International Online Team-Based Learning in Higher Education of Biomedicine - Evaluation by Learning Analytics

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Abstract

Teamwork skills are important to practice during higher educational studies to prepare students for the future working life. Since online learning has established itself as a relevant part of higher education, we present here an approach to online team-based learning and show the performance of students during the teamwork, proven by learning analysis data. In addition, results from a feedback survey of students´ opinions on teamwork are presented. Online teamwork was implemented for master level biomedicine students from four different Universities in Nordic countries, and student interaction was evaluated. Learning analytics data were collected from Discord, which was the communication platform for students and teachers during the teamwork. The Community of Inquiry (CoI) framework was used as guidance, and indicators of CoI's social, cognitive, and teaching presences were used as a scheme for coding the interaction. To recognize the process of collaboration, the data were first analyzed by using process mining. Further, to understand the multidimensional property of collaboration, we developed a network analysis and visualized the results using Gephi and the Fruchterman-Reingold layout algorithm. The quantitative results of the feedback survey were analyzed by using descriptive statistics and visualized using the R package likert.

The learning analytics data included 316 posts divided to 686 annotations, which were categorized to codes. Our results indicate that the most frequent codes were the ones related to the social dimension of CoI, determined with attributes such as 'interactive' (173), 'cohesion' (119) and 'affective' (116). The remaining most frequent codes alternated between 'facilitation' and 'cognition'. Thus, social presence, in the context of CoI was considerable in our online team-based learning approach. However, to enhance students' cognitive presence, and thereby their ability to construct and confirm meaning of what they are learning, students' work should be facilitated by increasing teaching presence through teacher's contribution online. In line with the learning analytics data, the results of the survey pointed out the need of more in-depth instructions on how to carry out the team exercises, which belongs to the teaching presence category in the frame of CoI.

Based on the results of this study and the existing literature, we aim to improve our team-based learning approach and outcomes in the future by increasing students' contribution through regular feedback assignments during the work and encouraging learners to reflect on their own work, contribution and thinking.

Keywords

Online teamwork, learning analytics, Discord, virtual collaborative learning, online team-based learning, Community of Inquiry

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1. Introduction

1.1. Online team-based learning in biomedicine

Team-based learning (TBL) is a form of collaborative learning that relies on small group interaction. The key elements for successful TBL are properly formed and managed teams, accountability, feedback and assignment design [1]. Accountability means that each member contributes time and effort to group work. Feedback should be frequent and timely and group assignments designed to promote both learning and team development. In TBL, the teachers' role shifts from dispensing information to designing, managing and instructing the assignment, whereas the students' role varies from being passive recipients of information to being responsible for content of the teamwork [1].

In higher education of biomedicine, team-based learning is an important, commonly used pedagogical approach, since many courses include laboratory work in small groups instead of self-studies or mass lectures. Biomedicine is a rapidly developing discipline covering, for example, several imaging, molecular biology and computational methods. It is not meaningful or even possible for every university with a biomedicine study program to specialize in all biomedical methods. Therefore, there has been an effort recently to organize a number of biomedicine courses jointly in the universities in Finland and in other Nordic countries. The idea has been that each university can focus on their own strengths regarding state of the art methodologies, such as proteomics, genomics, transcriptomics, translational pathology or bioimage analysis, and thereby increase the number of elective studies available for students. Although student mobility promotes learning and provides new experiences, it is often not possible or meaningful, or even desirable due to financial costs, schedule restrictions and the environmental impact caused by traveling. Therefore, biomedicine is a discipline that suits well for online teaching and learning in collaboration between universities.

Applying TBL in an online environment has both benefits and challenges. One defining factor is preferred timing, *i.e.* whether the course is asynchronous, meaning the students are able to work anywhere at any time, or synchronous, meaning that there are common online meetings at certain fixed times. Integrated Online-Team-Based Learning (IO-TBL) model is an online team-based learning course design that aims to combine the flexibility of asynchronous engagement with the connectedness offered through synchronous meetings [2].

1.2. Community of Inquiry

Students' collaboration with each other and engagement in the team projects are essential to improve their academic performance, especially in asynchronous settings where students are more likely to become disengaged and feel isolated [3]. According to the Community of Inquiry (CoI) model [4] learning occurs through three interconnected processes engaging both students and teachers: 'cognitive presence', 'social presence', and 'teaching presence'. Cognitive presence describes the process of collaboratively building of understanding [4], which is considered as the key component of critical thinking in higher education. Social presence refers to communication and ties among students, and it promotes collaborative work and higher order thinking that supports cognitive presence [4]. Teaching presence refers to the instructional design and facilitation provided by a teacher [4]. The key player students in the CoI improve overall student interactions, which are essential for developing cognitive and social presences [5]. These students share resources and knowledge with the team, as they connect to others [6], unlike the peripheral students, who are less connected to the community and contribute less [7].

1.3. Discord as a platform for interaction

Discord (https://discord.com/) is a free communications application for mobile phone and computer, that enables communication between users through sharing voice, video, and text chat. In addition, screensharing and private direct messaging (DM) between users are also possible. Although Discord was developed for gamers´ and streamers´ communication needs, it has become popular in other communities as well. Recently, it has been used in education, both in elementary school [8] and in higher education [9]. For example, in teaching of biomedicine and related topics in higher education Discord is currently being used to facilitate the building of community and engaged learning space both online and in classroom [10]. In this study, Discord was used to host the online project work group discussions.

1.4. The aim of the study

Our aim was to find out how students in biomedicine perform in online teamwork. Specifically, our interest was to investigate whether the instructions given by the teachers and the interactive learning platform provided, namely Discord, support their learning through cognitive presence.

Importantly, the long-term aim of this pilot study is to lay the foundation to further work of designing a larger study with improved teaching presence, which would deepen our understanding of the strengths and challenges of online teamworking our students face and, consequently, help students learn better and more effectively.

2. Methods

2.1. The online project work in groups

The data were collected from the Discord (Discord Inc., California, USA) channel created to host online discussions during online summer studies in 2022, organized by the University of Turku and the University of Eastern Finland in the field of biomedicine. The summer studies included four 1-4 ECTS online courses focusing on molecular characterization, imaging, and diagnostics of tumor samples. Students could have taken one or several of the four courses. In addition, two webinars and a final project were mandatory, donating an additional 1 ECTS. All together 20 students completed the course(s) including the final project. The online courses were organized in Moodle, webinars in Zoom and the students' project work, which was conducted as teamwork, in Discord. The project work was instructed asynchronously in Moodle and synchronously as a teamwork kickoff webinar in Zoom. As learning goals for the project work, students were expected to learn i) how to apply the biomedical tools learned during the online summer courses to design a meaningful study plan together with fellow students in an online environment, ii) to work in groups, and iii) to give an oral presentation of their work.

Six groups of 5-7 students were set by the teachers and the first group meeting in Discord was set and organized directly after the project work kickoff webinar. The groups were formed so that the students were from different courses, and, thus, each student had an individual expert role in their group. The groups were given free hands in planning of their own working methods, but four meetings, and content for these meetings were suggested by the teachers. Also, there were two two-hour slots when five course teachers were available at Discord for discussion and students' questions. Instructions for the project work prompted students to prepare a project plan that combines the skills learnt in the four different summer studies courses. Within groups, students adopted a role of an expert of their own specific domains defined by the course or courses they had taken.

The topic of the final project was breast cancer. First, the students were given a few recent research publications covering the topic to read for inspiration. They were advised to use existing data resources, for example on breast cancer genomics and digital pathology, to discover relevant molecular targets, focusing on one selected subtype of this cancer. This discovery data cohort was to be used as a starting point of the study. The idea was then to plan a translational study using human patient samples, proceeding from potential target candidates to diagnostics. The students' task was to combine their expertise obtained in the different courses they had taken to plan a coherent research project that connects both genomics and imaging data analyses. Short course-specific task descriptions were given to highlight the skills and knowledge that each expert could bring into the project.

Guiding questions were given by teachers to initiate the teamwork and to start the discussion on the theme (breast cancer and precision oncology) between group members with different backgrounds. Each group had its own channel in Discord for chatting and sharing material (text channel), and for live meetings (voice channel). The groups were allowed to freely plan their working habits and schedule, but a rough timeframe and recommendation for the meeting schedule were given by the teachers. At the end, the research project plans were presented to other students and teachers in the concluding seminar. After each presentation time was reserved for discussing the research plans together. In addition, each group was also assigned one peer review task, *i.e.* to read a project plan written by their peer group before its presentation and to be prepared to ask questions and give feedback on the research plan and its oral presentation during the seminar.

Once the final project was finished, the chat discussions were exported in CSV format and then anonymized by the teachers. After that, two of the authors coded the discourses for analysis purposes.

2.2. Discussion dataset

2.2.1 Coding

Coding for the dataset was done according to indicators of CoI's social, cognitive, and teaching presences. The coders began by assigning a value of 0 to indicate the absence of an indicator and a value between 1 and 5 to indicate the presence of an indicator according to its sequence in the discourse. As multiple indicators may accompany any given post, this resulted in a total of 686 annotations, rather than the original 316 posts.

The students' discourses were coded by two different coders. The inter-coder agreement between the two coders had a high level of reliability using Cohen's Kappa test (κ=0.87) [11]. In instances where the coders encountered disagreements, they met to resolve such cases.

Social: It is concerned with social interactions and attempts to simulate the students' social environment (table 1). We followed the scheme by Rourke et al. 1999 [12].

Cognitive: It is concerned with tracking the students' cognition through their interactions to improve critical thinking, construct knowledge and solve problems (table 2). We followed the modified scheme by Chen et al. 2019 [13].

Teacher: It is concerned with the role of the instructors either pre- or during courses. It can be carried out with the collaborative participation of community members (table 3). We applied the teaching presence scheme by Weerasinghe et al. 2012 [14] for students.

Table 1:
Social presence categories, their indicators and their illustrative quotations

Social presence categories	Indicators	Illustrative quotations
Affective	Expression of emotions, use of humour, self-disclosure	looks good on my end. thanks for the effort
Interactive	TextContinuing a thread, quoting from others' messages, referring explicitly to others' messages, asking questions, complimenting, expressing appreciation, expressing agreement	I agree on the subtype: Triple negative breast cancer with the research question: Which gene (BRCA1 or BRCA2) is more likely to develop a triple negative breast cancer?
Cohesive	Vocatives, inclusive pronouns to refer to group, phatics and salutations	Hi. before the next meeting on Friday, we'll try to wrap things up

Table 2:
Cognitive presence categories, their indicators and their illustrative quotations

Cognitive presence categories	**Indicators**	**Illustrative quotations**
Triggering event	Recognise problem, puzzlement	I can not submit the file because of it's size. I'm waiting for the teachers to allow bigger files or tell me how I can submit it.
Exploration	Divergence, information exchange, suggestions, brainstorming, intuitive leaps	According to the "Guidelines for the group work research plans", we have 11 parts to complete, I suggest we each take some of them. I can handle the immunoassays part following along the genomic findings
Integration	Convergence, synthesis, solutions	Read the 'Useful articles to start' from the course website. If you come across a good subtype during the reading, you can write it down on the google doc
Resolution	Apply, test, defend	Maybe you could also eliminate some of MAP3K1 alterations so that we can narrow down our options.

Table 3:
Teaching presence categories, their indicators and their illustrative quotations

Teaching presence categories	Indicators	Illustrative quotations
Organization	Informing notices, Establishing time parameters, Utilizing medium effectively, Establishing netiquette	We decided to meet next monday, 15th of August at 9 a.m
Instructions	Providing specific instructions or advice, Offering useful examples or illustrations, Providing additional explanations, Making explicit references or providing extra learning resources, Encouraging activities, Responding to technical concerns	please add the text to the section 6, I have made the headlines. Also, there is "Critical points for success" -headline to which something needs to be written on behalf of every 'method'/course.
Facilitation	Identifying areas of agreement/disagreement, Acknowledging or reinforcing student contributions, Encouraging or motivating students to participate in the discussion, Setting climate for learning, Re-focusing/re-addressing discussion on specific issues, Summarizing discussion	Good! I couldn't submit the images as a pdf file, because the file was too large, but hopefully it works that way for all.

2.2.2 Data analysis

We first calculated descriptive statistics to obtain a general idea of the most common codes and CoI dimensions in the dataset. Though useful, frequency analysis lacks the ability to provide insights into the temporal unfolding of the collaborative process, i.e., how certain events trigger one another. To gain insights into the temporal aspect of students' collaboration we relied on process mining. Process mining is an analytical technique that allows to gather insights from time-ordered trace-log data [15], [16]. Process mining allows one to discover the real process from data, compare and evaluate processes, or enhance them [16]. To map the collaboration process of the student groups, we make use of the pMineR R library, which allows to conduct process discovery using First Order Markov Models (FOMM), i.e., it considers that the probability of an event happening depends only on the event immediately before, and not the previous ones. The result is a process map showing the probability of transitioning from one code to another [15].

Process mining allows us to understand the process of collaboration and the transitions between codes. However, the constructed process is unidimensional, where only one code can take place at a time. In reality, a message can contain more than one code and a reply to that message is potentially a reply to all the codes present in it, and not only to the last code in the message. To capture this property of collaboration messages, we constructed a network in which each node represents a code, and an edge from code A to code B represents the existence of a message containing code A as a reply to a message containing code B. The network was plotted using Gephi and the Fruchterman-Reingold layout algorithm. The node size is proportional to the weighted degree centrality, and the thickness of the edge represents the frequency with which one node occurs as a reply to another. To group together codes that commonly happened in reply to one another, we used Louvain modularity and color-coded the distinct groups [15].

2.3 Student feedback data collection and analysis

At the end of the summer course, a survey was distributed among the students to gather their opinions about the course. The survey consisted of 14 statements with which students had to agree or disagree using a 5-point Likert scale (1 = Strongly Disagree --- 5 = Strongly Agree). The items covered students' opinions on the usefulness of the learning materials, their motivation and expectations of the course, their perceptions on the group work. The results of the survey were analyzed by using descriptive statistics and visualized using the R package likert [17].

3. Results

3.1. Frequency analysis showed that the most frequent codes were related to the Social Dimensions of CoI

The four groups sent a total of 316 messages over Discord, with a mean of 79 messages per group (MED = 77, SD = 22.23) and 15.8 messages per student (MED = 15, SD = 8.84). Each message had an average of 2.17 CoI codes. Table 4 shows the descriptive statistics for each of the codes, including the total number of times they appear in the messages, and the descriptive statistics per student and per group. The most frequent codes by far were the ones related to the social dimension of CoI (Interactive, Cohesion, Affective). The remaining most frequent codes alternated between facilitation and cognition.

Table 4:
Descriptive statistics of the CoI codes in the Discord messages.

		Student		Group	
Code	**Total**	**M**	**SD**	**M**	**SD**
Interactive	173	12.32	5.04	50.12	14.83
Cohesion	119	8.58	3.81	30.90	5.49
Affective	116	8.24	4.08	34.40	12.25
Instruction	56	5.21	2.28	16.93	7.35
Exploration	54	4.78	2.12	17.37	7.41
Integration	50	4.68	1.85	16.08	6.84
Organization	43	4.53	2.29	13.09	3.87
Triggering event	42	4.76	2.49	13.00	4.69
Facilitation	22	2.55	0.91	7.00	3.02
Resolution	11	1.91	0.83	3.18	0.87

3.2. Process mining revealed the chronological order in the collaborative process

Process mining allows us to look at the messages through a temporal lens, giving insights into the transitions among codes, and therefore into the unfolding of the collaborative process. Three of the groups started with cohesion, i.e., messages encouraging collaboration, whereas one started with an expression of affection (in this case, a smiley face emoji). The process map in Fig. 1 show that there are no highly dominating transitions where two codes constantly take place one after the other sequentially. The most likely transitions are from Facilitation to Interactive, and from Instruction to Interactive, where a student offered guidance to the group and another student directly addressed and responded to the help received. Triggering events also likely led to Interactive behavior, where a student raised a concern which was acknowledged and discussed. Another frequent transition is from Affective to Cohesion, meaning that students engage in socializing before addressing the collaborative task and/or group itself. It is also worth noting that the process maps show many of the codes with no incoming arrows, i.e., no transitions from any of the other codes took place with a likelihood greater than 10%. This is the case for Exploration, Organization, Resolution and Facilitation, which seem to happen as isolated events and not as a result of any other ones.

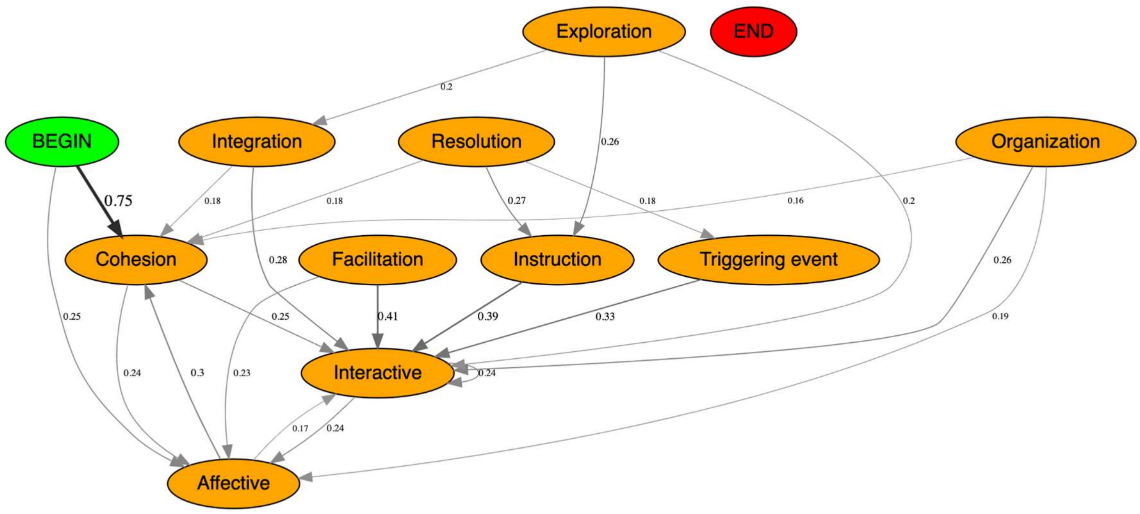

Figure 1: Each group as a process. The arrows indicate the transitions among codes.

3.3. Codes for Interactive, Affective and Cohesion showed strong heavy interconnection in the Network analysis

The network (Fig. 2) shows two distinct groups of codes that more frequently occur together. The yellow group consists of codes mostly related to the social dimension of CoI, whereas the blue group consists of codes mostly related to the cognitive dimension of CoI. The facilitating codes are split between both groups. It seems that students mostly use either social codes or cognitive codes, more often than a mix of the two types, whereas facilitating codes help bridge the two dimensions of collaboration. Particularly, the network shows a strong interconnection among Interactive, Affective and Cohesion, indicating that messages including these codes often follow one another or even several messages with the same code take place in a row (indicated by the loop arrows).

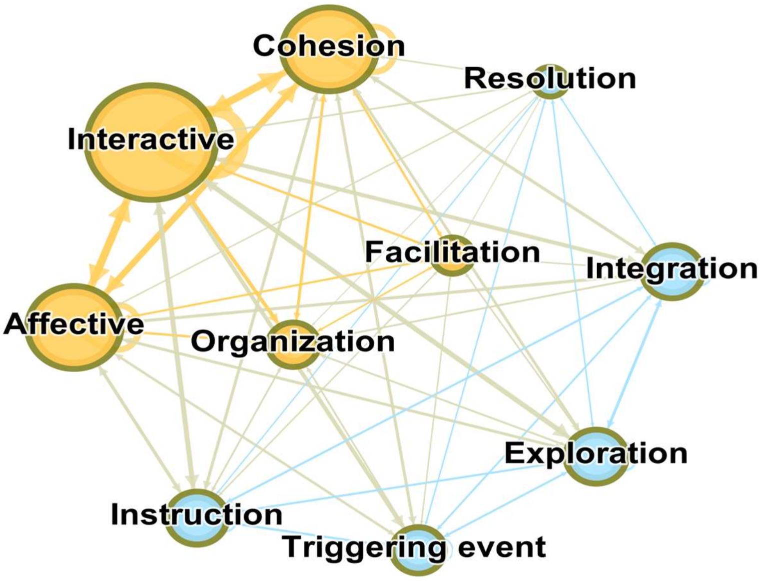

Figure 2: Network analysis indicating the interconnections between different codes of CoI. The thickness of the arrows indicates the amount of connections between codes and the size of the circles corresponds to the frequency of the code in the analysis.

3.4. Feedback analysis suggests that students wish stronger teacher intervention

Table 4 shows the results of the student questionnaire including, for each question, the mean (M), median (MED), and standard deviation (SD), along with the percentage of respondents of each answer.

Regarding the learning materials (lectures, further readings, and exercise instructions) available to students, students agreed for the most part that they increased their knowledge and skills in the course topic (M = 4.12, MED = 4, SD = 0.78). They agreed to a somewhat lesser extent that the materials complemented each other (M = 3.82, MED = 4, SD = 0.95). Most students strongly agreed that they were well motivated to get good grades on their courses (M = 4.29, MED = 4, SD = 0.85). Overall, students course agreed that the course met their expectations (M = 4.12, MED = 4, SD = 0.99) and they somewhat agreed that the workload of the course corresponds to the received ECTS (M = 3.76, MED = 4, SD = 1.09). The students were slightly polarized about whether instructions on how to carry out the group exercises were clear and easy to follow (M = 3.24, MED = 3, SD = 1.39). They mostly agreed that the group assignments helped them understand the theory of the course better (M = 3.82, MED = 4, SD = 1.19) and apply their learning better in practice (M = 3.88, MED = 4, SD = 1.05). Moreover, they mostly agreed that the group assignments were useful for improving their scientific reporting skills (M = 3.88, MED = 4, SD = 0.93). The students mostly felt that the responsibilities in their group were divided fairly (M = 3.94, MED = 4, SD = 1.34) and were able to get help from the instructors when needed (M = 4.18, MED = 4, SD = 0.73). For the most part, students agreed that sharing data within the group was easy and straightforward (M = 3.88, MED = 4, SD = 1.11). They also somewhat agreed that the suggested electronic teamwork tools on the course were useful and helped them perform the task (M = 3.59, MED = 4, SD = 1.33). Lastly, students were mostly neutral about the fact that the group work introduced them to new people and helped them build their professional network (M = 3.47, MED = 3, SD = 1.18).

Table 4:
Descriptive statistics of students' survey responses

Code	Question	M	MED	SD	Strongly Disagree	Rather Disagree	Neutral	Mostly Agree	Strongly Agree
Materials	The available materials (lectures, further readings, exercise instructions) increased my knowledge and skills in topic	4.12	4	0.78	0.00%	5.88%	5.88%	58.82%	29.41%
Complementing materials	The available study materials (lectures, readings, exercises, tests) complemented each other.	3.82	4	0.95	0.00%	11.76%	17.65%	47.06%	23.53%
Motivation	I am in general well motivated to get a good grade on my courses	4.29	4	0.85	0.00%	5.88%	5.88%	41.18%	47.06%
Expectations	Overall, this course met my expectations for the course (contents, quality etc).	4.12	4	0.99	0.00%	11.76%	5.88%	41.18%	41.18%
ECTS	Workload of the course correspond to the received ECTS	3.76	4	1.09	0.00%	17.65%	17.65%	35.29%	29.41%
Instructions	The instructions on how to carry out the group exercises were clear and easy to follow.	3.24	3	1.39	11.76%	23.53%	17.65%	23.53%	23.53%
Theory	The group assignments helped me to understand the theory of the course better	3.82	4	1.19	5.88%	11.76%	5.88%	47.06%	29.41%
Practice	The group assignments helped me to apply my learning better in practice	3.88	4	1.05	0.00%	17.65%	5.88%	47.06%	29.41%
Reporting skills	The group assignments were useful for my scientific reporting skills	3.88	4	0.93	0.00%	5.88%	29.41%	35.29%	29.41%
Responsibilities	I feel that the responsibilities in my team were divided fairly	3.94	4	1.34	11.76%	5.88%	0.00%	41.18%	41.18%
Getting help	I was able to get help from the instructors when needed	4.18	4	0.73	0.00%	0.00%	17.65%	47.06%	35.29%
Sharing data	Sharing data within the group was easy and straight forward	3.88	4	1.11	5.88%	5.88%	11.76%	47.06%	29.41%
Electronic tools	The suggested electronic teamwork tools on this course were useful and helped us to perform the given task	3.59	4	1.33	11.76%	5.88%	23.53%	29.41%	29.41%
Professional network	The teamwork introduced me to new people and helped to build my professional network	3.47	3	1.18	5.88%	11.76%	35.29%	23.53%	23.53%

4. Discussion

Biomedicine is a wide-ranging and rapidly developing discipline requiring specific methodological skills and in-depth expertise. Thus, international cooperation is the key to success, both in research and teaching, and international teams of experts from different areas of specialty are already the order of the day in biomedicine. University education aims to prepare students for the working life of the future, and therefore, the ability to work in diverse teams is essential for the future experts in biomedicine. In addition, to meeting the demands of working life, enhancing students' collaboration with each other through teamwork has been shown to improve their academic performance [3] as well.

In this paper, online teamwork was implemented for master level biomedicine students from four different universities in Nordic countries. Student interactions on Discord platform during teamwork were evaluated by using the Community of Inquiry (CoI) framework, which encloses the essential elements of a successful educational transaction: cognitive presence, social presence, and teaching presence. Frequency analysis showed that the social dimensions of CoI were emphasized most in teamwork. More specifically, process mining analysis revealed that the chronological order in the collaborative process through which the students engaged with each other was socializing before addressing the actual collaborative task and group itself.

Network analysis revealed abundant interconnection and high frequency between codes for CoI attributes 'Interactive', 'Affective' and 'Cohesion'. These codes are related to the social dimension of CoI, and support the other results. On the contrary, the frequency of codes related to the cognitive dimension of CoI was lower and the interconnection between the codes was weaker (Figure 2) indicating less collaboration between the students when building understanding of the core substance of the assigned task. However, based on the CoI model, social presence as such promotes collaborative work and higher order thinking, which in turn supports cognitive presence. Cognitive presence further refers to the process of collaboratively building of understanding, and is considered as the key component of critical thinking in higher education [4]. Reflecting our approach to online team-based learning and the presented results on the CoI model raises an important question regarding what kind of teacher presence would best promote shift from social presence to cognitive presence, and contribute to the best balance between these two dimensions during teamwork.

However, it is worth bearing in mind that all interactions between the students were not captured, as they interacted with each other also using other platforms than Discord. To better capture all interactions for learning analytics, students could be guided to use only Discord. On the other hand, forcing the use of just one platform for interactions might not be beneficial for the learning experience. The discussion what kind of space and means are best for students to help them explore and find new ideas together is ongoing. However, Saqr and López-Pernas suggest that instant messaging platforms, such as Discord, increase participative engagement in teamwork compared to conventional discussion forums [18].

The survey performed after the course indicated that the students were mostly satisfied with the teamwork, as the mean values between questions varied from 3.24 to 4.29 in the scale 1-5. Of all the questions, the students mostly disagreed with the statement "the instructions on how to carry out the group exercises were clear and easy to follow" (mean 3.24). However, almost a quarter of the students (23,53%) agreed strongly with this statement. In the CoI model, this statement belongs to the category of teaching presence, which was assessed weak also in our data analysis. Thus, based on our results, we suggest that more in-depth instructions on how to carry out the group exercises are needed. On the other hand, students mostly agreed (47.06%) that they were able to get help from the instructors when needed (mean 4.18).

Although in the CoI model codes for social presence were most common in the frequency analysis, in the feedback questionnaire students' agreement with the statement "The teamwork introduced me to new people and helped to build my professional network" was mostly neutral (mean 3.47). It is likely that this statement does not completely correspond the social presence dimension of the CoI model, which does not contain the professional network aspect.

Interestingly, the feedback questionnaire statement about division of responsibilities in the team "I feel that the responsibilities in my team were divided fairly" splitted students into two categories, while nobody answered neutral/3 to this question. More students agreed than disagreed with the statement, though. Students´ different behavior and performance in groups is well-known. For example, Haugland et al [19] showed that in the same online learning course, separate groups and individuals in those groups, chose different ways to work in regard to their ability to take responsibility for common learning. Sharing of the responsibilities unequally in teams is a well-recognized problem, and the biggest obstacle to group learning has been claimed to be students who do not participate [20].

Based on the frequency and feedback analyses, we conclude that our students would have benefited from more frequent teacher interventions during the teamwork to transfer their performance from social to cognitive presence and consequently, helping them increase their critical thinking. In the future courses, we propose that teachers could 1) contribute to the discussion with prepared statements that open up new directions of thinking [21] and 2) provide prompt and constructive feedback during the teamwork, as students have previously stated that a lack of feedback is detrimental to their online learning experience [22].

Suggested check list for teachers for designing the structure of effective teamwork online:

- Mode and frequency of teacher interventions
- Mode, frequency and timing of feedback assignments for students
- Platform(s) to be used

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