intervention.

The proposed coding choices are based on the results of the pilot Study 1.1 where a list of four choices was offered to the students reflecting the four phases of the PI approach. The particular coding schema has been implemented in the educational adaptive hypermedia system INSPIREus (Papanikolaou, 2014), for real-time coding in an asynchronous discussion, and was available to students in order to code their own and peers' messages. This schema used the message as an analysis unit.

The results of this research have shown that the four choices of the coding schema used could not cover the students' needs, i.e., more were needed to express all the possible PI phases that a message could belong to. Indeed, many messages may contain more than one unit of meaning (Gunawardena et al., 1997; Henri, 1992). Aiming to formulate a coding schema closer to the students' (coders) needs, these options were extended to include five more, in case a student would observe more than one unit of meaning in a message.

The reliability of the classifications proposed in this schema and its potential to reveal the students' capability of awareness are examined. In particular, the focus is on the following research question:

Research Question: Can the proposed coding schema reflect a reliable community perception for the cognitive presence of the discussion?

4.1.1. The final coding schema (proposal)

The proposed coding choices are presented below. The description of each choice was based on particular PI phases involving relevant cognitive presence indicators:

- Selection 1 describes the 1st phase of PI based on its indicators: recognize problems, puzzlement.
- Selection 2 describes the 2nd phase of PI based on its indicators: divergence, information exchange, suggestions, brainstorming, and intuitive leaps.
- Selection 3 describes the 3rd phase of PI based on its indicators: convergence, synthesis, solutions.
- Selection 4 describes the 4th phase of PI based on its indicators: apply, test, and defend.
- Selection 5 describes those messages that reflect evidence of the 1st and 2nd phase of PI.

- Selection 6 describes those messages that reflect evidence of the 2nd and 3rd phase of PI.
- Selection 7 describes those messages that reflect evidence of the 3rd and 4th phase of PI.
- Selection 8 describes those messages that belong to cognitive presence but the user cannot discern the phase in which they belong.
- Selection 9 describes those messages that do not belong to cognitive presence.

4.1.2. The community's perception measure for a message.

The three main measures that represent the central tendency of a data set are: a) the mean, b) the mode, and c) the median.

a) The mean is the result of dividing the sum of the data in a data set by the number of pieces on the set.
b) The median is the number in an ordered set of data that is in the middle. If the number of the items in a data set is odd, then the median is the data point in the middle. If the number of the items in a data set is even, then the median is the mean of the two data points in the middle.
c) The mode is the most frequent number in the data set.

The median is relatively unaffected by extreme scores at either end of the distribution. The median concerning the mean and the mode is also relatively unaffected by skewed distributions and can be used with ordinal, interval, and ratio data. It cannot, however, be used with nominal data.

Garrison (2017) characterizes the PI phases as "developmental" and the transition from one phase to the next as "progression through the phases of inquiry". Garrison (2017) also refers to the individual cognitive development through each of the phases of PI as a progressive construction from the first phase (triggering event) of the cognitive presence to the fourth phase (resolution). Since the PI phases follow progressively the Practical Inquiry cycle, the students' codings for every message are considered to represent ordinal data and express progress towards the resolution phase. Therefore, the calculation of the median of students' codings for a message is considered to be the most appropriate measurement to represent the main tendency of the community for the PI phase of every message of the discussion (community's perspective). For this, if five students have coded a message then the community's perspective on this message is considered to be the median of each student's coding for the message.

4.2. Methodology

4.2.1. Participants

In this section we describe the experimental design, the data collection process and instruments used, the analysis process adopted and the results of the study performed with 59 students of the department of civil engineering educators of the School of Pedagogical and Technological Education, Greece, attending an undergraduate course on Educational Technology. The students were involved in an asynchronous discussion as a learning activity of the course. Following this activity, the students were involved in coding selected discussion messages by using the proposed coding schema.

4.2.2. Research Design

In the research design three steps took place: Step 1) Preparation phase and discussion activity, Step 2) Training on the content analysis process and Step 3) Students working on content analysis.

Step 1: Preparation phase and discussion activity.

Initially, two researchers (one was the course instructor) presented the CoI framework and the three key elements of the cognitive, social and teaching presence, and analyzed them with the students. Then, the students got involved in a one-week asynchronous discussion activity using Facebook, about a relevant topic to their curriculum. In this discussion three different groups of twenty students and one group of nineteen students were involved, each based on the lab schedule of the course. Each group didn't have access to the other three discussion forums, whilst the instructors participated to all four discussions.

Step 2: Training on the content analysis process.

Afterward, the researchers presented a series of ten asynchronous discussion messages to the students. They provided the students with the proposed schema and asked them to individually code these messages using the schema. Having completed this process, students and researchers discussed the PI phase they had chosen for each message and the reasons they had done so.

Step 3: Students working on content analysis.

Students analyzed the 'asynchronous discussion test' which was a part of 28 messages of one of the four group discussions conducted by the students. These messages were selected according to concrete criteria (see Chapter 4.3) in order to represent a genuine discussion without refinements.

In more detail, the content of an asynchronous discussion consisting of 118 messages was given to the students. The 28 messages which were chosen by the researchers (asynchronous discussion test), had been highlighted in the text of the discussion for the students to code them according to the coding schema. Lastly, an e-questionnaire through the application "Google Form" was given to the students where each question included the content of the message (one question for each particular message) accompanied by the selection options of the proposed schema. The messages of the particular discussion had also been coded by two researchers (experts).

4.3. Data Analysis

The data analysis process consists of two parts. Researchers' coding is considered as the objective perspective of the discussion based on CoI. The **first part** of the data analysis examines the agreement of each message's coding of each learner with that of the researchers. In this process various instances of disagreement among students and teachers but agreement among students are also explored. The **second part** of the data analysis examines the proposed measure for calculating the main coding tendency by the students' codings for every message. It also examines whether this measure is related to the researchers' coding and c) whether it can represent reliably the cognitive development of the community.

At Step 3, students were given a specific discussion to analyze using the coding schema proposed, the 'asynchronous discussion test'. The way the particular discussion was constructed is described below.

When the students completed the discussion activity of Step 1 (Preparation step and discussion activity), the two researchers and experts on CoI coded the discussion messages of the four groups according to the four PI phases, teaching presence existence and social presence existence.

The unit of analysis was the message as it is mostly used for CoI content analysis (Garrison et al., 2001; Anderson et al., 2001). Inter-rater reliability is the measure of the amount of agreement among multiple coders for how they apply codes to the text data. For measuring *researchers'* coding agreement, inter-rated reliability was calculated, according to the suggestions of Rourke, Anderson, Garrison, and Archer (2001). The research methodology adopted is the one proposed in Garrison, Anderson, and Archer (2001), by calculating Holsti's coefficient of reliability and Cohen's Kappa. After the initial coding and calculation of researchers' agreement, the researchers met to negotiate their disagreements to reach the researchers' *'final coding' (experts' coding)*.

Following the coding procedure, the messages were *organized* according to four criteria:

Criterion 1) the PI phase they belonged to:

Value: 1 for triggering event phase

Value: 2 for exploration phase

Value: 3 for integration phase

Value 4 for resolution phase

Criterion 2) the teaching presence existence

Value 1: the message reflects teaching presence

Value 0: the message doesn't reflect teaching presence

Criterion 3) the social presence existence

Value 1: the message reflects social presence

Value 0: the message doesn't reflect social presence

Criterion 4) agreement of two coders (experts)

Value 1: there was agreement

Value 0: there was not agreement

Thus, one message could be described as i.e., a) belonging to the second PI phase (Value 2), b) reflecting social presence (Value 1), c) not reflecting teaching presence (Value 0) and d) for this message there was agreement between the two researchers on their choice of PI phase (Value 1).

Then, 28 messages were selected from the discussion for composing the 'asynchronous discussion test'. These messages have been selected so that they meet all the criteria combinations. They were chosen to ensure the authenticity of the 'asynchronous discussion test'. This way, the research will examine whether messages with different content will be reliably coded through the proposed coding schema. Indeed, as Krippendorff (2011) suggested, '*measurement theory equates reliability with the extent to which variation in the measures can be explained by variation in the nature of the units or phenomena measured. In the absence of such variation, researchers would not know whether their measuring instrument can respond to differences among units should they occur'*.

The data collected from Step 3 is the students' codings. Additionally, both the *data* from each researcher's coding (prior to negotiation) and the data that resulted from their negotiation (final codings) were captured to further explore the relation between the researchers' (experts') and the students' codings.

Finally, the data captured and analyzed for answering the research questions are:

a) The experts' codings for the 28 selected messages, prior to negotiation.
b) The experts' codings for the selected 28 messages after the negotiation (final codings).
c) The 28 messages' content of the 'asynchronous discussion test'.

d) The students’ codings according to the proposed coding schema.

<u>First part of the data analysis:</u>

Initially, students' codings were compared with those of experts. To do so, the students' messages were adjusted to the four PI phases to correspond to the experts’ codings.

- In particular, selections 5, 6 and 7 of the coding schema were interpreted according to the heuristic that has been proposed (Garrison et al., 2001) in cases of coders’ disagreement ‘*code up (i.e., to the later phase), if clear evidence of multiple phases is present*’. This procedure is justified by noting *‘…higher levels of critical thinking, such as integration and resolution, borrow characteristics and process from previous phases’*. For this, the message which is coded with the selection 5 of the proposed coding schema reflects the second phase of PI, the message which is coded with the selection 6 of the proposed coding schema reflects the third phase of PI and the message which is coded with the selection 7 of the proposed coding schema reflects the fourth phase of PI. In compliance with these guidelines, presented are: a) the experts’ choices according to social presence existence (see Table 4, column 2), b) the PI phases that both experts chose in case of agreement (see Table 4, column 3), c) the experts’ disagreements (see Table 4, column 4) in coding messages according to PI phases, d) the experts’ choices according to teaching presence existence (see Table 4, column 5) and e) the students’ frequency for every coding choice for each message (see Table 4, columns 6, 7, 8, 9, 10, 11).

(A) Content Analysis by the instructors (experts): To address the research question, two experts who were also the instructors, coded the messages of the discussion according to the CoI framework and *specifically* a) to the four PI phases according to the cognitive presence indicators, b) to the social presence existence and c) to teaching presence existence.

Regarding the cases of disagreement between the experts, the 'coding up' heuristics were applied (Garrison et al., 2001) to result in a unique PI phase for each message for ensuring the reliability of the coding. This way, the experts resulted in the experts' final coding.

Out of 118 total messages that *compose* the full discussion, 26 were instructors' messages and 92 were students' messages.

<u>Assessing cognitive presence:</u> According to the experts' final coding, the first message was an instructor's message and the one that belongs to the triggering event phase. Thirteen (13) messages of the students' 92 messages, were coded by the experts as messages not belonging to the cognitive presence, 55 as messages belonging to the exploration phase, 21 as messages that belong to the integration phase, and finally three messages that belong to the resolution phase.

The inter-rater reliability analysis using the Cohen's Kappa statistic and Holsti's coefficient reliability was found to be Kappa = .84 ($p < .001$) and C.R. = .92 for the full discussion of 92 messages. This measure was achieved for all four PI phases, teaching and social presence, suggesting that the proposed coding schema is a reliable representation of the inner dynamics of the discussion.

<u>Assessing social presence:</u> From the 118 discussion messages, 33 messages reflected social presence.

<u>Assessing teaching presence:</u> From the 118 discussion messages, 28 messages reflected teaching presence.

(B) Content Analysis by the students: Regarding the expert's coding for the 28 messages of the 'asynchronous discussion test', the inter-rater reliability analysis using the Cohen's Kappa statistic and Holsti's coefficient reliability, was found to be Kappa = .54 ($p < .001$) and C.R. = .61.

Concretely, according to:

a) the experts' final coding based on the cognitive presence, there was one message that reflected the 1st phase of PI, 10 messages that reflected the 2nd phase of PI, 13 messages that reflected 3rd phase of PI, 2 messages that reflected 4th phase of PI and 2 messages that didn't belong to cognitive presence,

b) the experts' final coding based on the social presence, there were 11 messages which reflected social presence and 17 which did not,

c) the experts' final coding based on the teaching presence, there were 2 messages which reflect teaching presence and 26 which do not and

d) the experts' agreement on the PI phases, there were 9 messages in which, the researchers disagreed and 17 messages for which experts' coding was the same.

Firstly, each message's final *coding* in cognitive presence was compared to the one by the students. Cohen's Kappa statistics *for* students' and experts' agreement was calculated for the 28 messages of the test-discussion.

Afterward, the messages for which the experts disagreed in coding were isolated and Cohen's κ *statistics* was calculated again. This way "subjective" messages that originated from the CoI framework and not from the proposed schema design were excluded.

Then, every message for which the experts' coding differed to the coding chosen by the majority of the students was thoroughly *examined*.

<u>Second part of the data analysis:</u>

In the second part, what needs to be examined is whether the students' codings for every message tend to represent a reliable perspective. In this phase, descriptive and inferential statistics were used for quantitative analysis. For the experts' coding, the data from the *coding* prior to experts' negotiation were analyzed. The proposed schema was examined for the potential to value the discussion messages without the need for negotiation, as negotiation raises concerns about loss of data and specifically the viewpoints of each individual coder. For this, in case of experts' disagreement in a message, experts' coding was considered as belonging to selection 5, 6, or 7 of the coding schema.

Practical Inquiry is a process model, so attention to process in terms of ensuring cognitive development through the *PI phases* is essential (Garrison; 2011). In these terms, a 9 point scale is proposed in which the messages are rated (based on the coding that students have given according to the proposed coding schema selections) by attributing them a value of progress:

1. message which belongs to rate 1 is the message that the student had coded with the proposed coding option 9 (does not belong to cognitive presence),

2. message which belongs to rate 2 is the message that the student had coded with the proposed coding option 8 (belongs to cognitive presence but the user cannot discern the phase in which it belongs),

3. message which belongs to rate 3 is the message that the student had coded with the proposed coding option 1 (1st phase of PI),

4. message which belongs to rate 4 is the message that the student had coded with the proposed coding option 5 (elements of 1st and 2nd phase of PI),

5. message which belongs to rate 5 is the message that the student had coded with the proposed coding option 2 (2nd phase of PI),

6. message which belongs to rate 6 is the message that the student had coded with the proposed coding option 6 (elements of 2nd and 3rd phase of PI),

7. message which belongs to rate 7 is the message that the student had coded with the proposed coding option 3 (3rd phase of PI),

8. message which belongs to rate 8 is the message that the student had coded with the proposed coding option 7 (elements of 3rd and 4th phase of PI) and

9. message which belongs to rate 9 is the message that the student had coded with the proposed coding option 4 (4^{th} phase of PI).

First, the agreement between students' median rating for each message and experts' rating for each message is examined graphically and by calculating Kendall's τ correlation coefficient. The median rating is proposed to represent the community's perspective.

Finally, the students' median rating and the experts' rating for each message were converted to a 5 scale rating according to the four PI phases (and one category for the messages out of cognitive presence) as it is shown above. Then, the Cohen's Kappa and Holsti's coefficient were calculated to find the inter-rated agreement between the students' median rating and the experts' rating for each message.

The final step is to calculate the agreement *between* each student's rating and the main rating trend of the discussion messages (students' median rating) by calculating the Kendall's τ coefficient, and then to examine the correlation between a) the agreement of each student's rating to the students' group median rating for every message of the discussion and b) the agreement between the student's rating and the experts' rating for every message of the discussion. This process will investigate whether through the proposed way of calculating the community's perspective (students' median rating) for every discussion message the learners, whose coding deviates from the experts' coding, can be identified.

4.4. Results

Study 1.2. Research Question. Can the proposed coding schema reflect a reliable community perception for the cognitive presence of the discussion?

In the first part of the data analysis the agreement of each message's coding by each learner with that of the researchers is examined.

Firstly, each message's final coding in cognitive presence by the experts with the one by the students is compared. Validity can separate "true" variation from measurement errors. Experts' coding is considered as the objective data for measuring schema's validity, since researchers are experienced coders and they analyze the content based on CoI indicators for every PI phase.

After that, Cohen's Kappa statistic for students' and experts' agreement for the 28 messages of the test-discussion is calculated.

Afterward, the messages for which the experts *disagreed* in coding are isolated and Cohen's Kappa statistic is again calculated. The aim is to eliminate "subjective" messages that originate from the CoI framework and not from the proposed schema design.

Finally, every message, for which the coding of the experts differs from that of the students, is thoroughly examined.

For Cohen's Kappa, a widely accepted guideline for scale indication Landis, and Koch (1977), suggest five different levels of agreement, characterized "values < 0 as indicating no agreement,

0–0.20 as slight,

0.21–0.40 as fair,

0.41–0.60 as moderate,

0.61–0.80 as substantial, and

0.81–1 as almost perfect agreement".

In the 'asynchronous discussion test' of 28 messages, the Kappa value for the students' codings agreement with the experts' coding was *moderate* and averaged .46 ±.9. What needs to be mentioned is that agreement in test-discussion between the experts' coding before negotiation was estimated as moderate agreement (54%), whereas they disagreed.

Reliability in the analysis process of qualitative data requires the 'subjective interpretation of expressed responses relating to concrete experience in the physical world' (Giddens, 1984). The coders apply conceptual codes to these expressions, based on their interpretation of them. Indeed, typical examples are 'ambiguous' messages 52 and 131, where, the majority of students' coding differed to the experts' final coding, the two high-frequency students' coding selections coincide with either one or the other expert's coding (see Table 4, columns 4, 7and 8 for message 52 and columns 4, 8 and 9 for message 131). If messages that indicate differentiation between the two experts are isolated, to eliminate "subjective" messages and the Kappa value for experts' coding and each student's coding agreement is calculated, then the Kappa value between the students' codings and the experts' coding for messages 1, 14, 18, 19, 25, 33, 44, 60, 61, 64, 70, 72, 85, 87, 99, 111, 116, 129 and 132, averaged .62± .22.

A typical example of agreement between experienced coders has been referred in Garrison, Anderson, and Archer (2000), who reported a Kappa of 0.74 (substantial agreement), but as Rourke, Anderson, Garrison and Archer (2001) claimed, it was *'premature to declare a conventional level of acceptability'*. Another issue is that the present proposal requires interpretation of the latent content of the unit to reveal cognitive presence development. Ferguson (2009) states that, researchers with low '*interpretive burden'* demonstrate reliability and validity in their analysis of the extent of online interactions, but this '*meant that they had little to say about their quality'*. Consequently, the present proposal achieves a sufficient level of validity, ensuring the quality of the results, given the interpretive burden of latent content.

Discussion about the messages' coding:

Table 4 shows the experts' coding for the 28 messages of the "asynchronous discussion test" according to the:

(a) descriptors and indicators of the PI phases (column CP phase): value 1 if the message belongs to the triggering event phase, value 2 value 1 if the message belongs to the exploration phase, value 3 if the message belongs to the integration phase, value 4 if the message belongs to the resolution phase and value 9 if the message doesn't belong to the cognitive presence,

(b) the social presence (column SP): value 1 if the message reflects social presence and value 0 if the message doesn't reflect social presence,

(c) the teaching presence (column TP): value 1 if the message reflects teaching presence and value 0 if the message doesn't reflect teaching presence and

d) their coding agreement for each message's PI phase (column CP agreement): in case of disagreement the two phases chosen by the two researchers are presented.

Table 4 also, shows the students' percentage that coded each message as belonging a) to the 1st PI phase (column CP1), b) to the 2nd PI phase (column CP2), c) to the 3rd PI phase (column CP3), d) to the 4th PI phase (column CP4), e) to the 8th selection of the coding schema (the message belongs to the cognitive presence but not to a specific phase) (column CP8) and f) to the 9th selection of the coding schema (the message doesn't belong to the Cognitive Presence) (column CP9).

Table 4. *Experts' and students' codings for the asynchronous discussion test*

	Experts codings				Percentage of students who chose each presence and PI phase of the message %					
	SP	CP phase	CP agreement	TP	CP1 %	CP2 %	CP3 %	CP4 %	CP8 %	CP9 %
Msg. 1	1	1	YES	1	**88**	7	1	0	4	0
Msg. 14	0	2	YES	0	17	**58**	14	3	8	0
Msg. 17	0	2	3 OR 2	0	7	**55**	30	1	7	0
Msg. 18	0	2	YES	0	21	**42**	17	3	9	8
Msg. 19	0	2	YES	0	21	**33**	8	4	16	18
Msg. 25	0	2	YES	0	16	**36**	16	0	24	9
Msg. 33	0	2	YES	0	7	**53**	26	3	8	4
Msg. 44	0	3	YES	0	4	12	**68**	12	4	0
Msg. 52	1	2	2 OR 3	0	7	24	**36**	4	18	12
Msg. 60	1	2	YES	0	21	11	4	1	22	**41**
Msg. 61	0	3	YES	0	1	12	**67**	18	2	0
Msg. 64	0	2	YES	0	3	14	5	4	28	**46**
Msg. 70	1	9	YES	0	0	0	3	1	1	**95**
Msg. 71	0	3	9 OR 3	1	5	21	**46**	17	9	1

Msg. 72	1	3	YES	0	1	21	**38**	11	29	0
Msg. 85	0	3	YES	0	5	17	**41**	24	9	4
Msg. 86	1	3	3 OR 2	0	0	33	**36**	9	18	4
Msg. 87	1	9	YES	0	3	5	13	11	**32**	**32**
Msg. 99	1	3	YES	0	4	12	29	**54**	1	0
Msg. 104	0	3	3 OR 2	0	1	11	**51**	37	0	0
Msg. 111	1	3	YES	0	1	7	24	**67**	1	0
Msg. 116	1	2	YES	0	12	21	21	12	**26**	8
Msg. 117	1	3	3 OR 2	0	3	28	**32**	13	21	4
Msg. 118	0	3	3 OR 2	0	1	24	**53**	16	4	3
Msg. 129	0	4	YES	0	9	5	29	**49**	8	0
Msg. 130	0	3	3 OR 4	0	0	14	**45**	39	1	0
Msg. 131	0	3	3 OR 4	0	4	21	**36**	**36**	4	0
Msg. 132	0	4	YES	0	13	8	18	**58**	3	0

Message 60 is coded as belonging in the exploration phase by both experts but a high frequency of students coded it as not belonging to the cognitive presence (see Table 4, columns 3, 4, and 11). By examining the content of message 60 it has been found that it expresses a direct technical question not aiming on the cognitive subject and the majority of the students characterized this message as “no cognitive presence”.

Similarly, in message 64 the author answers directly to another student for a resource reference that they were looking for and although experts had coded it as belonging to the exploration phase, a high frequency of the students coded it as not belonging to the cognitive presence (see Table 4, columns 3, 4 and 11).

Message 87 is composed of two sentences. In the first sentence, the author addressed the first instructor by just stating agreement with a previous message. In the second sentence, they praised the second instructor for her help in the discussion (see Table 4, columns 3, 10, and 11).

In message 99, the first comprehensive effort for the final solution is expressed, so it is logical for the students to assume that it may belong to the resolution phase while experts had characterized it as belonging to the integration phase (see Table 4, columns 3 and 9).

In message 111, the author refers to message 99 and completes the original idea that has been previously expressed, so probably students concluded that this message may also belong to the resolution phase (see Table 4, columns 3 and 9).

In message 116, the author just adds an element (without offering a reason for the proposal) in a previous message. It is obvious that while for the experts the message belongs to the exploration phase (see Table 4, columns 3, 6, 7, 8, 9 and 10) however there is no specific tendency on the students’ coding, with 26% of them claiming that the message belongs to cognitive presence but they cannot recognize the phase.

Another observation is that in messages 14, 18, 19, 25, 60 there is a noticeable level of frequency of coding as a first phase (see Table 4, column 6) of cognitive presence (triggering event). In the first 4 messages, the students were trying to identify secondary issues/problems that needed to change to provide a partial solution to the initial problem 'triggering event'. Indeed, if the instructors had allowed further discussion of these secondary problems then these messages could be the triggering event for these sub-discussions to find resolution for these secondary problems. Message 60, as mentioned above, expresses a technical question.

In the second part of the data analysis, the median, as a measure for calculating the main tendency of the community for every message, is examined.

Students, whose ratings are close to that of experts', are considered capable to monitor the cognitive development of the discussion. Thus, for comparing the experts' rating with the students' rating at a glance, the students' rating of the asynchronous discussion has been evaluated by graphically depicting the data through box plots. For this, the research question examines if the main tendency of students' rating is similar to the experts' one, which would mean that students' coding data could reliably represent the cognitive presence development of the discussion. Thus, the relation between the students' median rating for every message with the experts' rating will be examined. If a high relation is found (which shows that the students' rating as a group is similar to the experts' perspective) then the next step is to find out whether the students' ability to monitor cognition can be revealed, using data gathered only from students' coding. For this reason, the correlation between: a) each student's rating correlation to the main tendency of the students' rating (data that derive only from students) with b) the student's rating correlation with the experts' perspective will be examined.

In Figure 12, the box plot for every message is presented. The box plots display the range of students' ratings for every message. In the center of the plot is the median which is surrounded by a box. The top and bottom of the box are the limits within which the middle 50% of observations fall (the interquartile range). Out of the top and bottom of the box there are two whiskers that extend to the most and least extreme scores. If the top or bottom whisker is much longer than the opposite whisker then the distribution is asymmetrical (the range of the top and bottom 25% of scores is different). The little circles above or below the box plots are students which are the outliers. The number next to the circle tells us which student is the outlier, i.e., a case that differs substantially from the main tendency of the data.

The values in axis Y are 1 to 9 according to the values that have been proposed in Data Collection and Analysis section. From Figure 12, it is obvious that there are messages with short box plots depicting that these students have a high level of agreement for the specific messages (e.g., Message 1, Message 33, Message 70). The level of the students' agreement varies for every message but the messages 72, 116, and 117 students hold quite different opinions. This is because these messages’ box plots are comparatively longer.

Additionally, in specific messages (e.g., Message 1, Message 33, Message 64) extreme outliers have been detected (a point beyond an outer fence is considered an extreme outlier).

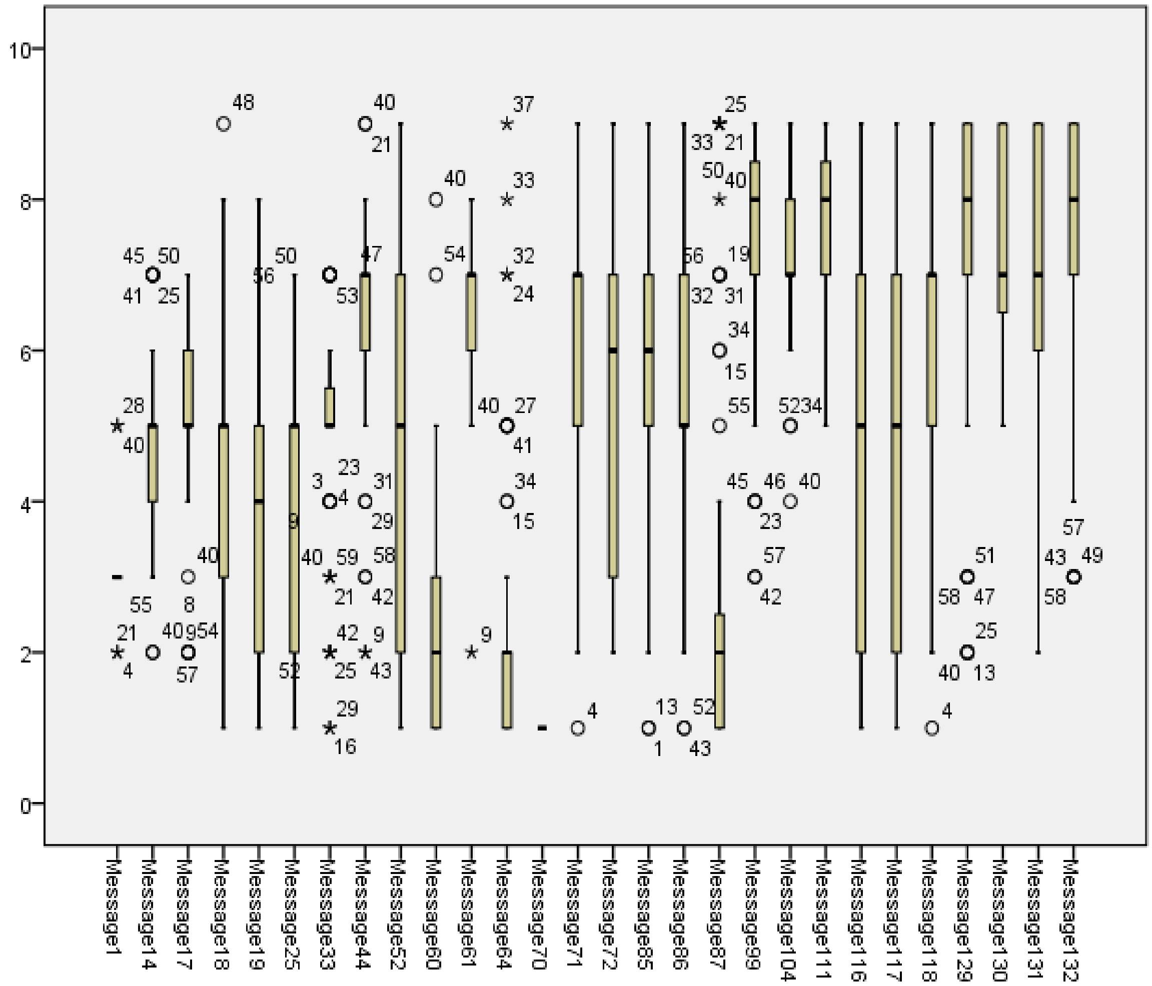

Figure 12. *Box plots for the rating of the messages given by the students*

But does the median of each message's student ratings, relate to experts' rating? At this stage, the median of students' rating for each message is being calculated and then compared to the experts' rating. Figure 13 shows the median of students' rating and the experts' rating for every message. Median is selected because it is relatively unaffected by extreme ratings (outliers) and can be used for ordinal data.

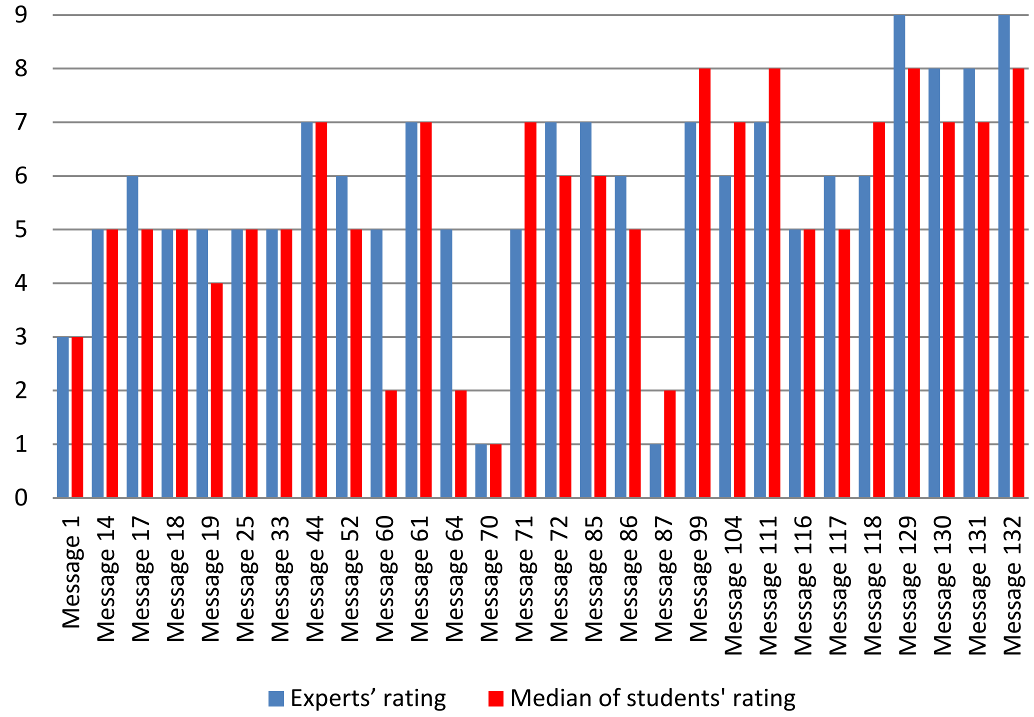

Figure 13. *Bar chart of the students' median rating and experts' rating for every message of the 'asynchronous discussion test'*

Figure 13 demonstrates that the medians of students' ratings are the same with the experts' rating in many messages (1, 14, 18, 25, 33, 44, 61, 70 and 116). In messages 17, 19, 52, 72, 85, 86, 87, 117, 118, 129, 130, 131 and 132, the median of students' ratings is very close to the experts' ones since they differ only by one rate. In messages 64 and 71, the difference increases to two rates and in message 60 to three rates. Thus, the main conclusion is that students' ratings are quite close to the experts' ones since there are no high differences between them for the majority of the messages.

The students' 9 scale median rating and the experts' 9 scale median rating will be converted to the 5 scale rating of according to the cognitive presence phases ((1) out of cognitive presence, (2) triggering event, (3) exploration, (4) integration and (5) resolution). The conversion follows the rules (Garrison et al., 2001) that have been explained in Section 4.3. The agreement between the two ratings is Kappa= .67 ($p < .001$) and C.R. = .75.

Then, the correlation between experts' rating and students' median rating is calculated to examine whether the students' rating (as a group) represents a reliable rating. To this end, the following steps are taken: (a) initially Kendall's statistic was calculated to check the agreement between the experts' and students' group median rating for every message, (b) each student's rating agreement with the students' group median rating for every message was calculated. Then, for every student, the Pearson correlation coefficient was used in order to calculate the relation between the Student-Community (students' group) agreement and the Student-Experts agreement.

For the first step, although Spearman's statistic is the most popular coefficient for ordinal variables, there is much to suggest that Kendall's statistic is actually a better estimate of the correlation in a population (Howell, 1997). The calculation of Kendall's statistic, in order to associate experts' rating to students' (as a group) rating of the messages, revealed a **significant high positive correlation** (Kendall's τ (28) =0.75, $p<.001$).

Then, aiming to examine whether a) the relation between each student to the students' main tendency rating (Student_Community_agreement variable) is correlated with b) the relation between each student's and the experts' rating (Student_Experts_agreement variable), the process followed is:

1. The Kendall's τ correlation coefficient was calculated for estimating the agreement between each student's and the students' main tendency rating for every message. In this way it is estimated the level of agreement between each student and the community's perspective for the cognitive presence phase of each message (Student_Community_agreement variable).
2. It was examined if the agreement between each student's coding and the main tendency of the students' coding (Student_Community_agreement variable)

increases when its relation to the experts' coding (Student_Experts_agreement variable) also increases.

To this end, the Pearson correlation coefficient was calculated to correlate the Student_Community_agreement variable with the Student_Experts_agreement variable for every student of the Community (group of students).

The calculation of Pearson's correlation coefficients revealed a **significant medium positive** correlation between students' distance from the main tendency of rating and students' rating association with the experts' rating ($r=.54$, $p<.001$).

This significance value ($p<.001$) reveals the probability of getting a correlation coefficient this big in a sample of 59 students with the same characteristics, if the null hypothesis was true (there was no relationship between these variables) is very low (close to zero in fact) and that as the degree of agreement of the student with the students' group increases, so does the degree of agreement of the student with the experts' rating.

The main conclusion is that the students as a group, with the use of the proposed coding schema, managed to rate the discussion, according to cognitive presence development phases, quite similar to the experts' rating choices and that as much as a student's rating was differentiated from the other students' (as a group) rating, this student's rating was less associated with the experts' rating. Moreover, it can be inferred that through the specific coding schema, the students as a group, managed to capture the cognitive presence development of the discussion similar to the most accurate one, performed by the experts.

In addition, there is evidence that through the proposed calculation of a single students' group rating for every message of the discussion the students that deviate from the "objective perspective" (as the experts' rating is considered) could be detected.

4.5. Discussion-Conclusions

This study proposes a peer content analysis approach for asynchronous discussions, based on CoI model, aiming at cultivating metacognitive skills.

The reliability of the coding schema involved in this approach has been assessed. According to the results, there is strong evidence of its validity based on the sufficient level of coding agreement between students and experts. Findings, coming from the qualitative analysis of the messages, provided some additional insight into how extraneous circumstances affect the students' coding choices and have to be investigated further to improve the validity of the content analysis results. For example, there is evidence that students tend to evaluate a message according to their estimation for its relevance to the learning object to the cognitive development of the discussion rather than the cognitive phase it reflects according to the proposed coding schema's selections.

Another important finding, based on the specific reliability results of this coding schema, is that the students' coding data provided strong evidence of its potential to represent the development of the discussion close enough to the 'valid' one (as per experts' coding) based on the inquiry cycle. Specifically the main tendency of the students' ratings were proved to be accurate enough (Kappa=.67) to reveal the potentiality of the proposed measure.

Additionally, students' coding data, gathered through this schema, have the potential to correlate with students' ability to monitor the discussion. Specifically, students' agreement with the group's coding was positively correlated in coding agreement with the experts' perspective ($r=.54$, $p<.001$) which is considered to be reliable.

The study's cumulative results pave the way to further research; the development of a LA visualization tool, based on the CoI content analysis framework that will open peer content analysis data to learners. In particular, the aim is to visualize the learners' perspective for the development of the community's cognitive presence during the discussion, as well as the cognitive presence development level a) of each particular learner according to the peers' perspective and also b) the perspective of each user for the cognitive development of the discussion. Through this proposed coding schema, the intention is to improve students' metacognitive abilities such as monitoring and regulating an effective inquiry in the context of the community they participate in, contributing both to their own and their peers' progress.

A critical aspect is the capability of the tool to detect the level of metacognitive dimensions as the 'monitoring of cognition' of each student, based on data derived mainly from students without instructors' intervention. In this line of research, a first aim is to further examine ways of reaching higher levels of validity, based on the qualitative analysis of the 'ambiguous messages' that has been deducted in the present study. A second aim is to thoroughly examine learners' variables that connect to the CoI model for the personalization of an online peer content analysis tool which will support visualization through LA techniques to cultivate metacognitive skills.

5. PHASE 2. STUDY 2.1: ADAPTABILITY VARIABLES FOR ADVICE'S VISUALIZATIONS

5.1. Introduction- Research Question

In the literature different sets of measurements have been proposed based on characteristics of internet communities built around social media to assess the engagement of the members within the community (Koohang et al. 2010). Some of the most representative metrics include the traffic among the members, their activity by the content area, the sessions to which the members are engaged, and a scoring about the influence of their involvement (Qiany et al. 2014). The metrics estimated for student communities can also provide valuable information on the assessment of factors like teaching, cognitive and social presence of the class.

Currently, the majority of studies on CoI assess the development of an asynchronous discussion according to the three presences but just a few have attempted to measure an individual's critical thinking skills development through a discussion forum (Perkins & Murphy 2006; Corich et al., 2012).

Based on the above observations, the present study focuses on: (a) the cognitive contribution; and (b) the individual participation of the learner as individual measurements in the context of the CoI theory aiming to use them as adaptability factors in order to stimulate the learners' reflection. In particular, the research question of this study is:

Research Question: Are there variables within the Communities of Inquiry that represent the behavior of the individual learner?

5.2. Methodology

In (Papanikolaou et al. 2014) a design rationale for constructivist pre-service teacher training on TEL was proposed, based on a view of teachers as designers of innovative content working individually and collaboratively, discussing and interacting with the instructor and their peers. Throughout the course, students work individually and in groups, and communicate through asynchronous Forums, beyond the class time.

Especially asynchronous forum interaction is organized in two stages: (a) at the first stage an introductory activity was proposed asking each student to comment on specific advantages and disadvantages of various WebQuests (a list of advantages and disadvantages was proposed) (Forum 1) and (b) then at a next stage students working in groups used the asynchronous Forum (Forum 2) to discuss the design and implementation of a technology-enhanced course.

The first stage aimed at familiarizing with asynchronous interaction around an educational goal. In this case the educational goal was the exploration of the inquiry-oriented instructional approach of WebQuests from various perspectives. In order to facilitate students' participation, various advantages and disadvantages were proposed as well as the URLs of specific paradigms of WebQuests. Moreover, as dealing and interacting with learning content during the learning process is considered to cultivate awareness and reflection (Boud & Walker., 1998; Janson, 2014), complementary learning content was also provided such as presentations, manuals, papers, and specific web resources.

In the second stage, the forum functioned as a transcription of the evolution of each group's design choices. Students had to progressively design a technology-enhanced course comprised of discrete learning activities of various types

(Laurillard, 2013) integrating digital resources and objects developed with Web 2.0 technologies, aiming at various knowledge processes based on the New Learning framework (Kalantzis & Cope, 2012).

5.2.1. Participants

The above rationale guided a six-month course on Technology Enhanced Learning, provided by the School of PEdagogical and Technological Education, Greece (ASPETE) in the context of a graduate certificate in Informatics at the Technological Educational Institute of Central Greece. The course took place between September 2013 and January 2014 with 80 students. The course builds on participants' content knowledge as it is their third year of specialization in Informatics.

5.2.2. Proposal

In the literature, different sets of measurements have been proposed based on characteristics of internet communities built around social media to assess the engagement of the members within the community (Koohang, 2010). Some of the most representative measurements include the traffic among the members, their activity by the content area, the sessions to which the members are engaged and a scoring about the influence of their involvement (Qiany et al., 2014). The measurements estimated for student communities can also provide valuable information on the assessment of factors like teaching, cognitive and social presence of the class.

Especially when a community of inquiry is considered, most studies exploring the degree of development of cognitive or teaching presence are based on data from questionnaires (such as CoI survey (Arbaugh et al., 2008)) or CoI qualitative content analysis (Garrison, 2000). A new approach recently proposed by (Shea et al., 2010) analyses system log data adopting social network analysis methods.

This study aims to correlate the instructor's design choices (teaching presence), which guide the selection of specific log data from students' interaction with content and peers, with data that derive from CoI qualitative content analysis. CoI qualitative data reflect each student's cognitive development.

5.3. Data Analysis

To address the research question, quantitative data from Forums 1 and 2 were used, as well as qualitative data from Forum 2 resulting from analyzing messages exchanged in the particular forum. The quantitative data relate to the students' participation in Forum 1and their behavior Forum 2. Specific measurements were calculated on log data of Forum 2 which reflect a score for students' participation in the community along with their cognitive presence within the forum (qualitative data). Qualitative content analysis of students' messages in Forum 2 was performed by two instructors participating in the course who were also experts in CoI content analysis. As far as content analysis is concerned, the unit of analysis was the message, so each message was characterized by only one cognitive presence phase. The messages that belong to the triggering event phase, which is the initial phase of the discussion, have been posted by the instructors so students' cognitive messages could belong only to one of the rest three cognitive presence phases.

The Forum 1 discussion task lasted for two weeks and was comprised of 69 messages whilst Forum 2 lasted for one and a half months and was comprised of 413 student cognitive messages. In the following paragraph, the measurements calculated are presented.

For students' involvement in the introductory asynchronous discussion task of Forum 1, we only considered if they participated or not, organizing students in two groups: students belonging in Group 1 are those who got involved both in Forum 1 and Forum 2 task, whilst students belonging in Group 2 are those that got involved only to Forum 2 task.

Concerning Forum 2, several types of log data were gathered for each student reflecting their involvement in the particular discussion task.

5.3.1. Individual Variables' Calculation

For students' involvement in Forum 2, the following variables were considered:

Quantitative analysis

- **student participation** in the discussion is calculated by:

*s_participation= a*Forum_view_threads + b* Forum_view_discussion +c* Forum_add post* (1)

where:

(a) *forum_view_threads*: factor reflecting how many times a student has viewed the Forum threads,

(b) *forum_view_discussion*: factor reflecting how many times a student has viewed the discussion Forum,

(c) *forum_add_post*: factor reflecting how many times a student has added a post.

The a, b, c weights reflect each factor's importance for the particular task.

Qualitative analysis. The messages of Forum 2 were initially analyzed and characterized based on the PI phase they belong to. Then the percentage of messages exchanged in Forum 2 at each of the three PI phases of cognitive presence was calculated. This analysis resulted in three variables that reflect students' cognitive presence development.

1. contribution to exploration: the percentage of messages that have been posted by a student and belong to phase 2 (exploration),
2. contribution to integration: the percentage of messages that have been posted by a student and belong to phase 3 (integration),

3. contribution to resolution: the percentage of messages that have been posted by a student and belong to phase 4 (resolution)
4. cognitive progress reflecting the student's level of development from the second phase of exploration until the final phase of resolution taking the following values:
    (a) Level 1: The student's messages belong only to exploration or integration phase.
    (b) Level 2: The student's messages belong to two discrete phases showing that s/he moved from one phase to another such as from exploration to integration or from exploration to resolution (without posting messages that belong to integration phase) or from integration to resolution.
    (c) Level 3: The student's messages belong to three phases showing that s/he moved from the exploration to the integration and then to the resolution phase.

5.4. Results

Study 2.1. Research Question. Are there variables within the Communities of Inquiry that represent the behavior of the individual learner?

Contribution to every phase of Cognitive Presence

Analyzing Forum 1 log data, two groups of students emerged, those who participated in Forum 1 (Group 1) and those who didn't (Group 2). Aiming at investigating whether there was any difference between the two groups of students, a two-way analysis of variance (ANOVA) for mixed design was performed on the following dependent variables:

- contribution to exploration variable for phase 2 of cognitive presence,
- contribution to integration variable for phase 3 of cognitive presence,
- contribution to resolution variable for phase 4 of cognitive presence

The difference between the two groups on the cognitive progress dependent variable was not calculated because this was an ordinal variable.

Initially, from the means plot of the variables (Figure 14) it is obvious that the means vary between the two different groups of data (Group 1 and Group 2).

Figure 14 presents a statistically significant interaction between students' involvement in Forum 1 and the three types of their contribution, which was also demonstrated by the two-way ANOVA. [F (2, 138) =3.31, p=.04, η^2=.046]. In particular, involvement in the asynchronous discussion task has the opposite effect between Group 1 and Group 2 for the three types of contribution. Concretely, Group 2 has achieved a higher contribution to the exploration phase than Group 1, but as far as its contribution to integration is concerned, this has considerably lower levels than the relative contribution of Group 1. The same stands for the resolution phase although with lower values. This makes Group 1 looks like a more mature group in the discussion process.

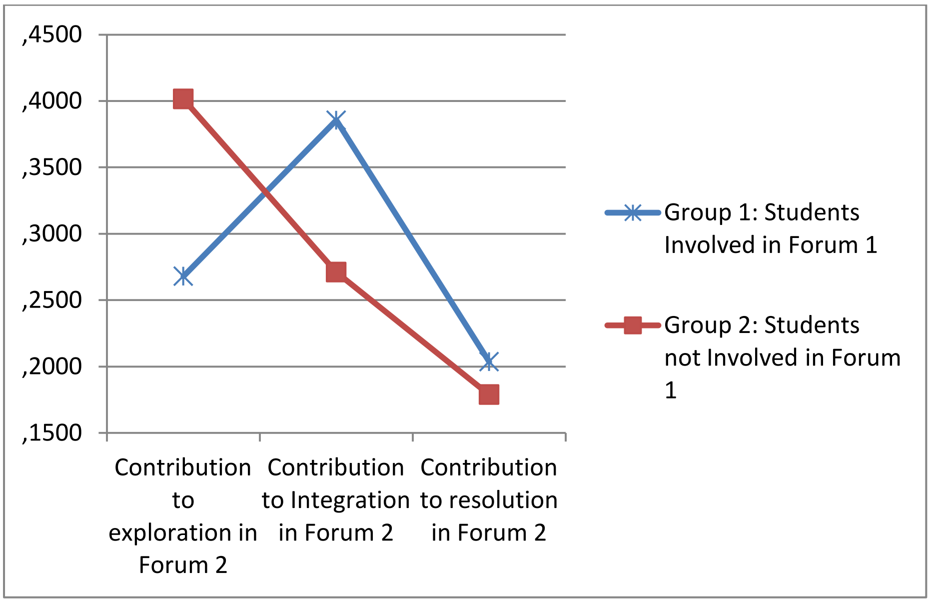

Figure 14. *Means plot shows means of contribution to exploration, contribution to integration and contribution to resolution for Group 1 and Group 2*

Then, to break down this interaction between the IVs, the simple main effects were calculated. Specifically, three one-way ANOVAs were performed on each of the three types of students' contributions at Forum 2, testing the effect of involvement in the introductory discussion task of Forum 1.

Table 5. *One-way ANOVA results for students' involvement in Forum 1 discussion task*

Variables	N	Mean Group 1	Mean Group 2	Std. Deviation Group 1	Std. Deviation Group 2	F	Sig. (p)
Contribution to exploration	71	.27	.40	.33	.16	F(1,69)= .17	.03
Contribution to integration	71	.39	.27	.34	.36	F(1,69)=1.75	.19
Contribution to resolution	71	.20	.18	.31	.35	F(1,69)=0.90	.77

Based on the results appearing in Table 5, a significant effect of students' involvement in Forum 1 on Contribution to exploration in Forum 2 was observed with Group 2 having a higher contribution. There was not a significant effect of students' involvement in Forum 1 task on a) student Contribution to integration and b) student Contribution to resolution in Forum 2 ($p > .05$).

Concluding, although there is no statistically significant difference between the two Groups to Contribution to integration or resolution, the interaction between the two Groups that has been earlier observed, provides important evidence about the potential of Group 1 over Group 2 in promoting its students' cognitive development.

Participation

To answer the research question, regarding the participation variable, Pearson correlation coefficients were calculated to correlate the Participation quantitative variable of Forum 2 reflecting students' behavior (s_participation variable) to qualitative ones reflecting student contribution to the PI phases (contribution to exploration, contribution to integration, contribution to resolution variables).

Spearman's rho correlation coefficients were then calculated to examine the relation of Forum 2 (s_participation variable) quantitative variable with qualitative ones that reflect cognitive progress.

The calculation of Pearson's correlation coefficients revealed:

(a) a significant medium positive correlation between student participation in Forum 2 (s_participation variable) and contribution to resolution in Forum 2 variable ($r=.45$, $p<.001$),

(b) a statistically significant but weak positive correlation between student participation in Forum 2 and Contribution to exploration ($r=.27$, $p<.05$) and

(c) a statistically significant but weak positive correlation between Forum 2 participation and Contribution to integration ($r=.24$, $p<.05$).

(b) statistically significant positive and medium correlation between the student participation in Forum 2 participation (s_participation variable) and the students' cognitive progress (Spearman rho (71) =.57, $p<.001$).

It is quite encouraging that quantitative data are significantly correlated with qualitative data. In particular, it is worth noting that participation in the learning design discussion task is medium correlated to contribution to the resolution which is the most demanding phase of the PI cycle.

Moreover, the high correlation of cognitive progress with the participation and study variables provide evidence about the importance of students' active involvement in the learning design discussion task (in terms of posting messages, viewing peers' messages but also study of various types of content) in their cognitive development according to the CoI model.

5.5. Discussion-Conclusions

Aiming at investigating the added value of such an orchestration for students' cognitive development quantitative with qualitative data was combined for analysis. Initially, the students were divided into two groups: Group 1 that participated in the introductory discussion task and Group 2 that didn't. The evidence showed that each of these groups has a considerably different contribution to the various phases of the PI process reflecting students' cognitive development. Especially, it was observed that students of Group 2 have a significantly higher contribution to exploration but they have lower results than the students of Group 1 to the integration and resolution phases. This clear trend should be further investigated in various learning contexts.

Moreover, quantitative log data are strongly correlated to content analysis data, especially for cognitive progress where medium and large positive correlation was found.

Results provide evidence about the potential of teaching presence and especially of the design and organization of asynchronous forum tasks, as an important factor affecting students' cognitive presence development. Such design decisions can impact students' cognitive presence development both at community and individual level. For this research, community's cognitive presence through individual variables was examined.

Various log data coming from students' interaction (with content or peers) through a discussion task were used to assess the individuals' cognitive development along with qualitative data coming from content analysis. The development of such measurements is worth noting that it may have a significant value for the assessment of the individuals' cognitive development within the community. This is an issue that worth to be further explored.

6. PHASE 2. STUDY 2.2: COGNITIVE CONTRIBUTION AS ADAPTABILITY VARIABLE FOR ADVICE'S VISUALIZATIONS

6.1. Introduction-Research Question

According to the results of Study 2.1, four individual variables reflecting the behavior of learners within the Communities of Inquiry have emerged. The first variable is the learner's participation, which results from quantitative analysis and derives from community-independent data. The other three variables reflect the learner's contribution to each phase of the cognitive presence except for the first phase, the triggering event that initiates the topic of the discussion.

Since participation is a variable that has already been studied in several surveys and its relationship with the CoI and in particular with the cognitive presence has been emerged, this research focuses on the innovative proposal of the learner's contribution to the community for each phase of the cognitive presence.

Based on the above observations, an individual qualitative variable is proposed. This variable is called "cognitive contribution" and reflects the learner's contribution to the discussion which includes the three last phases of the cognitive presence. In particular, the main research question is:

Research question: Is there a relationship between learners' monitoring of the inquiry process and their cognitive contribution?

6.2. Methodology

6.2.1. Participants

The study performed to 41 students of the Department of Civil Engineering Educators of the School of Pedagogical and Technological Education, Greece, attending an undergraduate course in Educational Technology.

6.2.2. Research Design

Students and teachers participated in one asynchronous discussion at two lab sessions of two hours each submitting 213 messages in total. Afterward, all these messages were coded according to the four phases of PI by two researchers who were also experts in content analysis. Inter-rater reliability was computed using Cohen's Kappa. After negotiation, the experts agreed to the same message coding. Then, the students participated in a training session on content analysis in which they were asked to code 30 messages of the above discussion according to the four phases of PI using the coding schema proposed in the Study 1.2. The particular messages were selected by the researchers so that the four phases of the PI process to be covered. Then, the students' codings were converted by the researchers to correspond to the four phases of cognitive presence with a specific process that is described in the Study 1.2, to adjust to experts' codings. In this way both experts' and students' codings are structured in the four phases of PI.

6.3. Data Analysis

The data collected and analyzed are:

Experts' coding: Analyzing the content of the asynchronous discussion messages based on the four phases of PI, the experts resulted in a final coding for all discussion messages.

Learners' coding of the 30 messages of the discussion:

Aiming to assess student's ability to coding i.e., the relationship between each student's coding with the experts' one was measured. The experts' coding of the discussion is considered as the most "objective" and independent of the proposed coding schema.

Student's and experts' correlation was chosen over student's and experts' agreement as although students may share the experts' rationale, they perceive the discussion evolution differently. So, Kendall's τ was chosen, as it does not treat all misclassifications equally, for the learner_monitoring variable.

6.3.1. Proposal

Based on the experts' coding of each message the learner_cognitive_contribution variable was calculated. This variable reflects each student's cognitive contribution to the asynchronous discussion.

Using variables that correspond to the three phases of PI (exploration, integration and resolution) with various weights as proposed in the Study 2.1., the learner's cognitive contribution variable is proposed to be calculated as:

Learner_cognitive_contribution= 0.15*contribution_to_exploration + 0.35*contribution_to_integration + 0.5*contribution_to_resolution (1)

where:

1. *contribution to exploration*: the percentage of student's discussion messages from the total messages of the community of the exploration phase based on the experts' coding,

2. *contribution to integration*: the percentage of student's discussion messages from the total messages of the community of the integration phase based on the experts' coding,

3. *contribution to resolution*: the percentage of student's discussion messages from the total messages of the community of the resolution phase based on the experts' coding.

The weights in the form (1) reflect the value of the exploration, integration, and especially the resolution phase to the discussion, since, as the phases evolve, they require more cognitive effort.

This variable's nature is both individual and collaborative since, although it reflects the individual student's effort, it is calculated based on the messages sent by the student in relation to the messages of the community. Moreover, this variable has a qualitative dimension as these messages are measured according to the Cognitive Phase they belong to. Given the fact that cognitive presence is claimed to focus and assess critical thinking processes, it is assumed that the particular variable reflects learner's critical thinking.

6.4. Results

Study 2.2. Research question. Is there a relation between learners' monitoring of the inquiry process and their cognitive contribution?

Analyzing the content of the messages of the asynchronous discussion, the experts resulted in a Cohen's κ agreement: κ =.96. After negotiation there was total agreement.

According to the experts' coding, both discussions had (a) 172 messages belonging to cognitive presence from which 89 messages belong to the exploration phase, 67 messages belong to the integration phase, and 16 messages belong to the resolution phase, (b) 14 messages belonging to Social Presence and (c) 27 messages belonging to Teaching Presence.

The learners' monitoring variable mean is Kendall's $\tau = .51$ with Standard Deviation = .16 meaning that, on average, there is a significant positive moderate correlation between experts' and each student's coding.

To answer the research question, the Pearson's correlation coefficient between the learners' cognitive contribution variable and learners' monitoring on the discussions was calculated. The results revealed a significant medium positive correlation between learners' cognitive contribution variable with learners' monitoring and the significance value is less than .001 ($r=.502$, $p<.001$). Hence, the findings highlight the genuine moderate positive relation between learners' cognitive contribution and their ability on monitoring the inquiry process.

The degree to which learner's cognitive contribution predicts their monitoring skills was assessed based on a Linear Regression analysis between the learner_cognitive_contribution (predictor variable) and the learner_monitoring (response variable) calculating the statistical relationship of the two variables.

The mean cognitive contribution variable is calculated .07. A significant regression equation was found ($F(1, 39) = 14.264$, $p<.000$), with an R^2 of .249. Students' predicted monitoring variable is equal to .297+1.703 (cognitive_contribution variable). Students' monitoring measurement increased 1.703 units for each unit of cognitive_contribution measurement.

There might be many measurements that can explain this variation, but our model, which includes only cognitive_contribution measurement, can explain approximately 25% ($R^2=.249$) of it. On top of that, the b coefficient ($\beta=1.703$, $p<.000$), which is the value for the regression equation for predicting the monitoring measurement from the cognitive contribution variable, is statistically significant and highlights the value of the results.

6.5. Discussion-Conclusions

This research study performed to identify quantitative variables that reflect qualitative features of a community of inquiry as those of the monitoring element of metacognition and of critical thinking. Study 2.2 has extended the Study 2.1 (Chapter 5) to propose variables about metacognitive skills. These variables could be visualized to learners and promote the cognitive development of the community and also learning outcomes.

The results indicate a significantly moderate positive correlation between critical thinking performance and the ability of monitoring the inquiry process. Moreover, they indicate that cognitive contribution could be used as a parameter for estimating the learners' metacognitive monitoring ability. This type of information can be extremely valuable to be provided to the learner allowing them to compare their or the total community's perspective for the discussion cognitive development with those perspectives of community groups of students with specific critical thinking skills. In the next phase the particular variables will open to students in the proposed LA tool and the variables' influence on the cognitive development of Communities of Inquiry will be assessed during an asynchronous discussion in real educational conditions.

7. PHASE 3. MAIN STUDY: DEVELOPMENT AND EVALUATION OF ADVICE

7.1. ADVICE overview

ADVICE is a LA visualization tool which is currently implemented in the discussion forum of INSPIRE*us* (Papanikolaou, 2015). It captures both quantitative and qualitative data such as each student's perspective for the type of their own and peers' contributions to the asynchronous discussion. The tool analyzes these data in real-time, and presents to the user (student or instructor) adaptable visualizations of the discussion's cognitive progress, according to the PI. In this way, each student has the opportunity to co-interpret the discussion data. The ADVICE visualizations are adaptable, allowing users to choose the visualization parameters from a preset list. In this way, the student can reflect on various users' subgroup perspective for their own or their peers' cognitive development.

From student's view

As students participate in an online asynchronous discussion through the forum of INSPIREus, ADVICE, augmenting the particular forum, provides them with specific capabilities allowing them to code the messages posted on the forum and to access specific visualizations that enable them to reflect both on their own and the discussion's cognitive development.

a) ADVICE forum interface: Message Coding

The tool requires from the student, composing a message, to code it before posting it to the forum. In this way, every student's message has at least been coded by its author.

Additionally, each forum participant (student, instructor) is able to characterize every message posted on the forum, including their own messages. Thus, for every student's message, a menu is available from which any user can select one of the nine codings according to the ADVICE coding schema (see Fig. 15, Message 3) reflecting the development of a discussion based on the discrete and mixed phases of PI in which the studies in Phase 1 resulted.

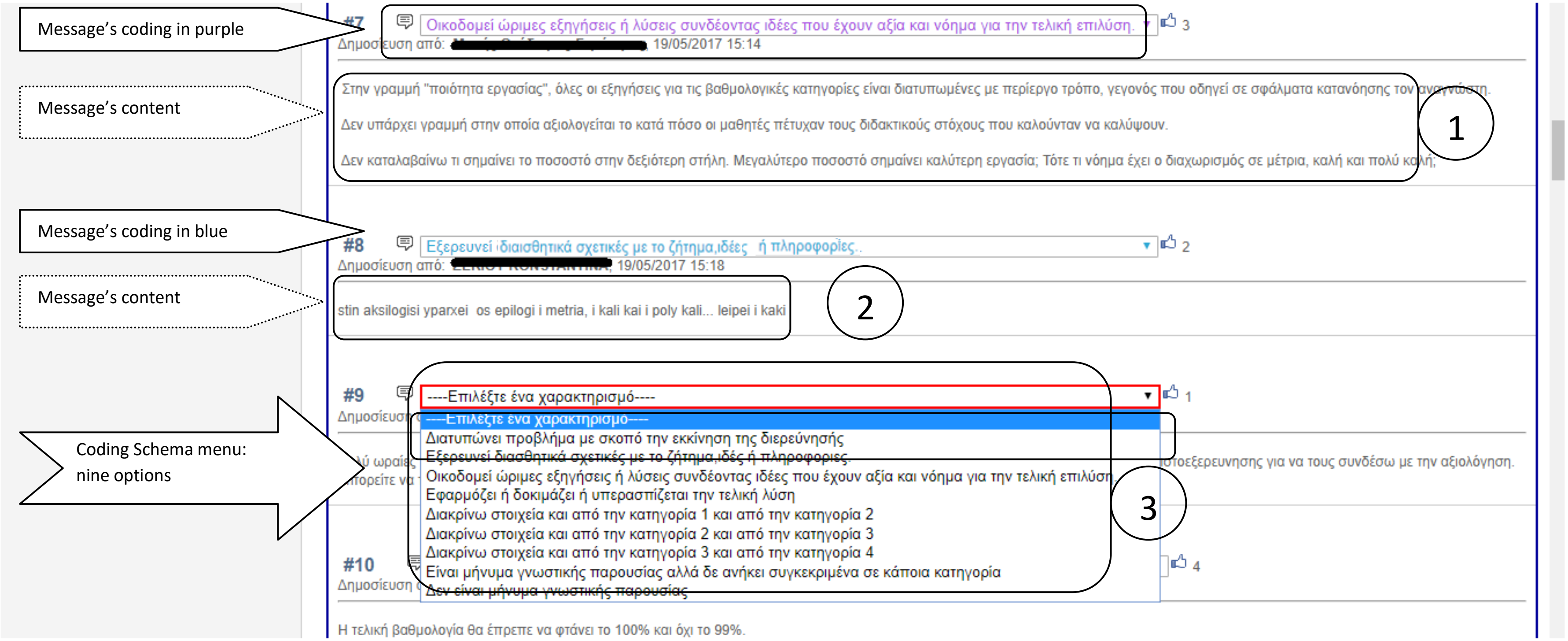

Figure 15. *ADVICE forum interface*

b) Adaptable Visualizations

While navigating to the ADVICE forum, the participant is also able to view visualizations reflecting qualitative information about their own contributions to the forum but also about the discussion progress based on the phases of PI. In particular, the visualizations depict the community's perspective for a) each subgroup's cognitive development, b) the community's cognitive development, and c) individual cognitive contribution to the discussion, accordingly. The first two are also adaptable allowing the user to select among various groups of users based on specific measurements like contribution, participation, and learning style.

The particular visualizations and the way they have been calculated and depicted are presented in detail in sections 71.2.1 and 7.1.2.2.

ADVICE design rationale

The ADVICE design rationale is described based on the LA process proposed by Chatti et al. (2012). According to the specific reference model, the overall LA process is often an iterative cycle carried out in three major steps that are described below: (1) data collection and preprocessing, (2) analytics and action, and (3) post-processing.

1. Step 1: Data collection and preprocessing

The first step of the LA process is to collect appropriate data for the successful discovery of useful patterns. The two critical points of this step are a) the appropriate selection of raw data and b) the appropriate pre-processing of these data in order to be transformed into a format that can be used as an input for a specific LA method.

Data Collection*.* In particular, ADVICE collects a) data from INSPIRE*us*' log files (quantitative data) and b) qualitative data from students' and instructors' coding provided for each message on the forum. Using statistical analysis and developing appropriate calculations, the tool results in key measurements such as student's participation, cognitive contribution, and learning style, which are used in the next step as adaptability sources (see Table 6).

Table 6. *The data captured and analyzed by ADVICE*

Qualitative Data	Quantitative Data
instructor_coding	message_author
student_coding	time_spent_forum_view_threads
	time_spent_forum_view_discussion
	time_spent_composing_message
	student_learning_style

Data preprocessing: *calculating messages' codings*. ADVICE captures the codings selected by the users (teacher or student) for each message. In case that the discussion is moderated by one teacher then their coding is considered as the 'expert coding'. Otherwise, the 'expert coding' results from the agreement procedure between the teachers in which "coding up" heuristics are applied (Garrison et al., 2001).

Based on the "coding up" approach, in cases that a message seems to belong to *multiple phases of the PI process, then the later phase is selected,* ensuring the reliability of the coding. Consequently, according to this procedure, if two teachers have chosen different but adjacent PI phases for a message, then the final phase that ADVICE results is the later phase. In case that the two codings don't reflect adjacent phases (e.g., one teacher chooses the first phase and the second chooses the third one), then there is a disagreement and the message does not receive an "expert coding".

Accordingly, *if the users are students* then the message's codings calculated as the median of all the codings provided by students as it is proposed on the Study 1.2.

This median is presented in the adaptable visualizations of ADVICE (see section 7.1.2.1) as “community’s perspective” for the PI phase of the message.

Data preprocessing: *calculating measurements for formulating student groups.* The cognitive contribution and participation of each student to the discussion change during the discussion. Participation reflects the time that the student has devoted to the discussion activity and the cognitive contribution attributes the cognitive quality of the student's posts in the discussion. Participation is a quantitative measurement that is estimated by INSPIRE*us* log files while the contribution is a qualitative measurement which is based on the view of the community.

Since there are indications of a correlation between cognitive contribution and the ability of coding messages (see Study 2.2) as well as between cognitive development and student participation in the discussion (see Study 2.1), participation and cognitive contribution measurements were considered as appropriate parameters for organizing subgroups of students. The way that ADVICE calculates these variables is presented thoroughly below.

The calculation of the cognitive contribution variable has been presented in Study 2.2 where it resulted from the combination of the variables proposed and investigated in the Study 2.1: the contribution in exploration, the contribution, and the contribution resolution phase. The Cognitive Contribution variable is also used in ADVICE by adding the triggering event phase as well as providing to the teacher a choice of weights for each phase, thereby allowing the teacher to focus on whatever PI phase they want.

Cognitive Contribution variable. The cognitive contribution of each student is calculated through the following equation:

*Student_contribution = a*contribution_to_triggering +b*contribution_to_exploration + c*contribution_to_integration + d*contribution_to_resolution*

(1)

where

1. *contribution_to_triggering*: the percentage of student's discussion messages from the total messages of the community of the triggering event phase based on the community's coding,
2. *contribution_to_exploration*: the percentage of student's discussion messages from the total messages of the community of the exploration phase based on the community's coding,
3. *contribution_to_integration*: the percentage of student's discussion messages from the total messages of the community of the integration phase based on the community's coding,
4. *contribution_to_resolution*: the percentage of student's discussion messages from the total messages of the community of the resolution phase based on the community's coding.

The a, b, c and d weights reflect each factor's importance for the particular task/course and can be modified by the administrator or the instructor of the asynchronous discussion based on the learning context.

Participation measurement. The system analyzes quantitative data in order to calculate for each student the measurement of their participation to the discussion based on the following equation:

*Student_participation= d*time_spent_forum_view_threads + e* time_spent_forum_view_discussion +f* time_spent_forum_compose_post* (2)

where

1. *time_spent_forum_view_threads*: factor reflecting how much time a student spends to view the Forum threads,
2. *time_spent_forum_view_discussion*: factor reflecting how much time a student spends to view the discussion Forum,

3. *time_spent_forum_compose_post*: factor reflecting how much time a student spends to compose a post.

The d, e, f weights reflect each factor's importance for the particular task.

Learning Styles measurement. INSPIRE*us* also records each student's learning style according to Honey and Mumford learning style model (Honey & Mumford, 1992) that recognizes four types of learners: Activists, Theorists, Pragmatists and Reflectors.

7.1.1. Step 1: Data preprocessing: formulating student groups

Thereafter, ADVICE results to ten specific groups of users based on the above data preprocessing (student's participation, cognitive contribution and learning style):

1. Community (all the students who coded even one of the messages of the discussion)
2. Instructors (maximum two instructors)
3. Students with high contribution (students whose cognitive contribution is above the average)
4. Students with low contribution (Students whose cognitive contribution is below the average)
5. Students with high participation (Students whose participation is above the average)
6. Students with low participation (Students whose participation is below the average)
7. Group of Activists
8. Group of Theorists
9. Group of Pragmatists
10. Group of Reflectors

7.1.2. Step 2: Analytics and Action

The "Analytics and Action" step refers to the various LA techniques of analysis and visualization, which are applied to the data in order to reveal hidden patterns, as well as to the actions taking place to this information such as monitoring, personalization, and reflection. The outcomes of this step are adaptable visualizations and production of the teacher's reference file as will be described below.

7.1.2.1. *Adaptable visualizations*

ADVICE currently provides three visualizations: a) two visualizations that show the cognitive development of the discussion according to PI allowing students to intervene and adapt them by selecting the source of data to reflect on or compare with and b) one visualization that shows the student's contribution to the discussion based on PI.

In the two adaptable discussion visualizations, the discussion overview area depicts data on users' codings of the asynchronous discussion messages (see Fig. 16 and Fig. 17). For each message of the discussion (X-axis), an indication of the median coding of the students and/or the instructors is provided. In the discussion overview area (see Fig. 16 and Fig.17) the values in the Y-axis range from 1 to 9, according to the values of the ADVICE coding schema. The values in the X-axis indicate the time sequence of the discussion messages.

The aim of the first adaptable visualization (see Fig.16) is to compare the cognitive development of specific user groups according to a specific group's perspective. For example, the student can choose to see the community's perspective for a) their own cognitive development and for b) the community's development. The question that is answered through this adaptable visualization is: "According to the community, how did I evolve cognitively in relation to my peers?"

The second adaptable visualization aims to compare the various groups' perspectives for the cognitive development of a specific group. As it is shown in Figure 17, the visualization design of the cognitive development provides the user with a variety of options, enabling them to observe the perspective of different groups about the discussion and the messages exchanged such as the user's perspective compared to the one of the community (see Fig. 17). The user is also able to choose the groups whose cognitive development the user wants to observe. Through the visualization in Figure 17, the student can compare their own with their peers' perspective for the cognitive development of the community and probably answer the question "Do I have a similar perspective to my peers for the cognitive development of the community?"

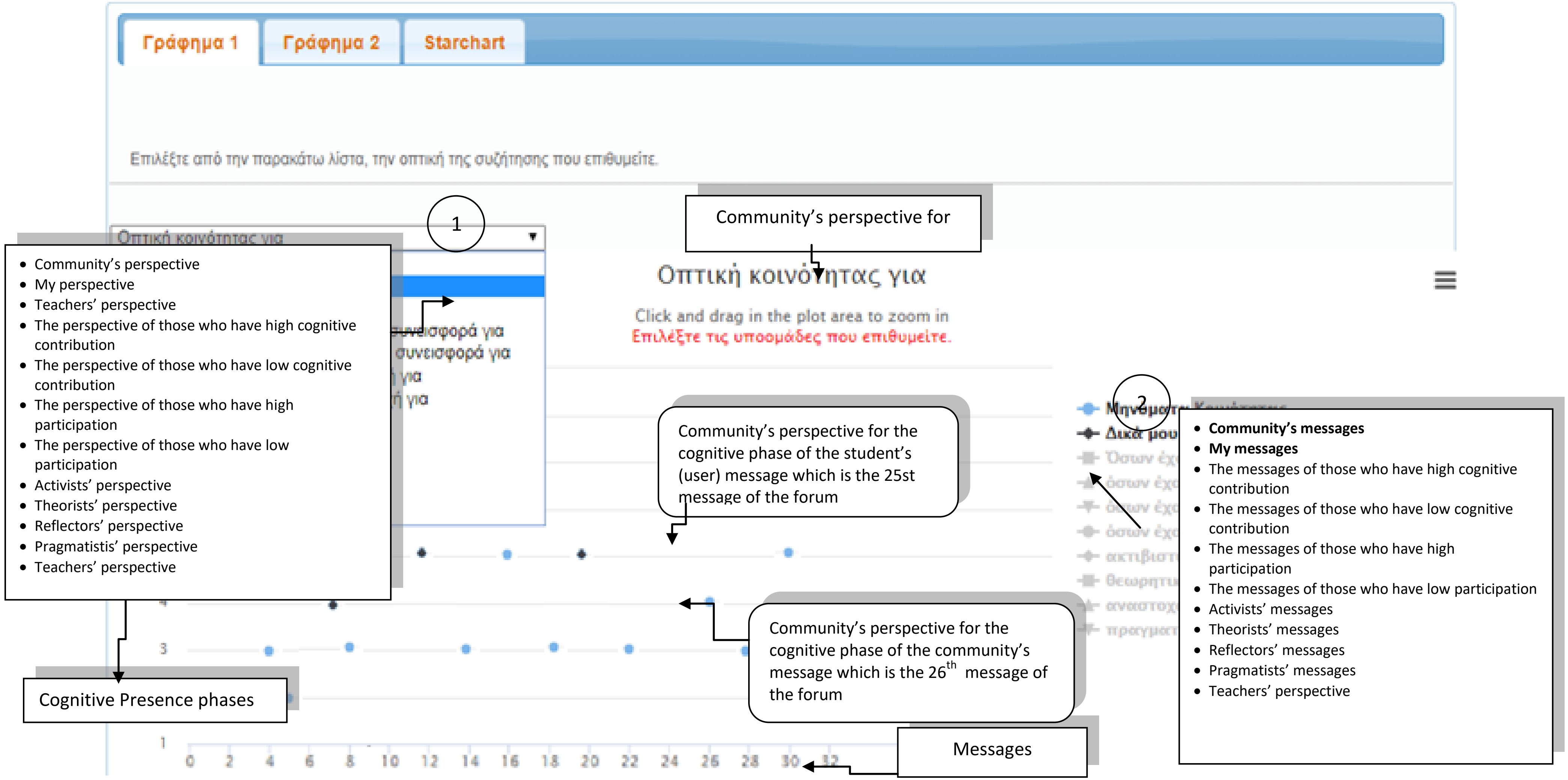

Figure 16. *First Visualization of the cognitive development of the discussion and adaptability options*

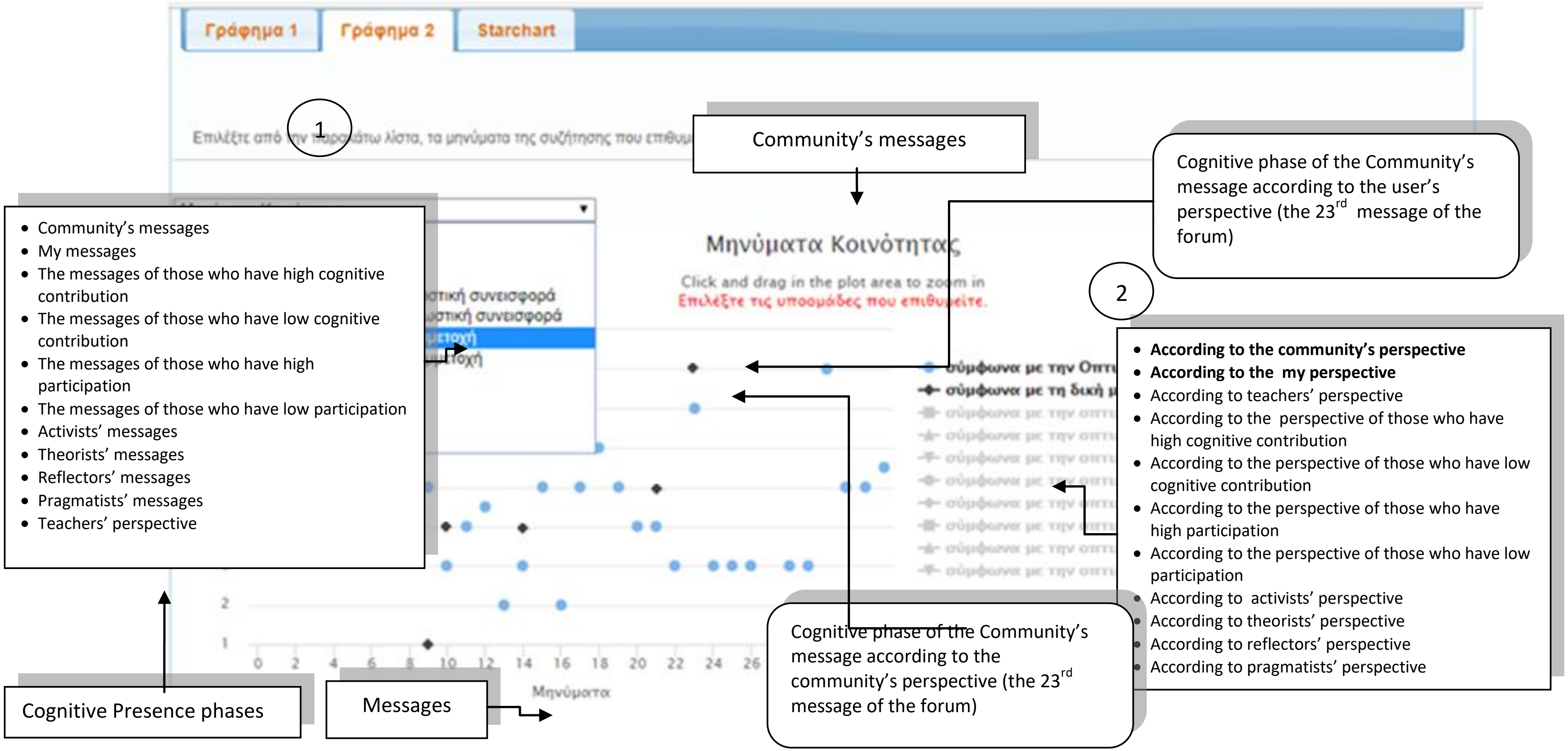

Figure 17. *Second Visualization of the cognitive development of the discussion and adaptability options*

7.1.2.2. *Visualization of the student's contribution*

To represent multivariate qualitative data like the contribution to each phase of the PI process, star chart visualization has been selected (see Fig. 18). Each axis represents a different variable, meaning contribution to a specific PI phase. In Figure 18 it is shown that the student has contributed most at the 2nd (exploration) phase of the PI

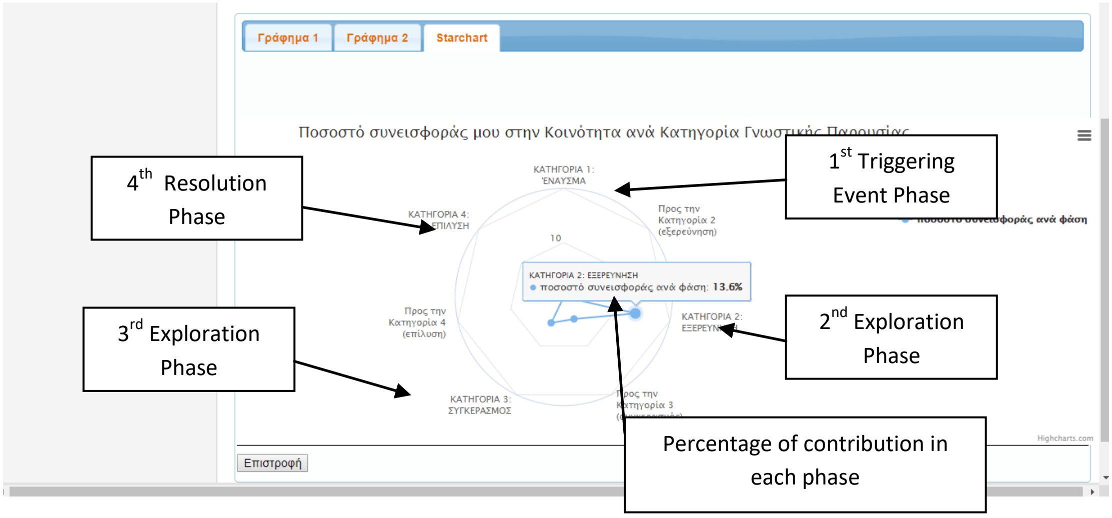

Figure 18. *Visualization of student's contribution to the discussion*

7.1.2.3. *Teacher's reference file*

Also, the teachers are able to download at any time, a reference file containing data for each student as well as for each message of the discussion. In this way, the teacher is able to have a detailed insight for each student and the discussion progress, while visualizations show only processed information per group of participants.

The reference file which is provided to the teachers, reports for every student the following data:

a) Student_raw_data: navigation time on the forum screen, navigation time on the discussion, number of posted messages, student's coding for every message of the discussion,

b) student_information: cognitive contribution, if the student's cognitive contribution is above or below the average cognitive contribution, participation to the discussion, percentage of the student's posted messages that have been coded from the community as not reflecting cognitive presence, percentage of the student's posted messages which according to the community's perspective reflect cognitive presence without reflecting specific phase, number of student's posted messages reflecting first phase of PI , number of student's posted messages reflecting the second phase, number of student's posted messages reflecting the third phase, number of student's posted messages reflecting the fourth phase, percentage of messages in which student's coding was an extreme value, percentage of messages in which student's coding was an outlier.

This way, the teachers are able to reveal information about specific behaviors of students e.g., "Who is the student with the most deviating codings?" or "Who is the student who has posted the most "non-cognitive presence" messages?".

Furthermore, the reference file reports data for every message: a) author, b) content, c) mean of students' codings, d) median of students' codings, e) average of students' codings, f) standard deviation of students' codings, g) interquartile range of students' codings, h) instructors' coding, and i) instructors' coding agreement.

The above information enables the teacher to identify specific behaviors such as the students' that post messages of large coding variation according to the community or teacher perspective.

7.1.3. Step 3: Post-Processing

ADVICE rational has resulted from the continuous process of the steps of the LA process model of Chatti et al. (2012). At the step of post-processing, the coding schema and the measurements that are used as sources for the adaptability options of the tool have already been evaluated. In the study presented below, ADVICE is evaluated in a real university context, to assess its usability and its potential for supporting student's reflection.

7.2. Introduction-Research Questions

This study aims to evaluate ADVICE from the point of view of students and to provide insights about students' involvement in asynchronous discussions using the proposed tool.

In particular, the following research questions will be attempted to answer:

Research Question 1: What is the accuracy of ADVICE?

Research Question 2: To what extent did students consider the ADVICE usable?

Research Question 3: To what extent did students consider that ADVICE promoted reflection during the discussion activity?

Research Question 4: Is the reflection promoted by ADVICE related to the students' performance through the discussion?

Reflection in the last research question refers to the three processes supported by ADVICE: a) coding messages, b) monitoring visualizations, and c) composing messages.

7.3. Methodology

7.3.1. Participants

ADVICE was used by 61 students in an undergraduate course on Technology Enhanced Distance Education of the Department of Civil Engineering Educators, at the School of Pedagogical and Technological Education, Greece. The students were involved in an asynchronous discussion as a learning activity of the course.

7.3.2. Research Design

Initially, the CoI framework, the PI phases and the ADVICE tool were presented to the students.

Then, the students held a discussion as a learning activity in the course they were attending. During the discussion, the students participated by a) posting messages through the ADVICE Forum interface b) coding their and their peers' messages according to the ADVICE coding schema, and c) monitoring the discussion's progress according to the ADVICE visualizations.

After the activity, the students completed the System Usability Scale (SUS) (Brooke, 1996) the ADVICE Usability questionnaire and the ADVICE Reflection questionnaire.

7.3.3. Data Collection

The data collected are the following:

a) Quantitative data (log files ADVICE): the number of messages that each student has coded,
b) Qualitative data (log files ADVICE): the median of the students' codings for each message, the content of each message
c) Students' perceptions for the Usability of ADVICE after the course according to their System Usability Scale scores.
d) Students' perceptions for the Usability of ADVICE after the course according to their ADVICE Usability questionnaire scores. The ADVICE Usability questionnaire consists of three components: a) the ADVICE Forum interface, b) the Coding Schema, and c) the Visualizations.
   The Likert questionnaire consists of 7 questions that were rated on a 1 (strongly disagree) to 5 (strongly agree) response scale. The first 2 items of the questionnaire are about the usability of the ADVICE Forum interface (Questions 1 and 2), the next 2 questions are about the usability of the coding

schema (Questions 3 and 4), and the last three questions (Questions 5, 6 and 7) focus on ADVICE visualizations.

e) ADVICE reflection questionnaire data

The ADVICE reflection questionnaire was developed in order to assess the students' perceptions regarding reflection during the discussion activity according to the three processes that are supported: coding messages, visualizations, and composing messages.

This Likert-like questionnaire consists of 11 questions that were rated on a 1 (strongly disagree) to 5 (strongly agree) response scale. The first 2 items of the questionnaire are about the coding process that is available through the ADVICE Forum interface, the next 6 questions are about the visualization provided (Question 3 to Question 8), and the last three questions (Questions 9, 10 and 11) focus on the process of composing messages.

7.4. Data Analysis

After the discussion activity, all the messages of the asynchronous discussions were coded by two independent researchers according to the three presences of CoI and to the four PI phases (Garrison et al., 2001). In the case of researchers' disagreement, there was negotiation and a second attempt of coding to reach a unique coding for every message. Researchers' agreement was calculated with Cohen's κ correlation coefficient (Cohen, 1960) ensuring the reliability of the content analysis to result in a final coding which will be called the "experts' coding".

The median of the students' coding for each message of the discussion is considered to be the "community's perspective" in the adaptable visualizations of ADVICE.

To assess in what degree ADVICE is better than chance at identifying the discussion messages' phase in the cognitive presence (accuracy), Cohen's κ, and Holsti's coefficient were calculated for each discussion, to test the agreement between the experts' coding and the community's perspective. Since the transition from one phase to the next indicates a progression of the discussion, the four PI phases could be considered as an ordinal variable rather than nominal (see Chapter 4.1.2.), and for this, Kendall's τ will also be calculated.

Regarding the internal consistency of ADVICE's Usability questionnaire and ADVICE reflection questionnaire, Cronbach's alphas were calculated.

Regarding the SUS questionnaire, only the answers of those students who had participated to the asynchronous discussion, had fully used ADVICE and had answered the ADVICE's Usability and ADVICE reflection questionnaires were considered as valid. Additionally, the students who were outliers to either of the two questionnaires were excluded.

Finally, the student contribution variable was calculated for each student, according to the equation (1) presented in chapter 7.1, with the difference that the data source was the experts' coding (two independent researchers' final coding) instead of the community's coding. For the research the weights in the equation are a=0, b=0.2, c=0.3 and d=0.50 so now the equation that results to student's contribution is:

*Student_contribution = 0.10*contribution_to_triggering +0.20*contribution_to_exploration + 0.30*contribution_to_integration + 0.40*contribution_to_resolution*

The contribution in each subsequent phase of the PI process corresponds to a higher weight because it has often been mentioned (Garrison, 2017) that the progression of cognitive presence is a challenge and thus it should be increasingly awarded as the student moves towards the resolution phase.

7.5. Results

As presented in Table 7, of the 61 students who participated in the activity, 41 were involved in all the processes of ADVICE: a) coding messages, b) composing messages to the discussion, and c) observing the visualizations. Lastly, one student was detected as an outlier on the ADVICE usability questionnaire and for this she was excluded, so the sample of the research resulted in 40 students.

Content Analysis Results

To measure the presence that each message reflects, all 118 messages from the online discussion forums were coded by two researchers and they achieved a complete coding agreement. Next, the 99 messages, that reflect cognitive presence, were coded using the CoI coding instrument described in Garrison, Anderson, and Archer, (2001). The two researchers were in excellent coding agreement (Cohen's κ = .95), disagreeing in three messages (total of 99 messages). The disagreements were resolved through the discussion between the researchers-coders. The results of the coding, which from now on will be referred to as "experts' coding", are shown in Fig. 19. There were recorded 996 students' codings for the messages of the discussion. According to the experts' coding (see Table 7), the discussion had 3 messages belonging to the triggering event phase (column CP1), 58 messages belonging to the exploration phase (column CP2), 33 messages belonging to the integration phase (column CP3), 5 messages belonging to the resolution phase (column CP4), 9 messages belonging to social presence (column SP) and 10 messages belonging to teaching presence (column TP).

Table 7. *Content analysis results by the experts*

Students	ADVICE discussion participants	Number of messages	CP1	CP2	CP3	CP4	TP	SP	Number of students' codings
61	41	118	3	58	33	5	10	9	996

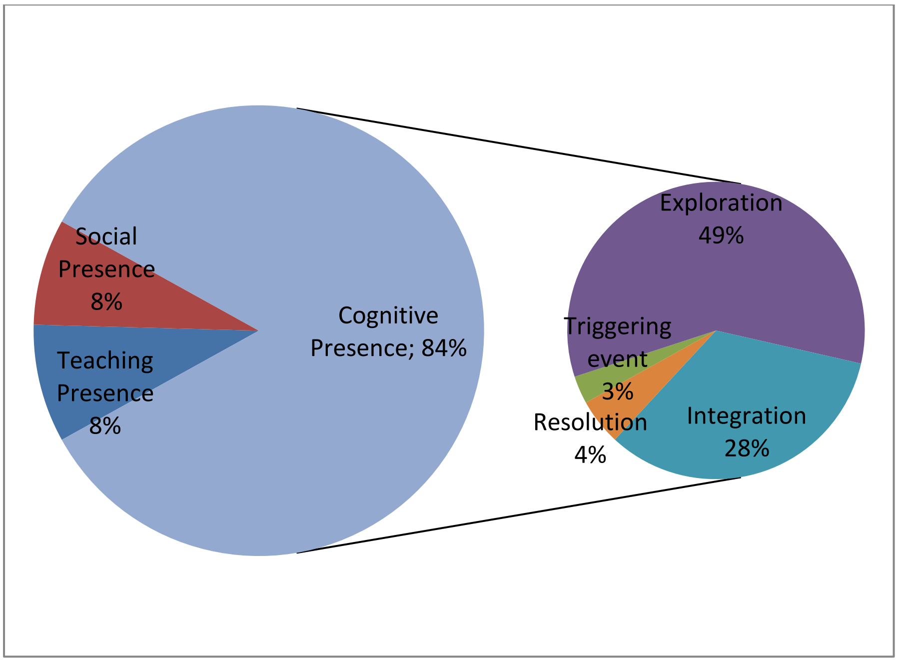

Figure 19. *Content analysis of the discussion according to CoI*

<u>Study 3. Research Question 1. What is the accuracy of ADVICE?</u>

According to the results of the statistical analysis, the value of the Kendall τ correlation reveals that there is a strong positive correlation between the experts' coding and the ADVICE coding ($r=.88$, $p<.01$). The ADVICE obtained a high percentage agreement (76%). Besides, ADVICE reported a Cohen's κ of .68 which indicates the potential of the proposed tool.

<u>Study 3. Research Question 2. To what extent did students consider the ADVICE usable?</u>

The mean SUS score of the 40 participants-students in the discussions was 71, with a standard deviation of 14.7. The minimum SUS score was 42.5 and the maximum score was 97.5.

Regarding the ADVICE usability questionnaire, Cronbach's alpha for the 7 items (Q1 – Q7) was .7 which, according to (Field, 2009) is considered as an acceptable level of internal consistency for the questionnaire with this specific sample.

Table 8. *Descriptive Statistics for the questions of ADVICE Usability questionnaire*

ADVICE components	Question	Mean	St. Deviation
ADVICE Forum interface	1. The red frame at the top of the messages helped me to easily find the messages that I had not coded	4.31	.91
	2. The colors of the coding options helped me to easily distinguish the codings of the messages	3.73	.84
Coding Schema	3. The menu of the coding options was simple and comprehensible	3.54	.84
	4. I could easily understand in which code every message belonged	3.19	1.21
Visualizations	5. During the discussion, I was often tempted to look at the visualizations	3.24	1.04
	6. The way the visualizations were presented was simple and comprehensible	3.76	1.11
	7. The options in the visualizations were understandable	3.85	.99

The students' answers averaged high enough to show that they were positive regarding the overall usability of ADVICE (see Table 8). There is a high variance of the students' opinions regarding Question 4 which shows that despite the positive answers there is not a specific tendency in the usability of the coding schema.

Study 3. Research Question 3. To what extent did students consider that ADVICE promotes reflection during the discussion activity?

To answer research question 2, the mean score of the answers that the students gave to the ADVICE reflection questionnaire after the ADVICE activity and the overall mean score were calculated.

Cronbach's alpha for the 11 (Q12-Q20, Q22, Q23) items of the ADVICE reflection questionnaire was 0.62, which, according to Field (2009), is considered as an acceptable level of internal consistency for the questionnaire with this specific sample.

Table 9. *Descriptive Statistics for the questions of ADVICE reflection questionnaire*

ADVICE Processes	Questions	Mean	St. Deviation
Coding messages	1. The fact that I coded others' messages helped me to understand the course of the discussion	3.76	1.11
	2. The fact that I coded my messages helped me to understand the course of the discussion	3.76	1.18
Visualizations	3. The visualizations helped me to understand the progress of the discussion	3.46	.87
	4. Choosing various representations in the visualization helped me to see the progress of the discussion in multiple ways	3.54	.98
	5. The Starch art affected me when I was writing a message	2.98	1.04
	6. When I viewed how others coded the discussion, I tried to compose messages reflecting more advanced phases of the PI.	3.03	.96
	7. When I observed the position of my messages in relation to that of the community, I could figure out how to compose messages with more advanced PI phases.	3.54	.84
	8. When I observed the phase of my messages in relation to that of the	3.83	.86

	community, I was motivated to contribute to the discussion with an additional message		
Composing messages	9. When I was composing a message I was thinking about how it would be coded by my peers.	2.10	1.14
	10. When I was composing a message I was thinking in which coding it belongs	2.15	1.17
	11. When I was composing a message I was thinking about how it would be coded by my teacher.	3.17	1.09

Regarding reflection (see Table 9), the students' answers averaged high for coding messages and visualization which shows that they had a positive opinion for the reflection promoted by the tool. On the other hand, the mean score and the variance of questions 9 and 10, show that the students didn't clearly value the process of the composing message as sufficiently reflective.

R.Q. 4: Is the reflection promoted by ADVICE related to the students' cognitive contribution through the discussion?

For answering research question 4, the ADVICE reflection questionnaire was used. Initially, the means of the questions were calculated, so that a mean of answers per student would correspond to each subscale of the questionnaire. Concretely, a mean per student was calculated for the "coding messages" subscale (Questions 1 and 2), as was done for the subscale "monitoring visualizations" sub-scale (Questions 3,4,5,6,7 and 8) and also for the "composing messages" subscale (Questions 9, 10 and 11).

For correlation analysis, Pearson parametric tests were carried out and significant correlations confirmed mutually.

The analysis indicates a statistically significant and positive moderate relationship between the students' perceived reflection on the coding process of peers' messages and the students' cognitive contribution ($r=.50$, $p=.001$).

According to the analysis results, there is a significant linear relationship between the students' perceived reflection on the visualizations and their cognitive contribution. Concretely, a statistically significant positive medium correlation was found ($r=.43$, $p=.016$).

Finally, a statistically significant positive medium correlation ($r=.36$, $p=.024$) was found between the students' perception of the metacognitive value of the composing process and their cognitive contribution to the discussion.

7.6. Discussion- Conclusions

Aiming to contribute to the area of LA, we developed ADVICE, a LA tool that enhances inquiry-based learning. It focuses on stimulating learners' reflection by enabling them to code the discussion contributions and by providing adaptable visualizations of the learners' and the community's perspective for the cognitive development of the discussion.

Specifically, various existing LA tools in asynchronous discussions were presented as well as the theoretical background, the design rationale, and the evaluation of ADVICE. The study focused on the accuracy and the usability of the tool as well as on students' reflection while contributing to the discussion through composing messages, coding messages, and while using the ADVICE visualizations.

ADVICE's visualizations aim to show the community's perspective. The accuracy (76% and Cohen's κ= .68) that the tool achieved, highlights the potential of the proposed approach in comparison with other approaches that aim to detect cognitive presence automatically (Kovanović et al., 2016) and provides evidence about students' competency in interpreting the cognitive development of an asynchronous discussion. The usability of the tool is considered adequate and the learners' attitude for the tool was positive. Also, students' involvement in the coding process was acknowledged as helpful for the awareness of the cognitive development of the discussion. It is also shown that students' reflection was promoted by ADVICE since, during a) the coding messages process and b) the adaptable visualizations observation there was moderate relationship with students' cognitive contribution

All the above findings reinforce Garrison's (2016) suggestion that cultivating metacognitive awareness and reflection contributes to learners' cognitive development. In this way, promising directions emerge for future research.

A key limitation resulting from the design and application of this research is the small size of the participants making difficult the extrapolation of the findings of this study to other contexts. Hence, the impact of the coding process and the adaptable visualizations in students' reflection on the Communities of Inquiry would be clarified further. A worthwhile addition would also be to examine the learning outcomes of a Community of Inquiry using ADVICE to study the impact of ADVICE on the learning performance. Furthermore, it would be valuable to explore in depth students' behaviors (e.g., students who are outliers in the coding messages process) to find patterns which e.g., could indicate students who would be at risk failing to achieve the learning outcomes of the course.

8. Discussion And Conclusions

The dissertation presents the process of designing and developing an adaptable visualization LA tool for the cultivation of critical thinking and metacognition through discussion and reflection. Specifically, the design of the tool supports a) participating in the discussion, b) coding of the discussion, and c) visualization of the cognitive development of the discussion based on the PI progressive phases.

8.1. Impact of the present work

Overall, the thesis concludes with the results that are summarized as follows:

8.1.1. Phase 1: Coding of the discussion messages by the learners.

According to the Studies 1.1 and 1.2, although the coding validity of a learner's coding varies, there is strong evidence that using the appropriate coding schema, and resulting in a unique community's coding leads to a valid representation of a discussion's cognitive development. In particular, the dissertation resulted in the following findings.

- *A coding schema appropriately designed so that learners can code the cognitive development of a discussion (Chapter 3, 4) is proposed and positively evaluated for its accuracy.*

The studies showed that learners, based on the proposed schema are capable of demonstrating a valid cognitive process of the discussion. Specifically, in Chapter 3 it was revealed that the design of the initial coding schema that includes 5 choices for representing the cognitive presence indicators was adequate as there was sufficient agreement between the learners and the researchers but there was a need for improvement. The evaluation of the redesigned coding schema, in Chapter 4, showed that the learners were able to code close enough to researchers. Specifically, it was found that the students demonstrated a perfect to moderate agreement (Kappa = .98-Kappa = .61) with the researchers.

- *A proposed measure for community's perspective has been proved to represent a reliable cognitive development of the discussion. (Chapter 3, Chapter 4).*

A series of studies showed that the learners, based on the proposed schema are capable to demonstrate a relatively reliable cognitive process of the discussion. Specifically, in Chapter 3 it was revealed that the design of the initial coding schema that includes 5 choices for representing the cognitive presence indicators was adequate as there was sufficient agreement between the learners and the researchers but there was a need for improvement. The evaluation of the redesigned extended coding schema, in Chapter 4, showed that the learners were able to code close enough to researchers. Specifically it has demonstrated high accuracy (Kappa=.67 and C.R = .75)

8.1.2. Phase 2: Variables as learners' variables for adaptability and visualization

1. *Participation as a quantitative variable and, cognitive contribution as a qualitative variable are proposed for constructing adaptability variables (Chapters 5, 6).*

The study presented in Chapter 5 proposes the participation measurement and shows its relation to the cognitive presence of the CoI. Also, the study proposes a cognitive contribution variable representing the individual learner in terms of cognitive presence. It was shown that cognitive contribution's value was affected by the teaching presence of the CoI.

The cognitive contribution variable was again examined in the research presented in Chapter 6 and it is shown that it is representative of each learner's awareness in CoI. Specifically, it is shown that learners' cognitive contribution is a factor for estimating learners' awareness.

2. *There is evidence that there is a strong relation between monitoring a discussion within the CoI and the cognitive contribution to the discussion. (Chapter 6).*

In Chapter 6 the research has shown that the cognitive contribution of learners is a predictor of their ability to monitor the discussion (discussion coding). Therefore, it is suggested that learners' cognitive development could be used as a parameter for estimating monitoring.

8.1.3. Phase 3: The development and evaluation of ADVICE.

Through the coding and the visualization of the cognitive development of the discussion, awareness, and reflection proved to be promoted. For achieving positive results, a) a valid coding schema was carefully designed to be used by the users, b) a valid calculation of the cognitive development of the community was chosen through each learner's coding, and c) appropriate measurements were chosen that construct specific adaptability variables.

1. *A visualization tool used by the learners and combining a) Learning Analytics, b) Communities of Inquiry, and c) adaptability is proved to represent with sufficient accuracy the discussion cognitive presence (Chapter 7).*

The accuracy (76% agreement and Cohen's κ= .68) of ADVICE, highlights the potential of the proposed approach in comparison to other approaches that aim to detect cognitive presence automatically (Kovanović et al., 2016). The accuracy is sufficiently high enough a) to provide valuable insights to the learners regarding their cognitive presence development and b) to point out the students' competency in identifying the discussion's cognitive evidence through the proposed coding schema.

2. *Three representations of the learner's and community's cognitive development are proposed and positively evaluated (Chapter 7) for the reflection they promote.*

Three different visualizations are presented in Chapter 7. The first two are adaptable and visualize the cognitive development of the community and its subgroups according to the perspective of the community and/or the community's subgroups perspectives. The third visualization shows the percentage of cognitive contribution of the learner in the discussion in relation to the community's cognitive contribution for every PI phase.

The above visualizations were evaluated in terms of usability and reflection cultivated. The results for usability were highly encouraging (SUS score = 71). It was also found that reflection through visualizations provided had a positive correlation to the learner's cognitive development. Lastly, according to the learners, visualizing the cognitive development of the discussion promoted their reflection.

3. *The use of CoI as a reference point for a) composing messages, b) coding messages, and c) visualizing the cognitive development of the discussion (Chapter 7) is a vehicle for cultivating metacognition.*

The students' cognitive contribution within CoI, had a higher relationship with students' reflection promoted by ADVICE during the coding messages process (r=.50, p=.001) than during the adaptable visualizations (r=.43, p=.016) and during the composing messages process (r=.36, p=.024). These findings highlight the value of the coding process to the cultivation of metacognitive skills against other approaches. However, the correlation of the other two processes with reflection should not be ignored.

Therefore, the use of ADVICE by the learners while engaging in online discussions enhances their communication, critical thinking and learning skills, and instills a culture of collaboration through discussion to achieve a learning outcome without the necessity of teacher's intervention.

The following table summarizes the studies' findings. Table 10 shows a) the purpose (Row 1), b) the collected data (Row 2), c) the data analysis (Row 3), d) and the research questions answered (Row 4) of each study presented in the dissertation.

Table 10. *Overview of the aim, the data collection, the data analysis and the thesis findings by individual study*

		Phase 1		Phase 2		Phase 3
		Study 1.1	**Study 1.2**	**Study 2.1**	**Study 2.2**	**Study 3**
Object of the study		Proposal and evaluation of the coding schema	Redesign and evaluation of the coding schema	Proposal of measurements leading to adaptability variables related to CoI	Study of cognitive contribution for constructing visualizations and CoI adaptability variables	Development and evaluation of ADVICE for its accuracy, usability and for the reflection that promotes
Data collection	Learners' codings	√	√		√	√
	Messages' content	√	√	√	√	√
	Learners' likes for teachers' messages	√				
	Log Data			√		√
	Learners' opinion questionnaire	√				√
	SUS questionnaire					√
Data Analysis	Quantitative analysis (Statistics)		√	√	√	√
	Content Analysis	√	√			√
Findings		Coding schema proposed and positively evaluated for its accuracy		Participation and cognitive contribution proposed for constructing adaptability variables		Substantial accuracy
						Sufficient Usability
		Proposed measure for community's perspective proven to be valid		Strong relation between CoI discussion monitoring and the cognitive contribution to the discussion		Reflection positively evaluated
						ADVICE's potentiality to cultivate metacognition

8.2. Limitations and Future Directions

There are several limitations of the research and many novel directions for future work to expand the findings of this thesis. Generally speaking, future directions include exploration of ADVICE's effectiveness in various conditions.

The main limitation of the research is related to the size of the data set. The research was conducted in technology-enhanced learning courses in three universities and the sample consists of students who can be considered as pre-service teachers. However, the particular groups of students have different characteristics such as background knowledge, individual traits, discipline, which may affect the generalizability of the research findings in teacher education. Thus, in future work, ADVICE will be evaluated on different datasets, which would account for other important confounding variables recognized in the research of the CoI model such as course subject (Moreira et al., 2013; Arbaugh et al., 2010), disciplinary effects, level of education (i.e., undergraduate vs. graduate) (Garrison et al., 2010), mode of instruction (asynchronous vs. synchronous (Wanstreet & Stein, 2011) and blended vs. fully online vs. MOOC (Akyol et al., 2009a; Vaughan &. Garrison, 2005; Shea & Bidjerano, 2013)).

Thus, it appears to be warranted further examination of the impact of ADVICE on the dimensions of the CoI framework in multi-disciplinary, multi-institution, graduate course/teacher training -level research settings.

Moreover, in this research, the process of coding and the provision of the visualizations were not examined separately to determine which one particularly influenced the students and in which way. For this, to understand ADVICE's impact on the learning process, an important area of future work is to investigate it in the long run by comparing learner groups that use different processes of the tool e.g., only coding the discussion without having access to the visualizations, only viewing the development of the discussion with the expert's view without being able to code the discussion themselves, etc.

In this direction, it would be of value to the scientific and to the teacher community, to research separately the various visualization variables provided by ADVICE in order to investigate how each adaptability variable and each groups' perspective, stimulates reflection and promotes cognitive development.

In addition, by using ADVICE, the learner actually has control over their own learning and critical thinking processes. At the same time, students get acquainted with the stages of evolvement of a discussion for educational purposes. This way, involving ADVICE in the educational process we attempt to cultivate interaction, critical thinking, and collaboration with peers to solve a problem. Through ADVICE, students' cognitive development is gradually presented through appropriate visualizations aiming to affect their conscious and unconscious choices in the learning process. But how the integration of ADVICE in the educational process should be done to effectively affect learners' metacognitive skills remains open.

Moreover, exploring the use of the teacher's reference file provided by ADVICE is a future research direction. Through the information provided, the teacher can distinguish a variety of learners' groups according to the way they code the discussion, such as those coding with accuracy, those who are steadily lenient or rigorous in coding, in comparison to the community, or even those who consistently code completely different from the rest of the community (outliers). It would be useful to see how these learner groups contribute to the discussion and to link these observations to the learning outcomes. Therefore, it is worth exploring ADVICE's impact on the educational practice in order for the teacher to proceed to appropriate interventions. Findings from this study have important implications for research and practice for online courses.

CoI as a social constructive framework emphasizes also on social interactions. Social network analysis is conducted on networks of relationships between human and/or non-human entities. This approach has been recently proposed for automatic visualizations of learners' social interactions in terms of CoI, focusing mainly on social presence (Jan & Vlachopoulos, 2019). In this direction, the use of SNA will be explored to optimize the accuracy of ADVICE but also to upgrade the adaptable visualizations provided, by including all presences in addition to cognitive presence indicators that are currently provided. This upgrade will allow the structural dynamics between social, teaching and cognitive presence to be revealed as well as their corresponding impact on learning, based on the properties of the whole network (community) and the individual nodes (learners, teachers).

Furthermore, some first steps have been taken to investigate the impact of gamification on the cognitive development of CoI with positive results (Tzelepi et al., 2019). Towards this end, ADVICE could provide gamification elements to automatically empower learners to nurture metacognition and develop the discussion cognitively. Consequently, we intend to explore the integration of gamification into ADVICE as a promising technique for enhancing engagement and participation in learning communities (Ding et al., 2017).

Finally, the educational value of the learners' individual differences, despite being well-established in educational psychology, it has not received enough attention in CoI research. Regarding personalization, cognitive and learning styles have been revisited (Akbulut & Cardak, 2012) and they have been related to social and cognitive presence (Mouzouri, 2016). This future research direction offers a high practical potential for educational technology and a starting point for exploring the impact of students' individual characteristics (e.g., learning/cognitive styles) as adaptability variables for CoI visualizations in ADVICE.

REFERENCES

Adraoui, M., Retbi, A., Idrissi, M. K., & Bennani, S. (2017). Social learning analytics to describe the learners' interaction in online discussion forum in Moodle. In Information Technology Based Higher Education and Training (ITHET), 2017 16th International Conference on (pp. 1-6). IEEE.

Ahern, T., Peck, K. & Laycock, M. (1992). The effects of teacher discourse in computermediated discussion. *Journal of Educational Computing Research, 8*(3) 291-309.

Akbulut, Y., & Cardak, C. S. (2012). Adaptive educational hypermedia accommodating learning styles: A content analysis of publications from 2000 to 2011. *Computers & Education*, *58*(2), 835-842.Akyol, Z., & Garrison, D. R. (2011). Assessing metacognition in an online community of inquiry. The Internet and Higher Education, 14(3), 183-190

Akyol, Z., Garrison, D. R., & Ozden, M. Y. (2009a). Online and blended communities of inquiry: Exploring the developmental and perceptional differences. The International Review of Research in Open and Distributed Learning, 10(6), 65-83.

Akyol, Z., Garrison, D. R., & Ozden, M. Y. (2009b). Development of a community of inquiry in online and blended learning contexts. Procedia-Social and Behavioral Sciences, 1(1), 1834-1838.

Akyol, Z., Vaughan, N., & Garrison, D. R. (2011). The impact of course duration on the development of a community of inquiry. Interactive Learning Environments, 19(3), 231-246.

Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. (2001). Assessing teaching presence in a computer conference context. Journal of Asynchronous Learning Networks, 5(2)

Andresen, M. A. (2009). Asynchronous discussion forums: Success factors, outcomes, assessments and limitations. Educational Technology and Society, 12(1), 249-257.

Angelaina, S., & Jimoyiannis, A. (2012a). Analysing students' engagement and learning presence in an educational blog community. Educational Media International, 49(3), 183-200.

Angelaina, S., & Jimoyiannis, A. (2012b). Educational blogging: Developing and investigating a students' community of inquiry. In Research on e-Learning and ICT in Education (pp. 169-182). Springer, New York, NY.

Arbaugh, J. B., Bangert, A., & Cleveland-Innes, M. (2010). Subject matter effects and the community of inquiry (CoI) framework: An exploratory study. The internet and higher education, 13(1-2), 37-44.

Arbaugh, J. B., Cleveland-Innes, M., Diaz, S., Garrison, D. R., Ice, P., Richardson, J., Shea, P.,& Swan, K. (2008). Developing a community of inquiry instrument: Testing a measure of the Community of Inquiry framework using a multi-institutional sample. Internet and Higher Education, 11, 133–136.

Arbaugh, J. B., & Hwang, A. (2006). Does "teaching presence" exist in online MBA courses?. *The Internet and Higher Education*, *9*(1), 9-21.

Archibald, D. (2010). Fostering the development of cognitive presence: Initial findings using the community of inquiry survey instrument. The Internet and Higher Education, 13(1-2), 73-74. doi:10.1016/j.iheduc.2009.10.001 Atapattu, T., Falkner, K., & Tarmazdi, H. (2016). Topic-wise Classification of MOOC Discussions: A Visual Analytics Approach. In EDM (pp. 276-281).

Avella, J. T., Kebritchi, M., Nunn, S. G., & Kanai, T. (2016). Learning Analytics Methods, Benefits, and Challenges in Higher Education: A Systematic Literature Review. Online Learning, 20(2), 13-29.

Aviv, R., Erlich, Z., Ravid, G., & Geva, A. (2003). Network analysis of knowledge construction in asynchronous learning networks. Journal of Asynchronous Learning Networks, 7(3), 1-23.

Awasthi, P., & Hsiao, I. H. (2015). INSIGHT: a Semantic Visual Analytics for Programming Discussion Forums. In VISLA@ LAK(pp. 24-31).

Babbie, E. (1992). The practice of social research. New York: Macmillan

Bach, C. (2010). Learning analytics: Targeting instruction, curricula and student support. Office of the Provost, Drexel University.

Baker, E. L., & O'Neil, H. F. J. (2002). Measuring problem solving in computer environments: Current and future states. Computers in Human Behavior, 18, 609–622.

Baker, B. (2007). A conceptual framework for making knowledge actionable through capital formation. D.Mgt. dissertation, University of Maryland University College, United States - - Maryland. Retrieved October 19, 2010, from ABI/INFORM Global.(Publication No. AAT 3254328).

Bakharia, A., & Dawson, S. (2011). SNAPP: a bird's-eye view of temporal participant interaction. In Proceedings of the 1st international conference on learning analytics and knowledge (pp. 168-173). ACM.

Bangert, A. W. (2009). Building a validity argument for the community of inquiry survey instrument. *The Internet and Higher Education*, *12*(2), 104-111.

Boud, D., Keogh, R. & Walker, D. (2013), Reflection: Turning experience into learning, Routledge.

Bodemer, D., Janssen, J., & Schnaubert, L. (2018). Group awareness tools for computer-supported collaborative learning. In International handbook of the learning sciences (pp. 351-358). Routledge.

Boud, D., & Walker, D. (1998). Promoting reflection in professional courses: The challenge of context. Studies in higher education, 23(2), 191-206.

Bratitsis, T. & Dimitracopoulou, A. (2008). Interpretation Issues in Monitoring and Analyzing Group Interactions in. INT J E-COLLABORATION. 4, 1, 20–40.

Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7.

Brown, M., (2011) "Learning Analytics: The Coming Third Wave," EDUCAUSE Learning Initiative Brief, http://www.educause.edu/Resources/LearningAnalyticsTheComingThir/227287

Bozkurt, A., Akgun-Ozbek, E., Yilmazel, S., Erdogdu, E., Ucar, H., Guler, E., ... & Dincer, G. D. (2015). Trends in distance education research: A content analysis of journals 2009-2013. The International Review of Research in Open and Distributed Learning, 16(1).

Burgess, M. L., Slate, J. R., Rojas-LeBouef, A., & LaPrairie, K. (2010). Teaching and learning in Second Life: Using the Community of Inquiry (CoI) model to support online instruction with graduate students in instructional technology. *The Internet and Higher Education*, *13*(1-2), 84-88.

Oblinger, D., & Campbell, J. (2007). Academic analytics, educause white paper.*Retrieved October*,*20*, 2011.

Carlon, S., Bennett-Woods, D., Berg, B., Claywell, L., Leduc, K., Marcisz, N., Mulhall, M., Noteboom, T., Snedden, T., Whalen, K., & Zenoni, L. (2012). The community of inquiry instrument: Validation and results in online health care disciplines. Computers and Education, 59(2), 215-221.

Celentin, P. (2007). Online training: Analysis of interaction and knowledge building patterns among foreign language teachers. Journal of Distance Education, 21(3), 39–58.

Capozzoli, M., McSweeney, L. & Sinha, D. (1999). Beyond kappa: A review of interrater agreement measures. *The Canadian Journal of Statistics, 27*(1), 3-23.

Celentin, P. (2007). Online training: Analysis of interaction and knowledge building patterns among foreign language teachers. Journal of Distance Education, 21(3), 39–58.

Chatti, M. A., Dyckhoff, A. L., Schroeder, U., & Thüs, H. (2012). A reference model for learning analytics. International Journal of Technology Enhanced Learning, 4(5-6), 318-331.

Chen Y. (2018) "Cognitive presence in peer facilitated asynchronous online discussion: the patterns and how to facilitate" (Doctoral dissertation). Retrieved from https://surface.syr.edu/etd/912

Clow, D. (2012). The learning analytics cycle: Closing the loop effectively. Proceedings of the 2nd International Conference on Learning Analytics & Knowledge (LAK 2012), 134–138. http://dx.doi.org/10.1145/2330601.2330636

Cohen, J. (1960). A coefficient of agreement for nominal scales. Educational and psychological measurement, 20(1), 37-46.

Corich, S., Hunt, K., & Hunt, L.: Computerised content analysis for measuring critical thinking within discussion forums. Journal of E-Learning and Knowledge Society, 2(1), 47–60 (2012)

Corrin, L., Kennedy, G., De Barba, P., Bakharia, A., Lockyer, L., Gašević, D., & Copeland, S. (2015). Loop: A learning analytics tool to provide teachers with useful data visualisations.

Dawson, S. (2010). ‘Seeing’ the learning community: An exploration of the development of a resource for monitoring online student networking. British Journal of Educational Technology, 41(5), 736–752.

De Leng, B.A., Dolmans, D.H.J.M., Jöbsis, B., Muijtjens, A.M.M., & van der Vleuten, C.P.M. (2009). Exploration of an e-learning model to foster critical thinking on basic science concepts during work placements. *Computers & Education*, 53(1), 1-13.

De Liddo, A., & Buckingham Shum, S. (2010). Cohere: A prototype for contested collective intelligence.

De Liddo, A., Shum, S. B., Quinto, I., Bachler, M., & Cannavacciuolo, L. (2011). Discourse-centric learning analytics. In Proceedings of the 1st international conference on learning analytics and knowledge (pp. 23-33). ACM.

Dempsey, P. R., & Zhang, J. (2019). Re-Examining the Construct Validity and Causal Relationships of Teaching, Cognitive, and Social Presence in Community of Inquiry Framework. *Online Learning*, *23*(1), 62-79.

Dewey, J. (1933). How we think (rev. ed.). Boston: D.C. Heath

Díaz, S. R., Swan, K., Ice, P., & Kupczynski, L. (2010). Student ratings of the importance of survey items, multiplicative factor analysis, and the validity of the community of inquiry survey. Internet and Higher Education, 13(1-2), 22-30.

Ding, L., Kim, C., & Orey, M. (2017). Studies of student engagement in gamified online discussions. *Computers & Education*, *115*, 126-142.

Drachsler, H., & Greller, W. (2012). Confidence in learning analytics. In LAK12: 2nd International Conference on Learning Analytics & Knowledge.

Dron, J. and Anderson, T. (2009). On the design of collective applications, Proceedings of the 2009 International Conference on Computational Science and Engineering , Volume 04, pp. 368-374.

Durall, E., & Gros, B. (2014). Learning analytics as a metacognitive tool. Proceedings of 6th International Conference on Computer Supported Education (CSEDU), 380-384 Education, 2(2-3), 87-105.

Duval, E. (2012). Learning Analytics and Educational Data Mining, Erik Duval's Weblog, 30 January 2012. *Im Internet unter: https://erikduval. wordpress. com/2012/01/30/learning-analytics-andeducational-data-mining/, Zugriff*, *12*, 2017.

Efklides, A. (2009). The role of metacognitive experiences in the learning process. *Psicothema*, *21*(1).

Elias, T. (2011). Learning analytics: Definitions, processes and potential. Retrieved February, 9, 2012.Bull, S., & Kay, J. (2008, June). Metacognition and open learner models. In The 3rd Workshop on Meta-Cognition and Self-Regulated Learning in Educational Technologies, at ITS2008 (pp. 7-20).

Eteokleous-Grigoriou, N., & Ktoridou, D. (2012, June). Community of inquiry developed through blogs in a non-formal educational setting. In *EdMedia+ Innovate Learning* (pp. 2116-2123). Association for the Advancement of Computing in Education (AACE).

Eteokleous, N., Ktoridou, D., & Orphanou, M. (2014). Integrating wikis as educational tools for the development of a community of inquiry. *American Journal of Distance Education*, *28*(2), 103-116.

Fahy, P. J. (2001). Addressing some common problems in transcript analysis. *The International Review of Research in Open and Distributed Learning*, *1*(2).

Fahy, P. J. (2002). Epistolary and expository interaction patterns in a computer conference transcript. *Journal of Distance Education, 17*, 20–35.

Ferguson, R. & Buckingham Shum, S. 2011. Learning analytics to identify exploratory dialogue within synchronous text chat. In Proceedings of the 1st International Conference on Learning Analytics & Knowledge, (Banff, Canada, 2011).

Ferguson, R. (2009). The construction of shared knowledge through asynchronous dialogue (Doctoral dissertation, The Open University).

Ferguson, R. (2012). Learning analytics: drivers, developments and challenges. International Journal of Technology Enhanced Learning, 4(5-6), 304-317.

Ferguson, R., & Buckingham Shum, S. (2012). Social learning analytics: Five approaches. Proceedings of the 2nd International Conference on Learning Analytics and Knowledge, 23-33. DOI: 10.1145/2330601.2330616

Field, A. (2009). Discovering statistics using SPSS. Sage publications.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American psychologist, 34(10), 906.

Flynn, T., & Polin, L. (2003). Making sense of online learning: Frames, rubrics, tools and coding systems for analyzing asynchronous onlin e discourse. AERA, Chicago, April.

Galikyan, I., & Admiraal, W. (2019). Students' engagement in asynchronous online discussion: The relationship between cognitive presence, learner prominence, and academic performance. *The Internet and Higher Education*, *43*, 100692.

Garrison, D. R. (2003). Cognitive presence for effective asynchronous online learning: The role of reflective inquiry, self-direction and metacognition. Elements of quality online education: Practice and direction, 4(1), 47-58.

Garrison, D. R. (2009). Communities of inquiry in online learning. In P. Rogers, G. Berg, J. Boettcher, C. Howard, L. Justice & K. Schenk et al. (Eds.), Encyclopedia of distance learning (2nd ed.) (pp. 352–355). Hershey, PA: IGI Global

Garrison, D. R. (2016). *E-learning in the 21st century: A community of inquiry framework for research and practice*. Routledge.

Garrison, D. R.: E-learning in the 21st century: A framework for research and practice. Taylor & Francis (2011)

Garrison, D. R., & Anderson, T. (2003). *E-Learning in the 21 Century*. New York.

Garrison, D. R., & Akyol, Z. (2015). Toward the development of a metacognition construct for communities of inquiry. The Internet and Higher Education, 24, 66-71.

Garrison, D. R., & Arbaugh, J. B. (2007). Researching the community of inquiry framework:Review, issues, and future directions. Internet and Higher Education, 10(3), 157−172

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. The Internet and Higher Education, 2(2-3), 87-105.

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. American Journal of distance education, 15(1), 7-23.

Garrison, D. R., Cleveland-Innes, M., & Fung, T. S. (2010). Exploring causal relationships among teaching, cognitive and social presence: Student perceptions of the community of inquiry framework. The internet and higher education, 13(1-2), 31-36.

Garrison, D. R., Cleveland-Innes, M., Koole, M., & Kappelman, J. (2006). Revisiting methodological issues in transcript analysis: Negotiated coding and reliability. The Internet and Higher Education, 9(1), 1-8.

Gašević, D., Adesope, O., Joksimović, S., & Kovanović, V. (2015). Externally-facilitated regulation scaffolding and role assignment to develop cognitive presence in asynchronous online discussions. The internet and higher education, 24, 53-65.

Gašević D, Dawson S, Siemens G. Let's not forget: Learning analyticsareaboutlearning.TechTrends.2014;59(1):64–71.doi: 10.1007/s11528-014-0822-x.

Gašević, D., Siemens, G., & Rosé, C. P. (2017). Guest editorial: special section on learning analytics. IEEE Transactions on Learning Technologies, (1), 3-5.

Giddens, A. (1984). The constitution of society. Berkeley. ISO 690

Gokhale, A. A. (2012). Collaborative learning and critical thinking. Encyclopedia of the sciences of learning, 634-636.

Gorsky, P. (2011). Hidden structures in asynchronous course forums: Toward a golden ratio population parameter. In *Proceedings of Ninth International Conference on Computer Supported Collaborative Learning: Connecting Computer Supported Collaborative Learning to Policy and Practice.* Center for Information Technology in Education, University of Hong Kong.

Goy, A., Petrone, G., & Picardi, C. (2017). Personal and shared perspectives on knowledge maps in learning environments. In International Conference on Learning and Collaboration Technologies (pp. 382-400). Springer, Cham.

Greller, W., & Drachsler, H. (2012). Translating learning into numbers: A generic framework for learning analytics.

Gunawardena, C. N., Carabajal, K., & Lowe, C. A. (2001). Critical analysis of models and methods used to evaluate online learning networks. In American Educational Research Association Annual Meeting. Seattle: American Educational Research Association.

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. Journal of educational computing research, 17(4), 397-431.

Gutiérrez-Santiuste, E., Rodríguez-Sabiote, C., & Gallego-Arrufat, M. J. (2015). Cognitive presence through social and teaching presence in communities of inquiry: A correlational–predictive study. *Australasian Journal of Educational Technology*, *31*(3).

Hagelin, E. (1999). Coding data from child health records: The relationship between interrater agreement and interpretive burden. Journal of Pediatric Nursing, 14(5), 313-321.

Hara, N., Bonk, C., & Angeli, C. (2000). Content analyses of on-line discussion in an applied educational psychology course. Instructional Science, 28(2), 115-152.

Hayes, S., Smith, S. U., & Shea, P. (2015). Expanding learning presence to account for the direction of regulative intent: self-, co-and shared regulation in online learning. *Online Learning*, *19*(3), 15-31

Hendricks, M., Plantz, M. C., & Pritchard, K. J. (2008). Measuring outcomes of United Way–funded programs: Expectations and reality. *New Directions for Evaluation*, *2008*(119), 13-35.

Hennessey, M. G. (1999). Probing the dimensions of metacognition: Implications for conceptual change teaching-learning. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston, MA.

Henri, F. (1992). Computer conferencing and content analysis. In *Collaborative learning through computer conferencing* (pp. 117-136). Springer, Berlin, Heidelberg.

Hilgenberg, C., & Tolone, W. (2000). Student perceptions of satisfaction and opportunities for critical thinking in distance education by interactive video. *American Journal of Distance Education*, *14*(3), 59-73.

Horzum, M. B., & Uyanik, G. K. (2015). An item response theory analysis of the community of inquiry scale. International Review of Research in Open and Distance Learning, 16(2), 206–226.

Howell, D. C. (1997). Statistical methods for psychology (4th ed.). Belmont, CA: Duxbury.

Hoyrup, S. & Elkjær, B. (2006), 'Reflection: Taking it beyond the individual', Productive reflection at work pp. 29–42.

Hsu, J. L., Chou, H. W., & Chang, H. H. (2011). EduMiner: Using text mining for automatic formative assessment. Expert Systems with Applications, 38(4), 3431-3439.

Iiskala, T., Vauras, M., Lehtinen, E., & Salonen, P. (2011). Socially shared metacognition of dyads of pupils in collaborative mathematical problem-solving processes. *Learning and Instruction*, 21, 379–393

Jan, S. K., & Vlachopoulos, P. (2019). Social network analysis: A framework for identifying communities in higher education online learning. *Technology, Knowledge and Learning*, *24*(4), 621-639.

Janson, A., Ernst, S. J., Lehmann, K., & Leimeister, J. M. (2014). Creating awareness and reflection in a large-scale IS lecture-the application of a peer assessment in a flipped classroom scenario.

Jimoyiannis, A., & Angelaina, S. (2012). Towards an analysis framework for investigating students' engagement and learning in educational blogs. *Journal of Computer Assisted Learning*, *28*(3), 222-234.

Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). The 2011 Horizon Report. Austin, Texas: The New Media Consortium.

Junus, K., & Suhartanto, H. (2019). The Community of Inquiry Model Training Using the Cognitive Apprenticeship Approach to Improve Students' Learning

Strategy in the Asynchronous Discussion Forum. Journal of Educators Online, 16(1), n1.

Kalantzis, M., & Cope, B. (2012). New learning: Elements of a science of education. Cambridge University Press.

Kalelioglu, F., & Gülbahar, Y. (2014). The Effect of Instructional Techniques on Critical Thinking and Critical Thinking Dispositions in Online Discussion. Educational Technology & Society, 17(1), 248-258.

Kazanidis, I., Pellas, N., Fotaris, P., & Tsinakos, A. (2018). Facebook and Moodle integration into instructional media design courses: A comparative analysis of students' learning experiences using the Community of Inquiry (CoI) model. *International Journal of Human–Computer Interaction*, *34*(10), 932-942.

Keim, D., Andrienko, G., Fekete, J. D., Görg, C., Kohlhammer, J., & Melançon, G. (2008). Visual analytics: Definition, process, and challenges. In Information visualization (pp. 154-175). Springer, Berlin, Heidelberg.

Khan, T. M., Clear, F., & Sajadi, S. S. (2012, April). The relationship between educational performance and online access routines: analysis of students' access to an online discussion forum. In Proceedings of the 2nd International Conference on Learning Analytics and Knowledge (pp. 226-229). ACM.

Khemaja, M., & Taamaallah, A. (2016). Towards situation driven mobile tutoring system for learning languages and communication skills: Application to users with specific needs. Journal of Educational Technology & Society, 19(1).

Klašnja-Milićević, A., Vesin, B., Ivanović, M., Budimac, Z., & Jain, L. C. (2017). Personalization and Adaptation in E-Learning Systems. In E-Learning Systems (pp. 21-25). Springer, Cham.

Klerkx, J., Verbert, K., & Duval, E. (2017). Learning analytics dashboards.

Knight S, Buckingham Shum S, Littleton K. Epistemology, Assessment, Pedagogy: Where Learning Meets Analytics in the Middle Space.J Learn Anal. 2014;1(2):23–47. doi: 10.18608/jla.2014.12.3.

Knight, S., & Shum, S. B. (2017). Theory and Learning Analytics. The Handbook of Learning Analytics, 17-22.

Koh E., Shibani A., Tan JP-L, Hong H. A pedagogical framework for learning analytics in collaborative inquiry tasks: an example from a teamwork competency awareness program. Proceedings of the Sixth InternationalConferenceonLearningAnalytics&Knowledge.ACM;2016. p. 74–83.

Koohang, A., Floyd, K., Smith, T., Skovira, R. (2010). The Hype of using Social Networking as a tool for in e-learning, Issues in Information Systems, Vol. XI, No. 2, pp.30-36

Kovanovic, V., Joksimovic, S., Gašević, D., & Hatala, M. (2014a). What is the source of social capital? The association between social network position and social presence in communities of inquiry.

Kovanovic, V., Joksimovic, S., Gašević, D., & Hatala, M. (2014b). Automated content analysis of online discussion transcripts. Integration, 508, 29-08.

Kovanović, V., Joksimović, S., Poquet, O., Hennis, T., Čukić, I., de Vries, P., ... & Gašević, D. (2018). Exploring communities of inquiry in massive open online courses. *Computers & Education*, *119*, 44-58.

Kovanović, V., Joksimović, S., Waters, Z., Gašević, D., Kitto, K., Hatala, M., & Siemens, G. (2016, April). Towards automated content analysis of discussion transcripts: A cognitive presence case. In Proceedings of the sixth international conference on learning analytics & knowledge (pp. 15-24). ACM.

Kozan, K., & Richardson, J. C. (2014). New exploratory and confirmatory factor analysis insights into the community of inquiry survey. Internet and Higher Education, 23, 39–47.

Krippendorff, K. (2011). Agreement and Information in the Reliability of Coding. Communication Methods and Measures,5(2), 93-112.http://dx.doi.org/10.1080/19312458.2011.568376

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology*. Sage publications.

Kuhn, D., & Dean, Jr, D. (2004). Metacognition: A bridge between cognitive psychology and educational practice. Theory into practice, 43(4), 268-273.

Lambert, J., & Fisher, J. (2009, March). Wiki-based distance learning: Interpreting effectiveness through the community of inquiry framework. In Society for Information Technology & Teacher Education International Conference (pp. 429-434). Association for the Advancement of Computing in Education (AACE).

Landis, J.R.; Koch, G.G. "The measurement of observer agreement for categorical data". Biometrics 33 (1): 159–174. (1977)

Laurillard, D. (2013). Teaching as a design science: Building pedagogical patterns for learning and technology. Routledge.

Linn, M. C. & Eylon, B.-S. (2011), Science learning and instruction: Taking advantage of technology to promote knowledge integration, Routledge.

Lomicka, L., & Lord, G. (2012). A tale of tweets: Analyzing microblogging among language learners. System, 40(1), 48–63.

Lowenthal, P. R., & Dunlap, J. C. (2014). Problems measuring social presence in a community of inquiry. *E-Learning and Digital Media*, *11*(1), 19-30.

Makri, K., Papanikolaou, K., Tsakiri, A., & Karkanis, S. (2013, January). Training teachers to learn by design, through a community of inquiry. In Proceedings of the International Conference on e-Learning (pp. 274-283).

Mouzouri, H. (2016). The Relationships between Students' Perceived Learning Styles and the Community of Inquiry Presences in a Graduate Online Course. *International Journal of Emerging Technologies in Learning*, *11*(4).

Oh, E. G., Huang, W. H. D., Mehdiabadi, A. H., & Ju, B. (2018). Facilitating critical thinking in asynchronous online discussion: comparison between peer-and instructor-redirection. *Journal of Computing in Higher Education*, *30*(3), 489-509.

Poscente, K. R., & Fahy, P. J. (2003). Investigating triggers in CMC text transcripts. *The International Review of Research in Open and Distributed Learning*, *4*(2).

Rourke L., Anderson T., Garrison D. R., Archer W. (2001). Methodological Issues in the Content Analysis of Computer Conference Transcripts. International Journal of Artificial Intelligence in Education (IJAIED), 12, 8-22

Lias, T. E., & Elias, T. (2011). Learning Analytics: The Definitions, the Processes, and the Potential.

Ma, Z. Q., Wang, J., Wang, Q. Y., Kong, L. L., Wu, Y. J., & Yang, H. (2017). Verifying causal relationships among the presences of the community of inquiry framework in the Chinese context. International Review of Research in Open and Distributed Learning, 18(6), 213–230.

Marzouk, Z., Rakovic, M., Liaqat, A., Vytasek, J., Samadi, D., Stewart-Alonso, J., ... & Nesbit, J. C. (2016). What if learning analytics were based on learning science?. Australasian Journal of Educational Technology, 32(6).

May, M., George, S., & Prévôt, P. (2011). TrAVis to enhance students' self-monitoring in online learning supported by computer-mediated communication tools.

Computer Information Systems and Industrial Management Applications, 3, 623-634.

Mazza, R., Bettoni, M., Faré, M., & Mazzola, L. (2012). Moclog–monitoring online courses with log data.

McKlin, T. E. (2004). Analyzing cognitive presence in online courses using an artificial neural network. (Published doctoral dissertation). Georgia State University, USA

McKlin, T., Harmon, S.W., Evans, W., & Jone, MG. (2002). Cognitive presence in Web-based learning: A content analysis of students' online discussions. American Journal of Distance Education, 15(1), 7-23.

Mercer, N., Sociocultural discourse analysis: analysing classroom talk as a social mode of thinking. Journal of Applied Linguistics, 1, 2, (2004), 137-168.

Merceron, A., Blikstein, P., & Siemens, G. (2016). Learning analytics: from big data to meaningful data. Journal of Learning Analytics, 2(3), 4-8.

Meyer, K. (2003). Face-to-face versus threaded discussions: The role of time and higher-order thinking. *Journal of Asynchronous Learning Networks*, 7(3), 55-65.

Meyer, K. A. (2004). Evaluating online discussions: Four different frames of analysis. Journal of Asynchronous Learning Networks, 8(2), 101−114.

Moreira, J. A., Ferreira, A. G., & Almeida, A. C. (2013). Comparing communities of inquiry of Portuguese higher education students: One for all or one for each? Open Praxis, 5(2), 165–178.

Muñoz-Cristóbal, J. A., Rodríguez-Triana, M. J., Gallego-Lema, V., Arribas-Cubero, H. F., Asensio-Pérez, J. I., & Martínez-Monés, A. (2018). Monitoring for awareness and reflection in ubiquitous learning environments. International Journal of Human–Computer Interaction, 34(2), 146-165.)

Murphy, E. (2004). Recognizing and promoting collaboration in an online asynchronous discussion. *British Journal of Educational Technology*, 35(4), 421-431.

Muzio, J. (1989). Email and electronic transfer of data files for a distance education course. In R. Mason & A. Kaye (Eds.), Mindweave (pp. 198-200). Oxford: Pergamon Press.

Naranjo, M., Onrubia, J., & Segués, M. T. (2012). Participation and cognitive quality profiles in an online discussion forum. British Journal of Educational Technology, 43(2), 282-294.

Neuendorf, K. A. (2002). The content analysis guidebook. Thousand Oaks, CA: Sage.

Neuendorf, K. A. (2005). The content analysis guidebook online: An accompaniment to the content analysis guidebook by Kimberly A. Neuendorf. *Cleveland, OH: Cleveland State University. Retrieved March*, *1*, 2006.

Newell, A. (1990). *Unified theories of cognition*. Cambridge, MA: Harvard University Press.

Newman, D. R., Webb, B., & Cochrane, C. (1995). A content analysis method to measure critical thinking in face-toface and computer supported group learning. *Interpersonal Computing and Technology, 3*, 56–77.

Nistor, N., M. Derntl, & R. Klamma, Learning analytics: trends and issues of the empirical research of the years 2011–2014, in Design for Teaching and Learning in a Networked World, G. Conole, et al., Editors. 2015, Springer International Publishing. p. 453-459.

Olpak, Y. Z., & Cakmak, E. K. (2018). Examining the reliability and validity of a Turkish version of the Community of Inquiry Survey. Online Learning Journal, 22(1), 142-160.

Osguthorpe, R. T., & Graham, C. R. (2003). Blended learning systems: Definitions and directions. Quarterly Review of Distance Education, 4(3), 227-234.

Papanikolaou, K. A. (2014). Constructing interpretative views of learners' interaction behavior in an open learner model. *IEEE Transactions on Learning Technologies*, *8*(2), 201-214.

Papanikolaou, K. A. (2015). Constructing interpretative views of learners' interaction behavior in an open learner model. IEEE Transactions on Learning Technologies, 8(2), 201-214. Partnership for 21st Century Skills. (2009). Retrieved from http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf

Papanikolaou, K., Gouli, E., Makri, K.: Designing pre-service teacher training based on a combination of TPACK and Communities of Inquiry. In 5th World Conference on Educational Sciences (WCES), Sapienza, University of Rome, Italy, February 5-8, 2013, Procedia – Social and Behavioral Sciences. Elsevier (2014)

Pawan, F., Paulus, T. M., Yalcin, S., & Chang, C. F.: Online learning: Patterns of engagement and interaction among in-service teachers. Language Learning & Technology, 7(3), pp. 119-140 (2003)

Peña-Ayala, A. (2018). Learning analytics: A glance of evolution, status, and trends according to a proposed taxonomy. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 8(3), e1243.

Perkins, C., & Murphy, E. (2006). Identifying and measuring individual engagement in critical thinking in online discussions: An exploratory case study. Educational Technology & Society, 9(1), 298-307.

Petropoulou, O., Kasimatis, K., Dimopoulos, I., & Retalis, S. (2014). LAe-R: A new learning analytics tool in Moodle for assessing students' performance. Bulletin of the IEEE Technical Committee on Learning Technology, 16(1), 2-5.

Pool, J., Reitsma, G. M., & Van den Berg, D. N. (2017). Revised Community of Inquiry framework: examining learning presence in a blended mode of delivery

Potter, W. J., & Levine-Donnerstein, D. (1999). Rethinking validity and reliability in content analysis.

Qiany, Q., Huz, J., Jiny, R., Peiz, J. and Zhu, S. (2014). Distance Metric Learning Using Dropout: A Structured Regularization Approach, KDD'14, August 24–27, 2014, New York, USA.

Rife, D., Lacy, S., & Fico, F. (1998).Analyzing media messages: Quantitative content analysis. New Jersey: Erlbaum.

Ritsos, P. D., & Roberts, J. C. (2014). Towards more visual analytics in learning analytics. Proceedings of the 5th EuroVis workshop on visual analytics (pp. 61–65). .

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (2001). Methodological issues in the content analysis of computer conference transcripts. International Journal of Artificial Intelligence in Education (IJAIED), 12, 8-22.

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (2003). Appendix B: Methodological issues in the content analysis of computer conference transcripts. In D. R. Garrison & T. Anderson (Eds.), E-learning in the 21st Century (pp. 129- 152). London: RoutledgeFalmer.

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (1999): Assessing social presence in asynchronous text-based computer conferencing. Journal of Distance Education, 14, 51–70

Roussinos, D., & Jimoyiannis, A. (2013). Analysis of students' participation patterns and learning presence in a wiki-based project. *Educational Media International*, *50*(4), 306-324.

Santos, J. L., Govaerts, S., Verbert, K., & Duval, E. (2012). Goal-oriented visualizations of activity tracking: A case study with engineering students. Proceedings of the 2nd International Conference on Learning Analytics and Knowledge, 143-152. DOI: 10.1145/2330601.2330639

Schellens, T., van Keer, H., de Wever, B., & Valcke, M. (2009). Tagging thinking types in asynchronous discussion groups: effects on critical thinking. Interactive Learning Environments, 17(1), 77-94. doi:10.1080/10494820701651757

Sedrakyan, G., Järvelä, S., & Kirschner, P. (2016). Conceptual framework for feedback automation and personalization for designing learning analytics dashboards.

Semple, A. (2000). Learning theories and their influence on the development and use of educational technologies. Australian Science Teachers Journal, 46(3), 21-28.

Shea, P., & Bidjerano, T. (2009a). Cognitive presence and online learner engagement: A cluster analysis of the community of inquiry framework. Journal of Computing in Higher Education, 21(3), 199.

Shea, P., & Bidjerano, T. (2009b). Community of inquiry as a theoretical framework to foster "epistemic engagement" and "cognitive presence" in online education. Computers and Education, 52(3), 543-553.

Shea, P., & Bidjerano, T. (2010). Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments. Computers & Education, 55(4), 1721-1731.

Shea, P., & Bidjerano, T. (2012). Learning presence as a moderator in the community of inquiry model. Computers & Education, 59(2), 316-326.

Shea, P., & Bidjerano, T. (2013). Understanding distinctions in learning in hybrid, and online environments: An empirical investigation of the community of inquiry framework. Interactive Learning Environments, 21(4), 355-370.

Shea, P., Hayes, S., Vickers, J., Gozza-Cohen, M., Uzuner, S., Mehta, R., ... & Rangan, P. (2010). A re-examination of the community of inquiry framework: Social network and content analysis. The Internet and Higher Education, 13(1-2), 10-21.

Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist*, *57*(10), 1380-1400.

Siemens, G., & d Baker, R. S. (2012). Learning analytics and educational data mining: towards communication and collaboration. In Proceedings of the 2nd international conference on learning analytics and knowledge (pp. 252-254). ACM.

Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. *EDUCAUSE review*, *46*(5), 30.

Solmaz, O. (2016). # Beyond140: Helping Pre-Service Teachers Construct a Community of Inquiry on Twitter. *Turkish Online Journal of Educational Technology-TOJET*, *15*(4), 1-15.

Stein, D. S., Wanstreet, C. E., Slagle, P., Trinko, L. A., & Lutz, M. (2013). From 'hello'to higher-order thinking: The effect of coaching and feedback on online chats. *The Internet and Higher Education*, 16, 78-84.

Stenbom, S. (2018). A systematic review of the Community of Inquiry survey. *The Internet and Higher Education*.

Stewart C. Learning Analytics: Shifting from theory to practice. J Empower Teach Excel. 2017;1(1):10.

Strijbos, J. W., Martens, R. L., Prins, F. J., & Jochems, W. M.: Content analysis: What are they talking about?. Computers & Education, 46(1), 29-48 (2006)

Swan, K. (2019). Social Construction of Knowledge and the Community of Inquiry Framework. In *Open and Distance Education Theory Revisited* (pp. 57-65). Springer, Singapore.

Swan, K., & Shea, P. (2005). Social presence and the development of virtual learning communities. In S. Hiltz & R. Goldman (Eds.), Learning together online: Research on asynchronous learning networks (pp. 239–260). Mahwah, NJ: Lawrence Erlbaum.

Swan, K., Garrison, D. R. & Richardson, J. C. (2009). A constructivist approach to online learning: the Community of Inquiry framework. In Payne, C. R. (Ed.) Information Technology and Constructivism in Higher Education: Progressive Learning Frameworks. Hershey, PA: IGI Global, 43-57.

Swan, K., Shea, P., Richardson, J., Ice, P., Garrison, D. R., Cleveland-Innes, M., & Arbaugh, J. B. (2008). Validating a measurement tool of presence in online communities of inquiry. E-Mentor, 2(24), 1-12.

Tzelepi, M., Petroulis, I., & Papanikolaou, K. (2019, June). Investigating Gamification and Learning Analytics Tools for Promoting and Measuring Communities of Inquiry in Moodle Courses. In *International Conference in Methodologies and intelligent Systems for Techhnology Enhanced Learning* (pp. 89-96). Springer, Cham.

Valcke, M., De Wever, B., Zhu, C., & Deed, C. (2009). Supporting active cognitive processing in collaborative groups: Potential of Bloom's taxonomy as a labelling tool. The Internet and Higher Education, 12, 165–172

Van Leeuwen, A., Janssen, J., Erkens, G., & Brekelmans, M. (2014). Supporting teachers in guiding collaborating students: Effects of learning analytics in CSCL. Computers & Education, 79, 28–39.

Vaughan, N. D., Cleveland-Innes, M., & Garrison, D. R. (2013). Teaching in blended learning environments: Creating and sustaining communities of inquiry. Athabasca University Press.

Vaughan, D., & Garrison, R. D. (2005). Creating cognitive presence in a blended faculty development community. Internet and Higher Education, 8(2005), 1–12.

Viberg, O., Hatakka, M., Bälter, O., & Mavroudi, A. (2018). The current landscape of learning analytics in higher education. Computers in Human Behavior.

Vieira, C., Parsons, P., & Byrd, V. (2018). Visual learning analytics of educational data: A systematic literature review and research agenda. Computers & Education, 122, 119-135.

Voulgari, I., & Komis, V. (2010). "Elven Elder LVL59 LFP/RB. Please PM me": Immersion, collaborative tasks and problem-solving in massively multiplayer online games. Learning, Media and Technology, 35(2), 171–202.

Wang, W. (2011). A Content Analysis of Reliability in Advertising Content Analysis Studies.

Wang, Y., & Liu, Q. (2019). Effects of online teaching presence on students' interactions and collaborative knowledge construction. *Journal of Computer Assisted Learning*.

Wanstreet, C. E., & Stein, D. S. (2011). Presence over time in synchronous communities of inquiry. *American Journal of Distance Education*, *25*(3), 162-177.

White, B., Frederiksen, J., & Collins, A. (2009). 10 The Interplay of Scientific Inquiry and Metacognition. *Handbook of metacognition in education*, 175.

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., ... & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. Metacognition and Learning, 4(1), 63-85.

Wilson, A., Watson, C., Thompson, T. L., Drew, V., & Doyle, S. (2017). Learning analytics: Challenges and limitations. Teaching in Higher Education, 22(8), 991-1007.

Wise, A. F., & Shaffer, D. W. (2015). Why Theory Matters More than Ever in the Age of Big Data. Journal of Learning Analytics, 2(2), 5-13.

Wise, A. F., Zhao, Y., & Hausknecht, S. N. (2013). Learning analytics for online discussions: a pedagogical model for intervention with embedded and extracted analytics. In Proceedings of the third international conference on learning analytics and knowledge (pp. 48-56). ACM.

Yu, T., & Richardson, J. C. (2015). Examining reliability and validity of a Korean version of the Community of Inquiry instrument using exploratory and confirmatory factor analysis. Internet and Higher Education, 25, 45–52.

APPENDICES:

Appendix A:

Questionnaire - Part A
Q.1. Did the classification of instructors' messages give a different perspective on the discussion? (closed question)
Q.2. Did the classification of peers' messages give a different perspective on the discussion? (closed question)
Q.3. When did you choose "Like" for your instructors' messages?
Q.4. Generally which function did you find useful: Classification or "Like"? Why?
Part B
Q1. What made it difficult to classify instructors' messages;
Q2. Were the descriptions of the categories of teaching presence accurate and distinct?
Q3. Which instructors' messages did you find difficult to classify?
Q4. What made it difficult to classify peers' messages;
Q5. Were the descriptions of the categories of cognitive presence accurate and distinct?