

UNIVERSITY OF SZEGED, FACULTY OF ARTS
DOCTORAL SCHOOL OF EDUCATION
DOCTORAL PROGRAM OF INFORMATION AND
COMMUNICATION TECHNOLOGIES IN EDUCATION

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**Interaction and social networks of learners in inquiry
based, networked, technology supported learning
communities and the effects of collaborative inquiry**

Summary of PhD dissertation

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Szeged

2016

PROBLEM STATEMENT AND BACKGROUND: AN INTRODUCTION

Research reported here focuses on online interaction networks, social networks of undergraduate students' communities of inquiry and some effects of inquiry based learning on student behaviour and performance. This multidisciplinary study is grounded in education, sociology, social psychology, network science and computer science. We used visual, mathematical, statistical research methods for the analysis of the learning communities. The methods applied are social network analysis, content analysis of the interactions, descriptive statistical analysis and path analysis.

We chose to assume a network perspective to investigate student learning, because we live in learning and networked society (Castells, 2005 [1996]; Csapó, 2003; Wellman, 1999), where students are connected and learn with and from each-other and use networked technologies for their interactions. The social relations and interactions of the participants during the learning processes can be perceived as complex systems. The students in these complex systems are active, collaborative agents (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004), who can work and learn together towards common goals such as investigating a learning domain. Such learning situation could be implemented as community driven inquiry learning based on progressive inquiry and collaboration (Hakkarainen et al., 2004; Muukkonen, Hakkarainen, & Lakkala, 1999). In this way, the learners of the collaborative inquiry become part of a community of inquiry (D Randy Garrison, Anderson, & Archer, 1999; Gunawardena et al., 2006; Lipman, 1991), where teaching, social and knowledge building interactions could help the social and the knowledge building processes.

The students in these learning communities are active agents with various positions and centralities according to their given and received comments. Also, they team up with others to solve tasks, take part in various clusters that help them in the learning processes. These clusters, segments, groupings could be diverse. Learning communities could be characterized by various structural variables, like connectedness or

fragmentation, number of components, density of relations (Hanneman, 2005), the rate of the core/periphery structure (Borgatti & Everett, 2000), etc. These structural properties help understand the interactions in learning communities and the collaborative knowledge building mechanisms. Moreover, it could be assumed, that the interactions between the learners are based on their social relations that serve as backcloth (Atkin, 1977) for the potential communication. Therefore, knowing the structure of students' social network could help teachers and educational researchers to understand the structure of the interactions the students do in their task solving processes.

According to the literature, the students like to collaborate with their peers (Tapscott, 2009), and they prefer using online learning environments, like blogs, that can motivate them to take active part of discussions (Kang, Bonk, & Kim, 2011), and collaboration with peers (Deng & Yuen, 2011). Students tend to use blogs for intensive information exchange (Kang et al., 2011; Kim, 2008; Yang, 2009), or inquiry (Chong, 2010).

Another important factor is the sense of belonging (Nagy, 2002), and the sense of community (Halic, Lee, Paulus, & Spence, 2010), that may help learners in the learning. Blogs as online learning environments may help forming and shaping learning communities (Kang et al., 2011) thorough the learning period. This could enhance and strengthen the sense of community among students (Luehmann & Tinelli, 2008).

In order to investigate the interactions, social network, attitudes towards collaborative inquiry, the perceived learning and sense of community of learners, we built a learning environment consisting of classroom learning and online learning. We asked students to conduct a semester long research on a given topics in small groups, and asked them to write short summaries of academic sources and present their findings in lass. The students used blog based closed online learning environments to share and discuss their written summaries (see Molnar, 2011; P. Molnár, 2010a, 2010b, 2013, 2014; P. Molnár & Pintér, 2014; Pintér & Molnár, 2014).

RESEARCH QUESTIONS, SAMPLE AND METHODS

The present study focuses on exploring networks of interactions in online networked learning environments, networks of friendships, the effects of these networks on perceived collaborative learning in online learning environment and sense of community. We investigated student activity in the online networked learning environments based on the communication along their shared summaries of academic writings. Then we analysed the friendship networks based on the students' friendship ties in a widely used online social network (Facebook). Beside the interaction and friendship data we asked students to tell about their attitudes towards collaborative learning before the current inquiry learning experiment and about their perceived collaborative learning experiences in the online networked learning environment and finally about their perceived sense of community.

Based on our research target, networked communities, we formulated the following research themes and questions.

I. Interactions of inquiry based learning in online networked learning environments

- What are the patterns of collaborations between students? How can we characterize the interaction patterns of the learning communities in the whole network, in the subgroup/subnetwork and at individual level? How is the core/periphery structure of the interaction networks? Are there similarities and differences between the courses' learning communities? What patterns can be revealed in and between student groups? What are the positions of the students according to their interactions and collaborations?

II. Friendship networks of the students participating in collaborative inquiry

- What patterns of friendships can be identified in the learning communities? How can we characterize the friendship patterns of the learning communities at the whole network, at the subgroup/subnetwork and at the individual level? How is the core/periphery structure of the

friendship networks? Are there similarities and differences between the courses' learning communities? What is the position of the students in relation to their friendships?

- Is there any correlations between the interaction/collaboration networks and the friendship networks?

III. Patterns of interactions in the online networked learning environments

- What are the amount and proportion of the cognitive, social and teaching interactions (dimensions) in the students' communication networks in the online networked learning environments? What is the pattern of interaction dimensions over time during the semester?

- What are the network patterns of the (cognitive, social and teaching) interaction dimensions? Is there any difference between these interaction dimensions?

IV. Attitude toward collaborative learning, perceived sense of collaborative learning in online networked environments and perceived sense of community

- At the start of the course: What is the ratio of students who thinks the collaboration with peers is important/not important and whose attitude toward collaborative learning is positive/negative?

- At the end of the course: What do students think about collaborative learning? How do they perceive learning in online networked learning environments? How do they perceive the sense of communities in the classroom and in the online learning environment?

V. Effects of the networked inquiry based learning

- What effects and correlations can be detected between the individual network variables (centrality positions) based on interaction and friendship data and between the variables identified by a questionnaire?

Research design and methods

In the research reported in this dissertation, we used mixed methods: descriptive social network analysis for the whole network, the subgroups and individual level for interaction and friendship networks (Wasserman & Faust, 1994); statistical network methods for comparative network analysis (Hubert, 1987; Krackhardt, 1987), content analysis for interaction data (D. Randy Garrison, Anderson, & Archer, 2000, 2001), descriptive statistics for analysing questionnaire data and path analysis for effects and correlations between the various variables (Aunio & Niemivirta, 2010; Bentler, 1980; Dancs & Kinyó, 2015; Greiff, Wüstenberg, & Funke, 2012; Kenny, 1979; G. Molnár & Pásztor, 2015; Szabó, Nguyen, Szabó, & Fliszár, 2012).

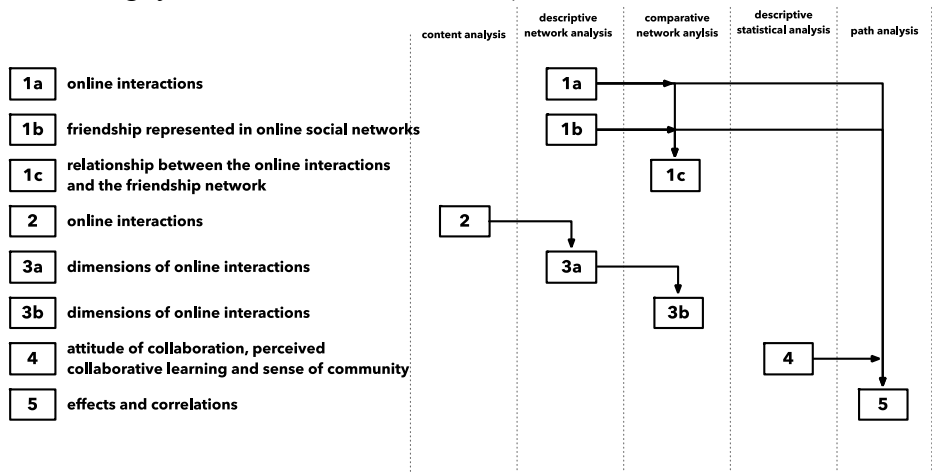


Figure 1 The research concept

Sample and measurements

Measurements were carried out in two phases. In the first phase, from the fall of 2009 to the spring of 2012, we collected network data from the courses' participants and tested some measurement tools: the tool that extracted students' social networks from online social network service with programming application interface, and the ways interaction data could extract from students' comments of the online learning

environments (course blogs). In the second phase, from the spring of 2013 to the spring of 2014, we collected all the data we used in the research.

Table 1. Sample

	Course 1		Course 2		Course 3	
	N	%	N	%	N	%
Registered students	46	100	57	100	50	100
Graded students (those completing the course)	41	89	54	95	44	88
Students participated in collaborative inquiry at the online learning environment (courseblog)	41	89	48	86	40	80
Sample size of friendship SNA	41	89	48	84	40	80
Sample size of students responded to the questionnaires	37	80	50	88	41	82
Sample size of the path analysis	36	78	44	77	39	78

Data collection involved network data extracted from the students' social networks represented in online social network site (Facebook), interaction data from the students' closed online research place (online learning environment), questionnaire data collected from the students at the beginning and at the end of the learning periods. (See Table 2. for questionnaires used in the study.

Questionnaire	Items	Course			All
		1	2	3	
		N=37	N=50	N=41	
At the beginning of inquiry learning					
Attitude towards collaborative learning ²	8	0,78	0,74	0,84	0,78
At the end of the inquiry learning					
Perceived collaborative learning ¹	8	0,89	0,78	0,76	0,82
Attitude towards collaborative learning ²	8	0,87	0,80	0,88	0,85
Perceived learning in the online learning environment ¹	7	0,90	0,80	0,80	0,83
Perceived sense of community ¹	12	0,86	0,80	0,84	0,86

Source: ¹Halic et al. (2010), ²Elen and Clarebout (2001)

RESULTS

Social network of students participating in inquiry based learning

The analysis focused on three levels: on the whole network, on the subgroup and on individual level. The statistical and visual network analysis revealed that in all of the three courses, students' networks were dense and well-connected. This feature is important for the cohesion of the communities (Moody & White, 2003; White & Harary, 2001), and to the information flow (Coburn, Choi, & Mata, 2010; Frank, Zhao, & Borman, 2004; Penuel, Frank, & Krause, 2010) in the communities. The analysis revealed the various centrality positions of the students in their learning communities: the friends of the students' (relative) counts (degree), which show students' positions in their immediate personal communities and the potential brokerage or intermediary positions (betweenness centrality), which is important for information flow and the reach of the communities members.

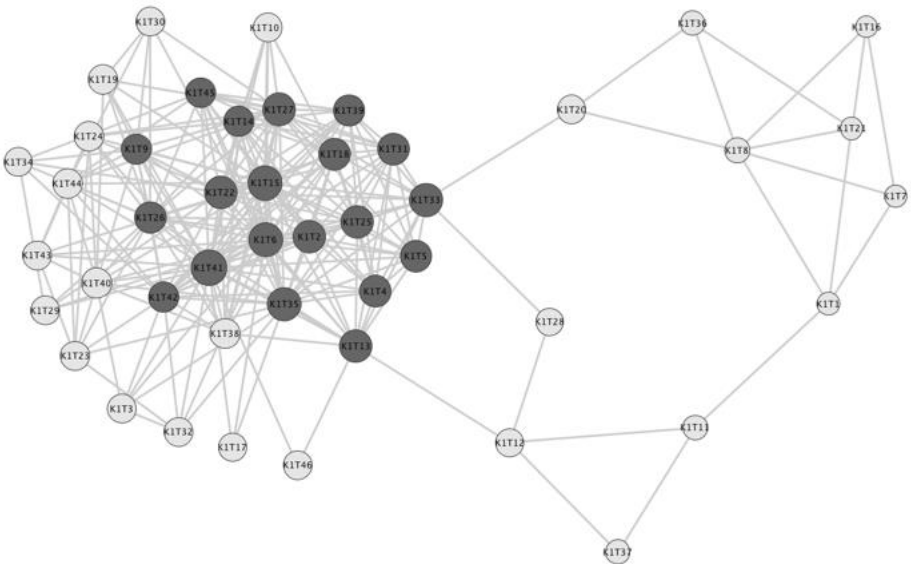


Figure 2 Core/periphery structure of Course 1 and the positions of students at their learning community

Results also revealed the connectedness and the core/periphery structure of the learning communities (see Figure 2). There was one giant component in the learning communities, which was connected and dense. Almost all the students were part of the giant components. Also, the results shows well established core/periphery structure in all the three learning communities. The core consists of cohesive, well-connected students, and the students at the periphery are only connected to the students of the core but not to other students from the periphery. Knowing the core/periphery structure could be important because the students in the core are usually more active, talk more with each others, could work harder, and could help the not so active or least experienced peers in the periphery. It may be helpful for the motivation of students to discuss such findings and then facilitate collaboration for collective actions, for meaningful learning results. As instructors or researchers we could shape and facilitate communities in a way to motivate members of the core to help not only fellow members of the core but also those of the periphery in the process of knowledge building interactions and knowledge creation. Also, students at the periphery could be inspired to ask from and talk to the students at the core. In this way, the community of the learners can be optimized, mobilized, and a supporting and productive community can be built. Such a structure can be especially important in learning situations where collective actions, collaboration, knowledge work is needed.

Students interactions in networked online learning environments

We revealed that the interaction networks were well-connected and dense in the networked learning environments. Cohesion of the collaboration network was also high in the learning communities. The reciprocity showed similar results: the rate of the mutually initiated interactions were high. It could be said that the students took remarkable efforts for mutual communication which resulted in continuous, reflective participation and sometimes in relational dialogue. The well-connectedness of the learning communities probably had an effect on the flow of information in the

communities, on peer effects and influences, on collective actions and on the learning itself.

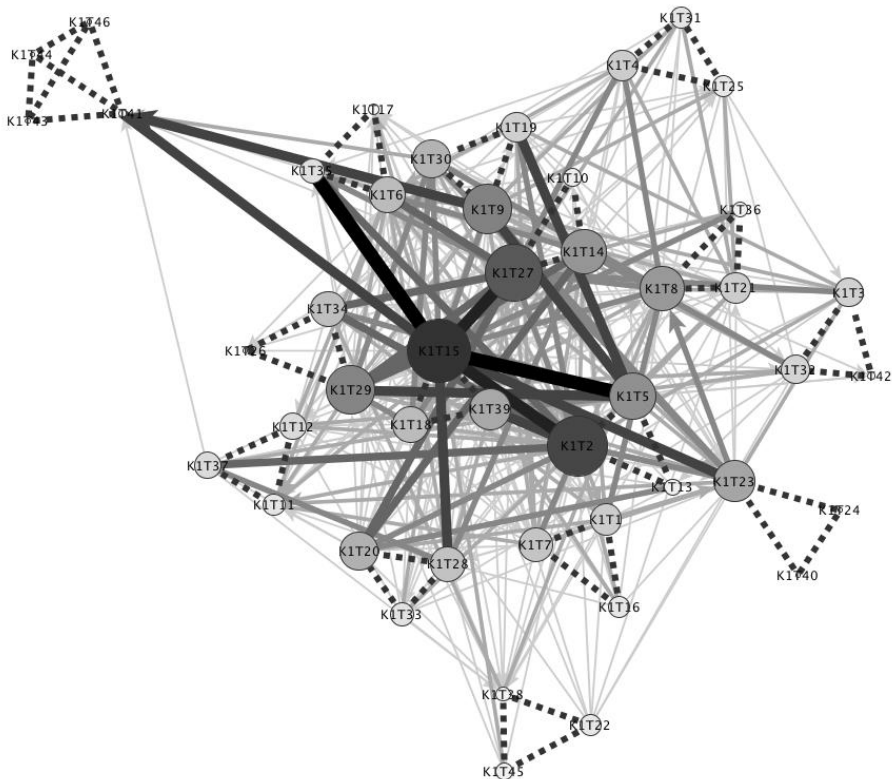


Figure 3 Interaction networks of Course 1 with group structure

The results showed that the positions of the students in the learning communities almost the same in the measured centralities. It involved the activity measured by initiated and received comments, and the potential brokerage. It seems that the active students who initiated more interactions got more comments from their peers and were in a more central positions according to their brokerage or intermediary. The order of the students' various positions showed significant difference. In the learning communities, the most active students initiated the most interactions in their learning communities.

Most of the interactions realized between learning groups were initiated by the students themselves at the beginning of the courses, not during the course (see Figure 3). The communication patterns show, that in almost every group there are some very active members who are connected by interactions and other group members who are not. The patterns of interactions can be perceived as collaboration networks of students, which show the alliances between students.

The core/periphery analysis showed,, that at the learning communities there were very active central groupings who not only entered into interaction with each other, but also with others outside this core. Students in the periphery were in interactions only with the members of the core, not with others from the periphery. The results showed that despite the size of the core, communication here was much more intensive and frequent than in the periphery. Moreover, the students of the core initiated more interactions towards the students of the periphery, than in the opposite direction. It seems that the students of the core not only took care of others in the core but also took care of students in the periphery.

The results of the comparative network analysis showed that there was no significant correlation and effects of the students' friendship network on the students' interaction network (at least as regards of the whole interaction network).

From the content analysis of the interactions extracted from the course blog (which served as an online learning environment) cognitive, social and teaching dimension of the discussions were revealed, including their amount and, proportions by weeks. All these dimensions were present in every discussion, but amounts and proportions varied. Most the messages were social: this dimension was dominant in the conversations, with about three times more social messages than cognitive or teaching ones.

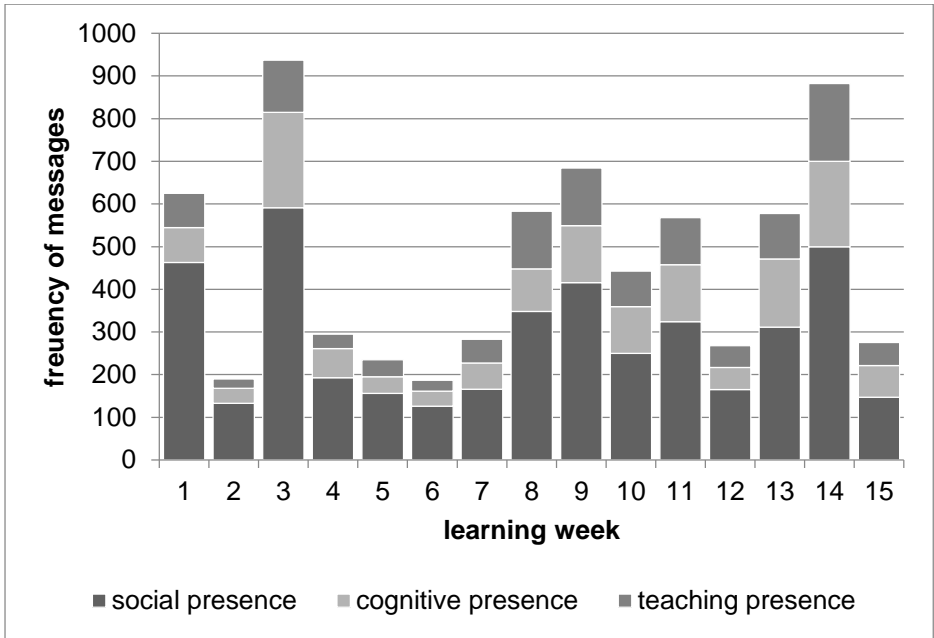


Figure 4 Cognitive, teaching and social presences of the students' interaction network at the online learning environment

After extracting and analysing the interaction dimensions, we also conducted a network analysis on these interaction data. The comparative network analysis revealed that there are significant, strong correlations among the three extracted dimensions of the networks. The structure of the three networks are not the same, however, they show remarkable differences. The structure of the network for cognitive intractions differs from the social and teaching ones. Therefore, it makes sense to analyse the content of the interactions, for example to reveal the structure of the cognitive dimensions of knowledge building discourses.

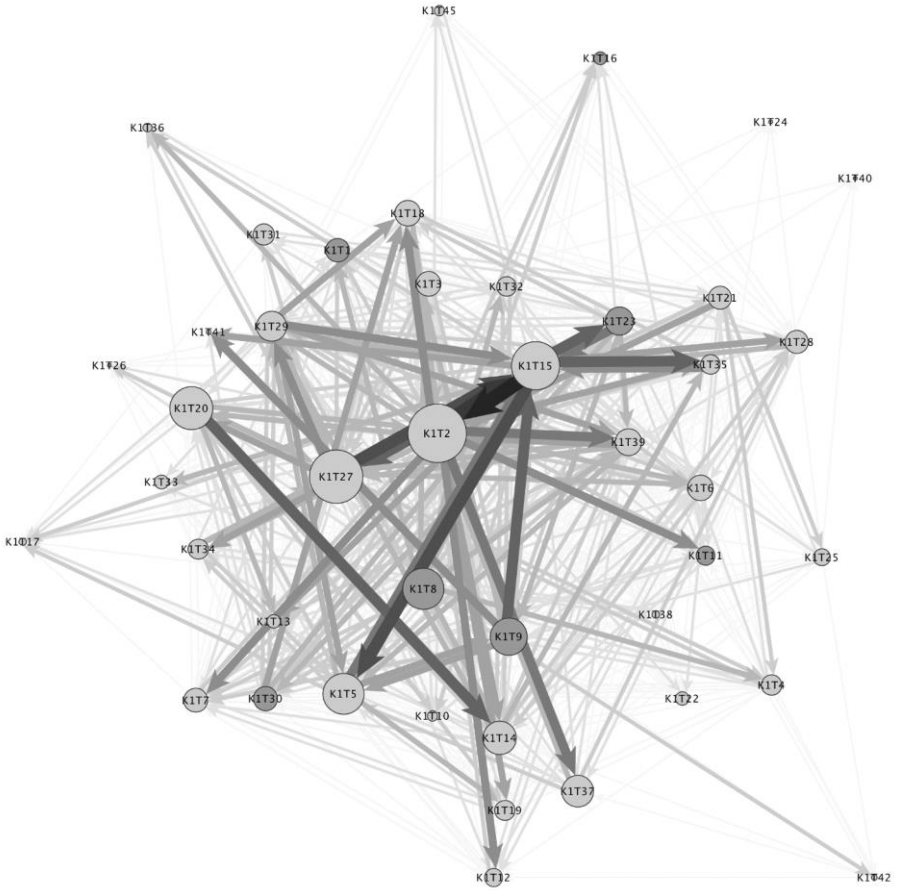


Figure 5 Interaction network of social presence

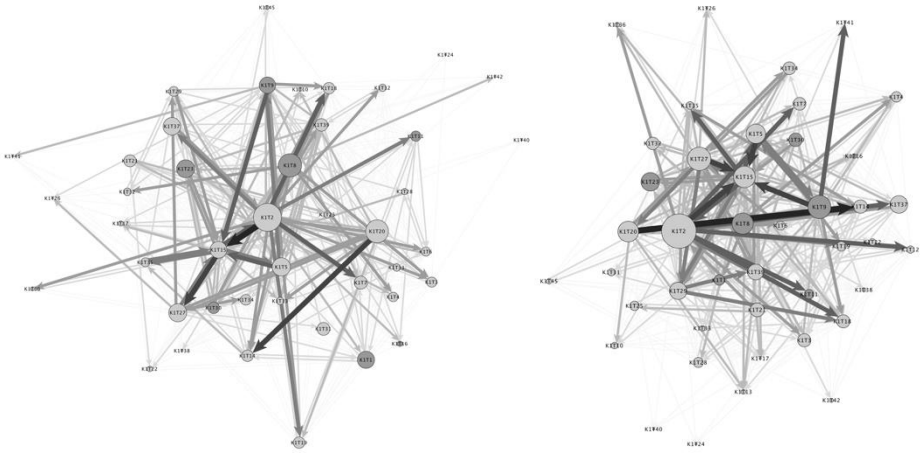


Figure 6 Interaction network of cognitive and teaching presence

Attitudes toward collaborative inquiry, perceived collaborative learning in online learning environments and the sense of community

The analysis of students responses to questionnaires revealed, that the majority of them found working in groups efficient and interesting, while it was considered not too easy by them. The students said that they liked to work and learn with their peers. This positive attitude is reflected in the intensity of the interactions and the density of networks. Almost three-quarters of the students thought that the collaboration with peers is important. These students gave more positive answers to all of the questions.

As for the perceived collaborative learning and the perceived learning in the online learning environment, the majority of the students gave positive responses. It was important for the students that they received feedbacks from their peers, their peers accepted their viewpoints and the discussions helped in the sharing of their knowledge and experience.

The perceived sense of community showed various results. The only positive answer was that the students are motivated to collect resources, read and do research related to the topics discussed in the online learning environments. As for the intensity of interactions and for

the supportive feeling of the online learning environments, the answers were various. Many students thought that they are part of the community, but there were students with an opposite opinion. We may conclude that according to the students, the usefulness of the online learning environment is questionable.

Effects of inquiry based learning in the learning community and in the online networked learning environments

In order to analyse the effects and correlations between the network variables and the variables from questionnaire data, we used path analysis. For the analysis, we modelled the various relationships between the proposed variables, and used various model-fits (Hooper, Coughlan, & Mullen, 2008). According to the literature (Barrett, 2007; Hu & Bentler, 1999), the model-fit in our study is acceptable ($\chi^2 = 6,489$, $df = 4$, $p = 0,1655$; $RMSEA = 0,072$; $CFI = 0,997$; $TLI = 0,929$; $SRMR = 0,012$).

For the analysis we used centrality measures of the interaction and friendship networks in comparison with the variables of the questionnaires. From the interaction networks we used outdegree (activity), indegree (received comments) and betweenness (brokerage) centrality, from the friendship networks the size of the immediate friends (count of friends) and the betweenness centrality (potential brokerage). From the questionnaire data, we used responses about the attitude towards collaborative inquiry, perceived collaborative learning, perceived learning in the online learning environment and the perceived sense of community.

The results shows some significant, but weak effects could be detected among some variables, and various levels of correlation between others (see Figure 7). It seems that the level of friendship connections has great effect on some variables, so in learning communities, the connectedness of the learners is important. The more connections the students had in the investigated learning communities and learning situations, more intensive learning efficiency and sense of community was perceived. It is important to note that the level of friendship in this

analysis refers to the relative size compared to all of the students in the learning communities, not to the count of friends. Therefore, it is the relative centrality of students in their learning community, and not the level of friendships that affects the perceived sense of community and learning efficiency.

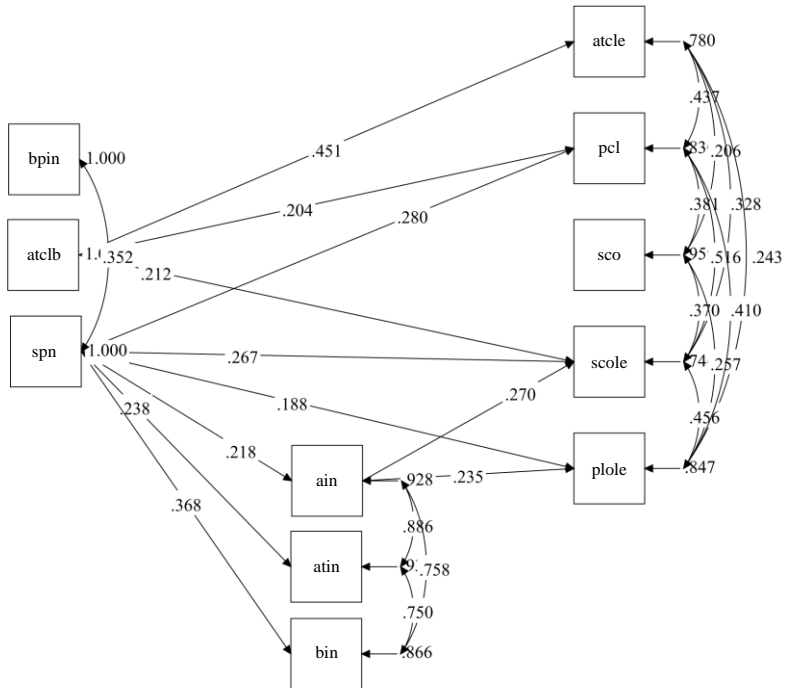


Figure 7 Results of the path analysis

Notes: atclb = attitude towards collaborative learning (at the beginning); spn: size of personal network; bpn: brokerage in personal network; ain = activity in interaction network; atin = attention in interaction network; bin: brokerage in interaction network; pcl = perceived collaborative learning; plole= perceived learning in online learning environment; scole= sense of community on online learning environment; sco= sense of community in classroom; atcle= attitude towards collaborative learning (at the end)

The analysis revealed, that the (relative) level of the friendship is also an important factor for the activity in the interaction/collaboration

networks in online learning environments. This result means that students with more friends in their learning communities initiated more interactions and received more answers, questions, advice, etc. than others. This correlation was confirmed by the correlation between the activity (initiated interactions) and the indicators of received interactions that were strong and significant.

It seems that the attitudes towards collaborative learning are important factors in the success of collaborations in learning supported by networked learning environments. The more positive the attitude of the students towards collaboration, the more intensive is their perceived learning experience in collaborative situations and in networked online learning environments.

Usability and impact of results

The research methods used and the results of the dissertation may help to understand the structure and the mechanism of collaborative learning in formal educational settings supported by networked online learning environments. This type of learning environments may be implemented with networked social technologies, like blogs, wikis, and social network services. The students are able and willing to use them if the learning tasks purposefully and meaningfully planned and managed, and if the students receive enough instruction and support from their instructors. The instructors can also benefit from the results. They can plan and optimize the learning environments to make them motivating and support purposeful discussions and knowledge building. Such an environment give possibilities for students to connect with each-others and with the contents relevant to the learning. The instructors can monitor their students' progress, participation and discussions, observe conflicts and react and reflect on them; and modify the motivational and the evaluation criteria, if needed.

The pedagogical added value and relevance of the results is, that it shows the structure, the mechanisms and the effects of mentored collaborative inquiry based learning in learning communities supported by online connected learning environment, where students can discover,

make sense and discuss important and relevant issues and create knowledge in collaborative and cooperative ways.

More research is needed to get clear picture about the effects and impacts of friendship, the interactions and the various attitudes of students. It is worth to investigate more relationships, like networks of attitudes (for example, willingness and disposition to collaborate), networks of peer support, networks of expertise/competence, etc. The complexity of attitudes, perception, competency, knowledge as manifest in learning environments provide numerous research opportunities for the future and may enhance teaching in collaborative networked learning environments.

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