COGNITIVE PRESENCE IN VIRTUAL COLLABORATIVE LEARNING: ASSESSING AND IMPROVING CRITICAL THINKING IN ONLINE DISCUSSION FORUMS

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ABSTRACT

The paper introduces a virtual collaborative learning setting called 'Net Economy', which we established as part of an international learning network of currently seven universities. Using the Community of Inquiry framework as guidance and Canonical Action Research (CAR) as the chosen research design, the discussion forum of the online course is assessed regarding its critical thinking value. We thereby measure critical thinking with the help of the according model provided by Newman et al. (1995), which differentiates 40 indicators of critical thinking from ten different categories. The calculated critical thinking ratios for the analyzed two discussion threads indicate a strong use of outside knowledge, intensive justification as well as critical assessment of posts by the students. But at the same time there are also weak spots, like manifold repetitions. Based on these results we derive changes for the next course cycle in order to improve the critical thinking of the students.

KEYWORDS

Virtual Collaborative Learning, Critical Thinking, Community of Inquiry, Forum Analysis

1. INTRODUCTION

Learning with new media is becoming increasingly popular in times of MOOCs and a continuing growth in the use of mobile devices. Outside the traditional classroom, learning can spread to more diverse settings, contexts, and locations. As at the same time virtual collaboration is gaining significance in business, virtual collaborative learning (VLC) as a sophisticated type of eLearning setting gains growing attention in both research and higher education practice. The accompanying pedagogical and technological innovations thereby create new challenges for the instructors and also redefine their roles.

Successful eLearning requires learning environments that motivate the students and facilitate meaningful and worthwhile learning. A suitable design and a well-structured learning process need to consider social, technical and didactic challenges as interdependent dimensions of a good learning experience (Garrison 2011). VCL-settings thereby aim at the skills that are required and considered indispensable for virtual collaboration, involving team members working from various international locations and with heterogeneous cultural and educational backgrounds.

This paper introduces our own VCL learning scenario 'Net Economy' as part of a continuous build-and-evaluate loop, while our improvement efforts follow the iterative steps of canonical action research (CAR): diagnosis, action planning, intervention, evaluation, and reflection (Davison et al. 2004; Susman & Evered 1978). Action research is committed to "[…] the production of new knowledge through the seeking of solutions or improvements to 'real-life' problem situations." (McKay & Marshall 2001) It thus serves both, research and practice by studying the real world while considering a particular theoretical framework.

For our eLearning action research the Community of Inquiry (CoI) as introduced by Garrison et al. (2000) serves as the required theoretical framework, consisting of the three interdependent elements of 1) social presence, 2) cognitive presence and 3) teaching presence. While social presence is "the ability of participants to identify with a group, communicate purposefully in a trusting environment, and develop personal and affective relationships progressively by way of projecting their individual personalities"

(Garrison 2011, p. 23), cognitive presence is "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry" (Garrison et al. 2001). Teaching presence, finally, is "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" and thus merges all elements in a balanced and functional relationship.

While in previous papers we developed solutions mainly for various problems of teaching and social presence, like e.g. the use of a dedicated social network instead of a learning management system, we have so far not explicitly addressed the eLearning elements of the setting with regard to the required cognitive presence. According to the CoI framework students need to be "engaged in a collaborative and reflective process which includes understanding an issue or problem, searching for relevant information, connecting and integrating information, and actively confirming the understanding" (Garrison 2011, p. 94). An obvious instrument to do so seem to be discussion forums, which are therefore commonly used in eLearning. Computer-mediated communication tools, like discussion forums, provide ways for learners to interact. Research suggests that asynchronous online discussions are even superior with regard to critical thinking and knowledge co-construction due to the available time for reflection and more critical and constructive contributions when compared to synchronous face-to-face discussions (Wang et al. 2009). On the other hand, in practice, it usually stays unassessed and questionable whether the initiated discussions really provided for the intended critical and reflective interaction among the participants and thus for cognitive presence.

In the following we, therefore, measure and analyze the critical thinking ratio of the discussion forum that we established in our 'Net Economy' setting as part of a required discussion task. Based on this diagnosis step we will then derive interventions that aim at improving the critical and reflective thinking and thus the cognitive presence. After a short introduction of our VCL-setting in section 2, we will outline the diagnosis approach as adapted from Newman et al. (1995) and assess the critical thinking in our implemented discussion forum in section 3. In section 4 we will then derive interventions as improvement suggestions for the next course cycle before we conclude in section 5.

2. THE NET ECONOMY VCL-SETTING

'Net Economy' is an annual cross-location virtual collaborative learning setting (VCL) in the framework of an international learning network which we established in 2008. The setting targets participants with heterogeneous educational backgrounds in the fields of business and economics, business informatics, international economy and hotel & tourism management, as well as different cultural backgrounds from Germany (Berlin, Mühlheim an der Ruhr, Soest), Indonesia (Jakarta), Crimea (Simferopol) and Sweden (Kristianstad). The course is taught in English and deals with entrepreneurship and business models in the net economy. Between 80 and 150 students took part in each course cycle so far and worked in virtual intercultural teams on exercises concerning eBusiness models and virtual collaboration. All partners agreed on the general learning scenario, leading to a stable VCL-concept which we systematically improve using the previously mentioned canonical action research approach.

'Net Economy' is a complete online class with only three parallel classroom meetings at the various locations at the beginning of the different phases of the course, as depicted in fig. 1. A closed social network (established with Wordpress and several plugins) serves as the major coordination platform for the course and facilitates social presence. Every student needs to set up a profile and join a team within the first weeks of the class, called Preparation Phase. During these weeks, the whole concept is introduced and the different tasks and roles within a team are described and assigned. The students team up to groups of five, in which every team member has a very specific role to fulfill. Only two members of the same university are allowed to be part of the same group so that a high diversity is given in each team. In the following Knowledge Development Phase, the students are then introduced to some major characteristics, concepts and challenges of eCommerce and the Web 2.0 and to major types of business models on the web. On each of the topics introduced by the instructors via eLecture, the individual students as well as the teams have to complete and submit assignments. Each participating location is responsible for one of these eLectures and an according online assignment. Knowledge Development Phase, ends with a multiple choice test on the topics covered in the eLectures. In the final Case Study Phase every team is then asked to apply the acquired knowledge and develop a business plan for an assigned business model type using the so-called business model canvas. This

Case Study Phase includes a peer review process in which each team receives feedback from at least two other teams. The top rated teams then present their business plan during a final live online meeting, in which all participants will vote for the top E-Venture of the class.

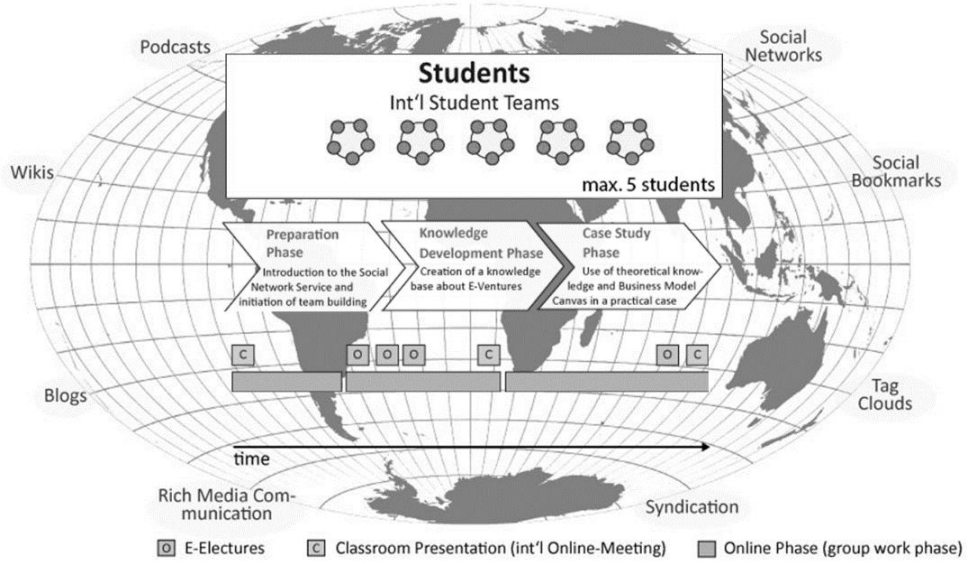

Figure 1. The Net Economy Learning Scenario

In the last course cycle accomplished between October 2014 and February 2015, students were asked to contribute to an online discussion individually as a first assignment. They could choose between two discussion threads on which they got a reading and had to write a first forum post pointing out their personal opinion and thoughts regarding the topics of the articles. In addition, they had to comment on at least two other posts and emphasize in their statements whether they support or rebut the post they are answering to, in order to facilitate critical and reflective thinking. Discussion thread 1 discussed the online available WIRED article "The Web is dead. Long live the Internet." by Chris Anderson and Michael Wolff and initiated discussion with the question: "How does the article and the discussion around it reflect today's eCommerce trends and what consequences would you expect from the development for popular online businesses?" Discussion thread 2 dealt with the as well online available Fast Company article "Encyclopaedia Britannica (EB) is dead, long live Encyclopaedia Britannica", raising the question: "Why did the original business model have to change and how did the Encyclopedia Britannica adapt? Do you believe in the viability of the business model?" The not any further moderated forum aimed to facilitate discourse and make the students think critically about the provided articles.

In total 80 members were registered on the 'Net Economy' network in the last course cycle. Next to the lecturers 13 teams of five active students, in total 65 students, were working on the platform. 56 students (86%) participated in this first individual assignment and 166 replies were posted, which are about three posts per participating student, indicating that the students fulfilled their task of writing one statement and two replies. To investigate the qualitative value of the forum posts, however, a closer look has to be taken at the posts themselves and a more qualitative analysis is required, as accomplished in the following chapters.

3. METHODOLOGY & APPLICATION OF METHOD

3.1 Critical Thinking

In the literature, many definitions of critical thinking can be found. According to the Foundation for Critical Thinking (2015) the word "critical" derives etymologically from two Greek roots: "kriticos" (meaning discerning judgment) and "kriterion" (meaning standards). Etymologically, then, the word implies the development of "discerning judgment based on standards." Ennis (1993) defines critical thinking as

"reasonable reflective thinking focused on deciding what to believe or do." In his opinion, a person needs to e.g. judge the credibility of sources and the quality of arguments, identify conclusions, reasons, and assumptions or develop and defend a position on an issue. Critical thinking therefore requires a wide set of information, generating processes and standards to base one's thinking on and relies on the person involved to have the intellectual commitment to make use of these skills and standards to guide his/her behavior.

Thus, critical thinking is a state of thinking that is beyond one's own, or even groups, interests and is dependent on the quality of standards and depth of experience the thinker has in respect to a particular problem or question. It also depends on different values and cultures, as differences in culture can have different effects and interpretations of being critical, as "in some cultures, being critical may be interpreted as 'argumentative' or 'being critical of others'" (Woo & Wang 2009). Simplified one can say that critical thinking involves seeking information, analyzing alternatives, evaluating the alternatives in relation to your aims and requirements and reaching a conclusion to the problem or answer.

In addition, critical thinking can also relate to other important areas in learning. Lai (2011) for example, says that "critical thinking skills relate to several other important student learning outcomes, such as metacognition, motivation, collaboration, and creativity." Being able to assess one's own arguments and reasoning is necessary for self-regulated learning. Tasks, which spark interest and are challenging the students usually call for critical thinking and trigger motivation. Collaboration requires the students to think in diverse perspectives and the more diverse they can think the better collaborators they may become. Opportunities for collaboration may also encourage higher quality thinking itself. Finally, also creative thinking incorporates attributes of critical thinking, such as open-mindedness and flexibility. All these attributes enhance the learning experience for the students and stimulate intellectual and personal growth (Lai 2011).

3.2 Assessing Critical Thinking through Content Analysis

In literature, many instruments are described which focus on content analysis and aim at providing evidence of learning and the knowledge construction taking place. These instruments represent a wide variety of approaches and differ in their level of detail, type of analysis categories and most important the diversity of their theoretical base (Wever et al. 2006). Content analysis instruments need to be objective, reliable, replicable, and systematic (Rourke et al. 2001). Instruments to measure critical thinking in terms of content analysis in a thematic unit of analysis were for example introduced by Newman et al. (1995) and Bullen (1998).

Whereas Bullen's framework is based on different conceptualizations of critical thinking and consists of four different categories of critical thinking skills, Newman et al.'s approach is based on Garrison's (1991) five stages of critical thinking and Henri's (1992; cited in: Wever et al. 2006) cognitive skills. In his papers, Garrison describes critical thinking as a problem-solving process in which the critical thinker will move through five stages: *problem identification, problem definition, problem exploration, problem applicability, problem integration.* Marra et al. (2004) evaluate the Newman et al. protocol to be good for high-level descriptive data of what is happening in a discussion and clearly defined with numerous codes and coding rules. In our study we, therefore, used this approach to analyze the critical thinking of our students in the above-described discussion scenario.

A prerequisite for this method, however, is that critical thinking indicators are identifiable, or in other words "critical thinking should be defined in such a way that it is measurable" (Woo & Wang 2009). In order to cover all possible types of posts in a discussion forum, Newman et al. (1995) expanded the five stages into the following 10 categories of critical thinking indicators: *Relevance, Importance, Novelty, Ambiguity, Outside Knowledge, Linking ideas, Justification, Critical Assessment, Practical Utility and Width of Understanding.* Each of the indicators has a pair of opposites, one for in-depth processing, and one for surface learning (Newman et al. 1995). Newman et al. have developed a full set of 40 indicators within the ten categories, as depicted in fig. 2.

Category		Positive Indicator		Negative Indicator	
R±	Relevance	R+	Relevant statements	R–	Irrelevant statements, diversions
I±	Importance	I+	Important points/issues	I–	Unimportant, trivial points/issues
N±	Novelty; new info, ideas, solutions	NP+	New problem-related information	NP–	Repeating what has been said
		NI+	New ideas for discussion	NI–	False or trivial leads
		NS+	New solutions to problems	NS–	Accepting first offered solution
		NQ+	Welcoming new ideas	NQ–	Squashing, putting down new ideas

Figure 2. Excerpt of coding indicators of the Newman et al. framework (Marra et al. 2004)

While the categories are provided in the left column, the individual indicators and their pairs with the matching codes follow in the second and third column. A positive indicator for the Novelty category could, for example, be new problem-related information (NP+) provided by a student or the welcoming of new ideas (NQ+). Negative indicators would, for instance, be repetitions (NP−), or even the dismissal of new ideas of a previous speaker (NQ−) as well as irrelevant statements (R−).

Along these provided categories with their various indicators, every post needs to be evaluated separately and codified accordingly. Statements may cover phrases, sentences, paragraphs or mere messages containing one unit of meaning and referring to least one of the indicators. It may even happen that some indicators overlap with each other (see figure 3 for example). This is why the coding needs to be carried out in chronological order, evaluating the first post first and the later posts to the end of the evaluation sequence. Only in this manner, the posts can be assessed properly and new content or repetitions can be identified correctly. Furthermore, the links between the different individual threads can be identified this way. But rather than classifying and coding every single word it is reasonable and even suggested to mark and count the obvious examples, and ignore the intermediate shades of gray (Newman et al. 1995).

After assessing all posts in this way the approach allows for the calculation of a critical thinking ratio based on formula 1 depicted below. The x ratio with x identifying the category is calculated by subtracting the sum of all negative indicator from the sum of all positive indicators, divided by the sum off all indicators. The resulting measure thereby expresses solely the quality of the text without depending on the quantity of participants. This way ten critical thinking ratios are calculated, one for each category, and all of them in a range of *−1 (all uncritical, all surface)* to *+1 (all critical, all surface)* (Newman et al. 1995).

$$x\,ratio = \frac{x^{+} - x^{-}}{x^{\pm}}$$

Formula 1. Calculation of critical thinking ratio (simplified according to Newman et al. 1995)

3.3 Forum Analysis

The following analysis of the above-explained discussion forum was conducted with the help of the students of the 'Net Economy' course themselves. One student of each team was assigned the role of a research partner and as such had to mark the transcripts of the discussion thread that he did not participate in himself. The research partners were introduced to the job and the approach in a web conference, and, in addition, a short tutorial was provided on how the free coding software QDAminer Lite can be used to do the job. The transcripts of the forums were provided to the students together with the indicators as a predefined project in QDAminer Lite. Nine out of the 13 research partners submitted complete and acceptable coding projects with four students covering discussion thread 1 and five students covering thread 2.

The analysis to follow is a merger of these nine complete coding projects provided by the students. Fig. 3 shows how the coding of a post looks like in QDAminer with the positive and the negative indicators being depicted in the right. Building on to these individual codings we then proceeded by summing up all appearances of the different indicators and by calculating the critical thinking ratio for each category. While the two discussion threads were coded separately we later also merged the results, since both threads were set up and managed in the exact same way. This way we were able to calculate critical thinking ratios also for the discussion forum as a whole.

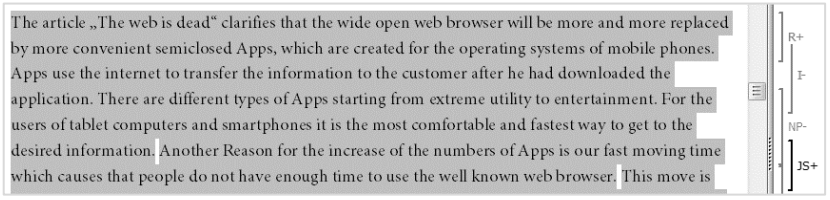

Figure 3. Coding of forum posts

Several problems accompanying the chosen analysis approach and research design need to be considered. Next to the apple-and-pear problem because of possible variances between the different codings of the students, also very small numbers of appearances of specific indicators lead to the risk of over-interpretation. We, therefore, do not consider the critical thinking ratios of the *Practical Utility* and the *Width of Understanding* category in our analysis, as these indicators were used too rarely. Another limitation to keep in mind is that the chosen critical thinking model does not answer any specific question or solve any specific problem, but rather develops an overall rating for the quality of the interactions between the students and their discussion behavior.

4. RESULTS & ACTION PLANNING

After merging the coding projects, the results shown in table 1 can be calculated for the ten categories. We were able to evaluate eight of the ten categories when considering the sample sizes. Only for the *Ambiguity* category a negative result was calculated, indicating that the coding students found many confusing statements. All other ratios are positive with mostly rather small differences between the ratios for the discussion threads 1 and 2. As Newman et al. do not provide a scheme for interpreting the results except for-1 indicating all uncritical and surface posts and +1 indicating all critical and deep contributions, there is a clear need to compare the derived ratios with the ratios of comparable settings. This actually matches our CAR approach of a continuous build-and-develop loop, since we will derive interventions in the next step that aim at improving the critical thinking in the implemented discussion forum, with the critical thinking ratios allowing us to assess and evaluate any achieved improvement.

Table 1. Critical thinking ratios in the 'Net Economy' forum calculated after Newman et al. (1995)

Category		Topic 1			Topic 2			Combined		
		Indicator		Ratio	Indicator		Ratio	Indicator		Ratio
		+	−		+	−		+	−	
R±	**Relevance**	118	46	0,44	125	85	0,19	243	131	0,30
I±	**Importance**	58	53	0,05	34	11	0,51	92	64	0,18
N±	**Novelty**	201	156	0,13	158	75	0,36	359	231	0,22
A±	**Ambiguity**	35	72	−0,35	19	42	−0,38	54	114	−0,36
O±	**Outside Knowledge**	189	27	0,75	102	14	0,76	291	41	0,75
L±	**Linking Ideas**	62	41	0,20	29	31	−0,03	91	72	0,12
J±	**Justification**	184	20	0,80	137	31	0,63	321	51	0,73
C±	**Critical Assessment**	55	12	0,64	74	6	0,85	129	18	0,76
P±	**Practical Utility ***	10	0	* (1)	5	5	0	15	5	* (0,50)
W±	**Width of Understanding ***	15	2	* (0,76)	12	7	0,26	27	9	* (0,50)

* These categories are not considered any further due to too small samples.

The high scores (CT≥0,70) among the above results nevertheless point at several positive characteristics of the students discussion behavior. Outside knowledge was used a lot (CT=0,75), justifications were regularly provided (CT=0,73) and the posts were mostly critically assessed by fellow students (CT=0,76). A drill-down into one of the higher and one of the lower scores provides a clearer view of the assessed discussion. Table 2 adds an overview of the samples of single indicators from the two categories *Linking Ideas* and *Outside Knowledge*. Personal experience and previous knowledge, as well as additional course material and external resources, were introduced frequently by the students. Furthermore, they were also able to link facts and ideas, but thereby continuously repeated information and statements provided by other students before.

Table 2. Closer Look on the Outside Knowledge and Linking Ideas category and the according numbers

Category	+ Indicator		Count	− Indicator		Count
O± bringing outside knowledge / experience to bear on problem	OE+	Drawing on personal experience	129	OQ−	Squashing attempts to bring in outside knowledge	6
	OC+	Refer to course material	54	O−	Sticking to prejudice or assumptions	22
	OM+	Use relevant outside material	60			
	OK+	Using previous knowledge	41			
	OP+	Course related problems brought in	19			
	OQ+	Welcoming outside knowledge	1			
L± linking ideas, interpretation	L+	Linking facts, ideas and notions	81	L−	Repeating information without making inferences or offering an interpretation	34
	L+	Generating new data from information collected	10	L−	Stating that one shares the ideas or opinions stated, without taking these further or adding any personal comments.	38

While these results indicate an overall positive discussion behavior from our point of view, the total number of posts points at a rather tightly focused fulfillment of the discussion task (one post + two replies). Students seem not to have participated in the discussion based on pure interest, curiosity or fun, but rather because it was a required task. The chosen topics and the way of raising and structuring the discussion seems not to have managed to turn the students' extrinsic motivation into intrinsic motivation, which should have resulted in some sort of over-fulfillment of the discussion task. The identified numerous repetitions of information support this interpretation.

As it is our goal to foster critical and reflective thinking and thus cognitive presence, we aim at engaging the students' in a more intrinsically motivated discussion in the future. Considering the above results we derived the following three interventions regarding the implementation of the discussion forum for the upcoming course cycle: 1) More polarizing discussion starters will be developed, including other media types, like e.g. video statements, pictures or podcasts in order address the students media behavior more systematically. 2) The instructors will contribute to the discussion with prepared statements that open up new directions of thinking from time to time so that the students get new ideas and notice that their posts are not only counted but read. 3) Discussion forums with consistent requirements and settings will be used in several phases of the course and critical and reflective thinking as a desired learning outcome will be turned into a subject of discussion itself in order to evolve a discussion culture.

After the next course cycle, we will assess the discussion forums and calculate the according critical thinking rations again in order to evaluate our interventions. This way we hope to have started an improvement process for the discussion forums as a major instrument of cognitive presence in eLearning.

5. CONCLUSION, DISCUSSION & FUTURE WORK

In this paper, we introduced the VCL-course 'Net Economy' and our iterative Canonical Action Research (CAR) approach aiming at a systematic improvement of the setting. Using the Community of Inquiry framework (CoI) as guidance, we focused on cognitive presence as one major requirement of successful online learning, which we intended to provide for by implementing a discussion forum and an according discussion assignment among other tasks. We evaluated the discussion forum regarding its cognitive value by calculating the critical thinking ratios for all ten categories suggested by the Newman et al. (1995) critical thinking diagnosis model. Using this approach we were able to diagnose some strength and weaknesses of our discussion setting and derived interventions to be implemented in the upcoming course cycle.

The Newman et al. model was simple to use and user-friendly since all categories and indicators are predefined. It provided for quality scores indicating the cognitive value of our discussion forum while not

depending on the number of participants. But despite this well-organized and user-friendly model, it turned out to be quite tedious and time-consuming to work through the assessed forum with regard to all 40 indicators contained in the model. A problematic aspect is also the interpretation of the derived results. While it is clear that the more the values tend towards −1 or +1 the worse respectively better discussion behavior they indicate, there is no guidance as where a good value might start or a bad value might end.

Regarding the analyzed discussion forum we found that the students frequently introduced outside knowledge to the discussion, that they argued intensely, and that they thereby addressed posts critically. On the other hand, they often repeated information and posted a high number of rather confusing statements. However, the various cultural and educational backgrounds of the students might also play an important role in this matter, opening up the field for further research. From the calculated results, we finally derived interventions for the upcoming course cycle aiming at turning the students' initial extrinsic discussion motivation into a more intrinsic one. A comparison of the results after the next course cycle will then allow us to assess the effects of the implemented changes, which would not be possible without a critical thinking diagnosis approach like the one provided by Newman et al. (1995) and used in this paper. Also, the process of analyzing a forum in such detail helped us a lot to understand the effects of the chosen discussion task with its strength and weaknesses better.

REFERENCES

Bullen, M., 1998. Participation and critical thinking in online university distance education. *International Journal of E-Learning & Distance Education*, Vol. 13, No. 2, pp. 1–32.

Davison, R. et al., 2004. Principles of canonical action research. *Information systems journal*, Vol. 14, No. 1, pp. 65–86.

Ennis, R. H., 1993. Critical thinking assessment. *Theory Into Practice*, Vol. 32, No. 3, pp. 179–186.

Foundation for Critical Thinking, 2015. *The Critical Thinking Community. Our Concept and Definition of Critical Thinking*. Available online at http://www.criticalthinking.org/pages/our-concept-of-critical-thinking/411, 5/6/2015.

Garrison, D. R., 2011. *E-learning in the 21st century. A framework for research and practice*. Routledge, New York.

Garrison, D. R. et al., 2000. Critical Inquiry in a Text-Based Environment: Computer Conferencing in Higher Education. *The Internet and Higher Education*, Vol. 2, No. 2-3, pp. 87–105.

Garrison, D. R. et al., 2001. Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of distance education*, Vol. 15, No. 1, pp. 7–23.

Garrison, D. R., 1991. Critical thinking and adult education: a conceptual model for developing critical thinking in adult learners. *International Journal of Lifelong Education*, Vol. 10, No. 4, pp. 287–303.

Henri, F., 1992. Computer conferencing and content analysis. *Collaborative learning through computer conferencing*. Springer, pp. 117–136.

Lai, E. R., 2011. Critical thinking: A literature review. *Pearson's Research Reports*, Vol. 6, pp. 40–41.

Marra, R. M. et al., 2004. Content analysis of online discussion forums: A comparative analysis of protocols. *Educational Technology Research and Development*, Vol. 52, No. 2, pp. 23–40.

McKay, J. and Peter M., 2001. The dual imperatives of action research. *Information Technology & People*, Vol. 14, No. 1, pp. 46–59.

Newman, D. R. et al., 1995. A content analysis method to measure critical thinking in face-to-face and computer supported group learning. *Interpersonal Computing and Technology*, Vol. 3, No. 2, pp. 56–77.

Rourke, L. et al., 2001. Methodological issues in the content analysis of computer conference transcripts. *International Journal of Artificial Intelligence in Education (IJAIED)*, Vol. 12, pp. 8–22.

Susman, G. I. and Roger D. E., 1978. An assessment of the scientific merits of action research. *Administrative science quarterly*, pp. 582–603.

Wang, Q. et al., 2009. Investigating critical thinking and knowledge construction in an interactive learning environment. *Interactive learning environments*, Vol. 17, No. 1, pp. 95–104.

Wever, B. de et al., 2006. Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education*, Vol. 46, No 1, pp. 6–28.

Woo, H. L. and Qiyun W., 2009. Using weblog to promote critical thinking-An exploratory study. *Proceedings of World Academy of Science: Engineering & Technology*, Vol. 37, pp. 431–439.