

An effective online learning for complex theoretical content: experience of Community of Inquiry

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Abstract—In this research to practice full paper we describe our implementation of CoI (Community of Inquiry). CoI is a framework for designing an effective online learning environment. It originates from Charles Sanders Pierce's ideas that knowledge can only be created in a community through inquiry. We applied the framework in a highly interactive course that was forced to be held online because of the pandemic. The theoretical core of the course is cognitive psychology, a topic considered difficult to learn in a short time. Besides describing our implementation, we evaluate the results of the students' inquiries and compare it with results from the previous year when we did not use CoI for this part of the course. Our findings show that the most important instructional strategy is to facilitate for students to work individually according to a scientific inquiry and then, in a community, use the knowledge gained in critical discourse to build an overall understanding. When the students worked according to this, the results exceeded our expectations, both regarding the depth of understanding and ability to apply the knowledge in ongoing course projects. Because more teaching will likely take place at a distance in the future, as a side effect of the pandemic, we believe that this could be a way to meet an increasing demand for online instruction, especially when designing educational settings for complex theoretical content.

Keywords— *Community of Inquiry, Information technology, Course design, User-centered design, Distance learning, Problem-based learning, Engagement, Learning management systems, Higher education*

I. INTRODUCTION

The Community of Inquiry (CoI) framework was created more than 20 years ago because of the increasing number of enrollments in online academic programs [1]. The framework is a collaborative-constructivist process model that describes the essential elements of a successful online higher education learning experience. The framework was developed at the University of Alberta in Canada by colleagues Randy Garrison, Terry Anderson, and Walter Archer based on two beliefs: 1) the belief that online learning would provide opportunities for communication between students and their instructor, and 2) on the belief that computer-mediated learning would cut out all types of interactions [1].

CoI builds on three core elements, cognitive presence, social presence, and teaching presence [2]. In short, cognitive presence assumes that the goal of any educational experience is critical thinking and refers to the extent to which learners can construct knowledge through discourse and reflection [2]. However, cognitive presence alone does not make learners part of a community of inquiry, it also must be a collaborative online learning environment. That is the role of social

presence, which is defined as the ability of learners to feel effectively connected with peers. Critical thinking and collaboration do not happen on their own. For it to happen, teaching presence is also needed [2].

The foundational work with CoI was followed by a series of papers expanding on each presence and their relationships and interdependence. There were some problems identified but also the conclusion that the different presences together influenced student satisfaction, perceived learning, and sense of community [1]. The supporting evidence of the three different constructs has resulted in making the framework one of the most extensively used in online teaching and learning [3]. The most common focus during the two decades that the framework has existed has, however, been to use it to make sense of what an efficient online learning experience is. According to Castellanos-Reyes [1], it is therefore time to move from that to designing such an experience. This research gap was also recognized by Fiock [4] who stated that there is a void in how to implement instructional strategies aligned with the CoI.

In 2020, the majority of higher education was transferred to online education because of the pandemic. This virtually removed all opportunities for face-to-face interaction between teachers and students overnight. This forced teachers to quickly respond and give courses designed for campus online without having the time to think about which strategies would be most beneficial for the students in the new situation. This also happened to us. We were forced to give a highly interactive course online more or less on the fly.

Overall, the implemented design 2020 worked well but there was one thing that we wanted to change when we had to do this again, in 2021, because of the pandemic not being over. The course has weekly themes, and one of these weeks is about the core theoretical part of the course, cognitive psychology, a theme considered difficult to grasp in a short time. In 2020, the students did not achieve the understanding of this subject that we wanted. To change this, in 2021 we developed a design based on CoI to see if this could lead to a deeper knowledge of the theoretical content. The overall goal of the study presented here is to investigate whether a course component based on the CoI can increase the students' understanding of cognitive psychology and thereby increase the quality of the course's interaction design projects. In doing so, it is also of importance to deeply discuss the implemented pedagogical strategies and thereby address the research gaps addressed by Castellanos-Reyes [1] and Fiock [4]. To investigate this, comparisons of course results between the last two course rounds were performed and combined with

qualitative data from surveys. In this paper, we report on the developed design for the theoretically oriented course week, its implementation, and the outcomes by answering the question: “How can a course component based on the CoI affect theoretical knowledge and practical theory application in a design course?”. Based on the answer, we provide practice recommendations (instructional strategies) as well as pointers for future research.

Before moving on to describe the implementation of CoI in focus in this paper, in section II we first provide a short theoretical background that introduces the basic components of CoI to give a clear framework for the course description. Following the description of the course in focus (section III), the mixed methods approach will be presented in section IV. The results, focusing on statistical comparisons of course results between the 2020 and 2021 course rounds as well as survey results, then follow in section V. The paper is then concluded by an in-depth discussion about both results and conducted methods, and a short conclusion.

II. THEORETICAL BACKGROUND

To understand what CoI is and implies we must go back to its roots. Community of Inquiry is a concept that has existed long before online learning [1, 9]. It was originally developed by Charles Sanders Pierce to explain the nature of knowledge formation and the process of scientific inquiry [10]. Pierce was a scientist and a philosopher who sought to bring the method of science to philosophy as a countermeasure against Cartesianism. According to Cartesianism scientific knowledge can be derived from innate ideas through deductive reasoning, and all knowledge is gained from experience and the senses. Furthermore, the faculty of deductive reason was believed to be supplied by God and could therefore be trusted, because God would not deceive us. Pierce believed that modern science and modern logic had to stand upon a very different platform than this. According to Pierce, single individuals cannot be judges of truth, this process must be carried out in a community. Truth is only possible when there is no one left that has doubts; and thus, individual opinions cannot form a basis for truth. The foundation for CoI was, hence, his view that to develop knowledge, people must come together and serve as a jury for ideas. “Where people come together in agreement, ‘one can speak of knowledge, truth, and reality, but these concepts will be grounded in the community of inquirers, not in the individual consciousness’”. Pierce rejected the idea that it is possible to gain significant insights and reliable knowledge from ourselves because it is impossible to scrutinize our thinking. Community and inquiry refer, thus, to a group of individuals employing an interpersonal scientific method for arriving at results [10].

A metaphor that has been used to explain a community of inquiry is that of the blind men and the elephant [9]. A group of blind men is fumbling around an elephant, all individually trying to figure out what it is they are touching. One of them touches the elephant’s legs and thinks it is a tree. Another touches the elephant’s trunk thinking it is a rope. A third feels the elephant’s side thinking it is a wall. They all disagree with what it is because they are limited in their own experience. If they would cooperate, forming a community of inquiry, they could overcome the problematic situation. A community of inquiry could, thus, be described as any group of individuals involved in a process of empirical or conceptual inquiry.

Pierce’s ideas have been borrowed, adapted, and applied in many fields and were moved to educational settings by, for example, Matthew Lipman [9]. Lipman, together with Ann Margaret Sharp, believed that philosophical inquiry should be one of the core elements of school life because education should empower recipients’ to be thoughtful about the lives they lead, and philosophy is important for that [10]. Consideration of different perspectives teaches ways of reasoning that enhance critical thinking. Students choose what is interesting and raise issues for discussion, the role of the teacher is to facilitate this. This implies a power shift from the teacher to participation in the classroom. By doing so students usually become more engaged in classroom discourse, take more speaking turns, and speak for longer periods. Students become an important part of the inquiry, responsible for creating and sustaining discussion, confronted with their thinking as well as the thought of their fellow students. It is the process of inquiry that is most important, but the teacher facilitates discussion and scaffolds appropriate forms of participation in the community. In a community of inquiry, students should listen to each other with respect, build on each other’s ideas, challenges one another’s thinking, draw inferences from what has been said, and seek to identify one another’s assumptions. An inquiry in a classroom is a sustained exploration of a topic or issue that is of interest to students; community members participate in inquiries to understand the many ways of thinking about an issue [10].

For online learning, it was the colleagues at Alberta who developed the CoI framework on the belief that online learning would provide opportunities for communication between students and their instructors [1]. The basis of the framework is three different elements: cognitive, social, and teaching presence. The framework was developed to address the problems of lack of connectedness and limited collaboration in online learning [2]. This is the role of social presence, which is “what set asynchronous computer-mediated learning apart from just consuming content” [1]. Social presence’s primary importance is, hence, “its function as a support for cognitive presence, indirectly facilitating the process of critical thinking carried on by the community of learners” [2]. One example is community building through collaborative problem-based projects where knowledge is exchanged peer-to-peer between and within student groups [4]. According to the framework, at the beginning of a course, it is good to focus on open communication while later in the course the focus should be on group cohesion. For critical thinking and collaboration to happen there also must be teaching presence [1]. Teaching presence consists of the design and facilitation of the educational experience [2]. One example is to create a narrative or path through the course [5]. After a decade of use of the framework in online learning, teaching presence received increased importance. It was found that without a well-thought-through course design, the students did not achieve high levels of critical thinking in online discussion boards [1].

The goal is to build a solid foundation of social presence and teaching presence to stimulate cognitive presence in a course [1, 2]. The intertwining of these presences can be illustrated (Figure 1) by their three shared sub-elements: setting climate, supporting discourse, and selecting content [2]. Setting climate and supporting discourse are elements of social presence, but setting climate is also part of teaching presence together with selecting content. In turn, selecting

content and supporting discourse are elements of cognitive presence [2].

Joop van Schie [8] has developed a concept map of the community of inquiry further detailing it. In this map, social presence is “the ability of learners to project their personal characteristics into the community of inquiry, thereby presenting themselves as ‘real people’”. Elements of this are open communication, group cohesion, and emotional expression. Elements of teaching presence are instructional design, facilitating discourse, and direct instruction. Lastly, elements of cognitive presence are triggering event, exploration, integration, and resolution. The framework is extensive providing guidance for teachers on how to design an effective learning environment online. In the next section, we describe our implementation of it.

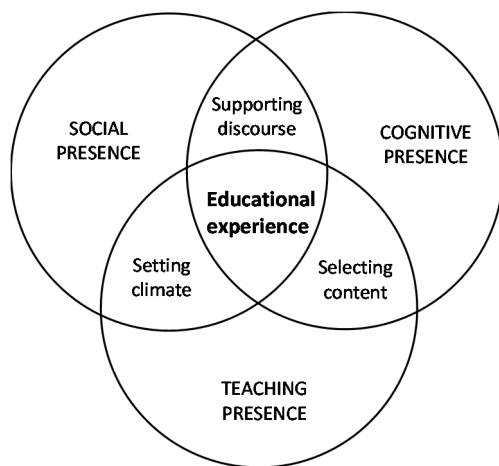


Fig. 1. Elements of an Educational Experience (adapted from Garrison et al. [2]).

III. THE CASE

In the pedagogical research presented herein, the community of inquiry was implemented in a university course component. After a brief presentation of the educational context of the case, the upcoming sections will present how cognitive, social, and teaching presence were implemented.

The case in focus in this paper builds on a course in interaction design given to around 110 students at the Programme of Systems Analysis at Örebro University. Since restrictions due to Covid-19 were in place during spring 2021, the course was held entirely online as was the case also during the 2020 course round. The five-week full-time course builds on project-based learning and focuses on the user-centered design process. During the entire scope of the course, the students work in project groups consisting of 5-6 students with the main task of developing a digital solution to help a chosen user group in a context decided by the course instructors. Most of the work is conducted by the students outside of scheduled time, although there are weekly seminars where the students meet to work on a specific aspect of the interaction design process. During the seminars, the project groups meet up with the teacher as well as other project groups. The five lectures as well as an individual task, elaborated on in the next section, are designed and positioned to coincide with the project phase in which the students are currently working. During the scope of the project, the students document their progress in an online, publicly accessible, project blog. The project blog, in

combination with the individual task, forms the basis for the grading. Since comparisons will be made between the last two course rounds in this paper, differences will be highlighted in the upcoming subsections.

A. Added focus on cognitive psychology

The connection between theory and practice is an important component in the course – the students are required to continuously reflect on their practice in light of theoretical concepts of importance to interaction design. The core theoretical component in the course is cognitive psychology, one of the fields that form the foundation of interaction design and human-computer interaction.

During the 2020 course round, the topic was covered in a lecture and the students were also tasked with reading some articles provided by the instructors. The students also discussed the read articles during a seminar. The students were then tasked with taking the concepts covered in the articles into account when making design decisions and motivating choices made in their ongoing projects. Both students and teachers thought that the topic was not elaborated enough, which was evident from both course evaluations and the handling of theoretical concepts in project blogs. This is the reason why the teachers decided to try a new approach, based on the COI framework, during the last course round – an approach meant to deepen the coverage of this theoretical area while still being able to fit an entire design process within five weeks.

B. Cognitive presence

Since the main aim was to increase the understanding of important aspects of cognitive psychology, it was deemed of utmost importance to create an arena that enabled critical discourse and reflection. The students were tasked to start with individual literature reviews around a self-chosen topic. Their task was to 1) use the acquired literature to give an overview of the chosen aspect, 2) discuss what the aspect means for the practice of interaction design, and 3) discuss how the aspect can inform the ongoing project. The students decided together in the project groups which aspects of cognitive psychology should be covered. They individually selected topics but with the instruction not to select the same in the group, and to make sure that as many aspects as members were covered in the group. After selecting topics, the students performed literature studies on them. This setup encourages learning different perspectives of the topic. After completion of the individual literature reviews, the students in the project groups gathered to discuss, critically, what had been read and, most importantly, how the acquired literature could be used to enhance the quality of the ongoing project work. This knowledge exchange was deemed necessary for the students to acquire a thorough understanding of cognitive psychology and how it works both in theory and in practice.

The main difference from the 2020 course round lies in the depth of the cognitive presence. During 2020, the students were provided articles assigned by the teachers and hence did never conduct an individual inquiry. Hence, they only scratched the surface of cognitive psychology, and they did not get the chance to search for material directly applicable to their projects. The other difference from the 2020 course round was that more aspects of cognitive psychology were listed as options to choose from, enabling a larger joint coverage of the area of cognitive psychology. The instructions

for the seminar were very similar between the course rounds, aside from an added emphasis on *critical discussions* in 2021.

C. Social presence

The social presence necessary for the new component to work was primarily supported by the fact that the groups collaborating on the literature task were already members of an ongoing project. They knew each other from the earlier project work and had shared goals, which of course the individual literature reviews should address. They did work individually searching for and summing up literature, but they did the synthesis together. The project teams had regular contact on digital platforms, including the university's official learning management system Blackboard. This created an arena for discourse and reflection, leading to synthesis and mutual learning applied to the project. During a seminar dedicated to the cognitive psychology component, the students sat in digital group rooms in Blackboard together with their project peers. The teachers visited these rooms regularly to listen to the ongoing discussions as well as to critically discuss aspects of cognitive psychology with the students. The seminar had two parts, one in which the students worked in their groups and one in which the different groups met to enable discussions between groups.

The difference between the two course rounds is mainly related to the teacher's moderation of the seminars, which was more focused on critical discussion with the students during the 2021 course round. Hence, the activity during the 2021 seminars was more in line with the basic ideas of the community of inquiry than during 2020 when the teachers mostly listened to the students' conclusions of their discussions.

D. Teaching presence

The overall design of the interaction design course is meant to create a narrative, from the identification of a problem to an evaluation of a digital prototype aimed to solve the problem. For the new component to work, it needed to form a natural part of the narrative and path through the course. This was ensured by connecting the literature review task to the ongoing project work and ensuring that the students understood, through instruction during a lecture, that the area of cognitive psychology is fundamental in interaction design. It was also highlighted on several occasions prior to the new course component that a thorough understanding of, and a good ability to use, cognitive psychology aspects was necessary for project success. The setup of the digital discussion seminar, where critical discourse, involving both students and teachers, could take place was of course also of importance in relation to teaching presence. The teachers were also ready to answer questions from students in Blackboard whenever they arose.

When it comes to teacher actions, care was taken to be very clear with instructions both regarding the individual literature review and the concluding critical discussion where the acquired knowledge was synthesized. The instructions were included in the study plan document that was posted on Blackboard well before the course started, and they were also repeated at the beginning of the seminar. The teachers also shared knowledge with the project teams during the ongoing discussions and helped to clear out some misunderstandings. The teacher's involvement was mostly based on open-ended critical questions.

In summary, all actions described were taken to facilitate the peer-to-peer processes necessary and to make sure that the work was carried out according to a scientific inquiry process.

The main difference regarding teaching presence between the two course rounds was that the literature review was not presented as an individual graded task during 2020 and hence, the importance of this part of the course was much more highlighted during the 2021 course round. In 2020, the task was not to perform a review but rather to read through some articles. This change enabled the students to perform a real critical inquiry in a community consisting of project groups. The emphasis on cognitive psychology, by the teachers, was also higher during 2021 to inspire students to investigate this subject and discuss its relation to the ongoing design work in depth. Last, the teachers also shared more own knowledge and reflections during the seminars in 2021 than in 2020, in order to further inspire critical reflection in the project groups.

IV. METHOD

Since the authors employ a teaching-as-research methodology in their teaching practice, the actual assessment of the project blogs will be presented as part of the research method in this paper.

A. Assessing the overall quality of theory application

The project blogs were graded based on an evaluation form consisting of two main parts. In the first part, the teachers checked off different aspects of the main phases of the user-centered design that should be covered in the project blogs. In the second part, which is in focus in this paper, the project was awarded 1 (not covered) to 5 (perfectly covered) points on 15 key areas, formulated as questions, of interaction design. The mean point gave the project grade, provided that all mandatory parts had been covered. One of the areas covered the overall design process:

Q1: How well is the (entire) design process presented, from vision to final solution?

Three of the areas related to the use of theory in the project work, these were:

Q2: To what extent is course literature/theories used to ground the ongoing design work?

Q3: To what extent does the group show an understanding of the meaning of the terms and theories that have been used?

Q4: To what extent is the content understandable and inspiring? (relates to correct references to theories)

These four areas, which were directly (2-4) or indirectly (1) related to how theory was handled in the project work, were used in the result analyses in this paper. These were the four areas on which the new course component of cognitive psychology was expected to have a large impact.

B. Comparing two course rounds

To judge the effects that the new COI-inspired course component had, the authors re-assessed the project blogs from one of their two seminar groups during the 2020 and 2021 course rounds. The seminar group that the respective teacher should re-assess was picked by a random generator. Since each seminar group contained five projects in 2020, ten projects from this year were re-evaluated. From 2021, eight projects were re-evaluated since each seminar group contained four projects that year. In the re-evaluation,

specifically, the four areas mentioned above were used, since the application of theory was of primary interest. The re-evaluation was performed to make sure that the projects were judged in the same way between the course rounds.

Aside from just evaluating based on the criteria in the project evaluation form, the number of used sources external to the course material was also counted and averaged across the two course rounds. The averages were then compared to investigate if the number of external sources was different between the course rounds. The same comparison was done for external sources that focused on aspects of cognitive psychology. A higher number of those external sources would indicate that the students dug deeper into the cognitive psychology literature and covered more areas of the subject.

C. Surveying the students

To gather student opinions and experiences the students were offered the possibility to fill in two surveys – one common course evaluation and one research survey. Results from both of these surveys were used to complement the comparison between the course rounds described above.

The course evaluation was handed out digitally to the students during the course's last week and was then accessible for two weeks. 33 students responded to the survey giving a response rate of 28.7%. The survey consisted mostly of statements for which students could answer on a 5-point Likert scale if they agreed or not. The statements of importance for this paper were the following:

- The individual literature reviews were helpful for the project work.
- The course developed my understanding of and my ability to apply cognitive psychology.

The research survey dug deeper into the different aspects of the course and was specifically designed to enable pedagogical research and most and foremost designed based on the teaching-as-research practice. This survey was published after the course was completed and remained accessible on the web for three weeks. In total, 18 students responded to the survey, giving a response rate of 16.0%. Given the low response rate, the results from this survey can only be used to discuss indications. The following questions are of importance for this paper:

- The scientific anchoring in Interaction Design takes place continuously during the course through provided scientific articles and scientific connections in lectures. The main focus, however, is during seminar 4. The seminar's structure is that each student must have carried out a shorter literature study in advance. The read articles are presented and then discussed in groups (and then applied to the project work). Do you think this is a good approach to scientific grounding? [Very good, Good, Bad, Very bad]
- How do you think this approach to scientific grounding has worked in distance education? [Very good, Good, Bad, Very bad]
- Do you have your own proposal for a plan for scientific grounding? [Free text]
- Any comment on scientific grounding during this year's course: [Free text]

V. RESULTS

The re-evaluation of the project blogs is presented in Table I and Table II. Table I shows the results from the project evaluations of eight groups from the latest course round (2021) that were randomly selected for analysis for this paper. The first column shows the group number. Column two to five shows the assessment for the criteria's Q1-Q4 (see IV Method). Column six shows the number of references used in total in the project, while column seven shows the number of references used related to the specific subject of cognitive psychology.

A. The overall quality of theory application

As can be seen in Table I, in the 2021 course round, the students performed well in relation to the questions Q1-Q4 and generally used a rather high amount of references as a theoretical base for their project work. In most groups, more than half of the sources related to cognitive psychology.

Table I: The outcome year 2021

Group #	Q1	Q2	Q3	Q4	# ref. total	# ref. subject
1	3	3	4	3	9	4
9	4	4	4	4	10	6
10	4	5	4	5	22	8
11	5	5	5	5	23	17
12	2	4	3	3	12	9
14	5	5	5	5	27	19
18	4	5	5	4	24	15
22	4	4	4	3	11	7
Average:	3,9	4,4	4,3	4,0	17,2	10,6

B. Comparison between two course rounds

In a second step of the analysis, results from the earlier course round (2020), from randomly selected groups, were used as a comparison. During 2020, the students performed around average (3/5) in relation to questions Q1-Q4 and used a fairly low amount of sources as a theoretical base for their projects. In most groups, less than 40% of these sources related to cognitive psychology concepts.

When comparing Table I with Table II, we can see a big difference both regarding the questions Q1-Q4 and with regards to the number of different kinds of sources that the students have used to back up their ongoing project work.

Just looking at the numbers it becomes clear that literature and theories are used to a much higher extent year 2021 than the year before. It is also clear that the understanding of terms and theories is a lot better. This was also very clear when reading the project blogs. In 2020, none of the groups explained the concept of cognitive psychology specifically, they used references in their text but without really elaborating on the subject. In 2021, all groups started by first explaining what cognitive psychology is, and the different aspects of it that they had studied, before applying it to the project.

Table II: The outcome year 2020

Group #	Q1	Q2	Q3	Q4	# ref. total	# ref. subject
1	4	4	4	5	15	4
2	4	3	4	4	7	4
4	4	3	4	4	9	3
11	4	5	4	4	13	5
19	2	2	1	2	4	2
20	3	4	4	2	10	4
21	4	3	3	4	9	2
24	3	2	2	2	4	2
28	3	2	3	3	5	2
30	3	2	2	3	6	2
Average:	3,4	3,0	3,1	3,3	8,2	3,0

C. Results from surveys

Overall, the results from the course evaluation survey gave many positive results. The handling of the course's theoretical content was no exception. In relation to the statement "The individual literature reviews were helpful for the project work", 69.7% of the respondents agreed or strongly agreed (18.2% gave neutral answers). With regards to the statement "The course developed my understanding of and my ability to apply cognitive psychology", 84.4% of the respondents agreed or strongly agreed (6.3% gave neutral answers).

The results of the research survey were also favorable. When it comes to scientific grounding in the course, 55.6% of the respondents thought that the setup was very good and 38.9% thought that it was good. This indicates that the students appreciated the new course component since this component was in focus when it came to the course's scientific grounding.

Since the course round had to be given entirely online due to Covid-19 restrictions, the students were also asked if they thought that the setup (regarding theoretical grounding) worked well in the forced distributed setting. On this question, 66.7% of the respondents answered "Very good" and 27.8% answered "Good".

A few comments and most of all ideas for improvements were given by some of the respondents on the open-ended questions related to the application of theory in the course. When it comes to ideas for improvement, especially related to the new course component, one student thought that the students should also be tasked with reading each other's reports within the project groups, so they are not totally dependent on content brought up during presentations and preceding discussions. Another comment was that it could have been made even more clear which points were of the highest importance within the aspects of cognitive psychology that the students could choose from. With regards to this course round's distance education, one student also noted that it would have been easier to discuss the individual literature reports if the literature seminar (the new course component) would have been given on campus.

The more general comments were all positive with regards to the new course component. For example, one student noted that he/she learned even more when engaging in critical discussions about the cognitive psychology concepts, especially when having to explain quite complex theoretical aspects to the peers. Some students also saw it as a positive

aspect that they could dig into the chosen aspects individually at first and later on elaborate on the aspects with their project peers.

VI. DISCUSSION

Overall, the results were positive and clearly showed that the new course component had a large effect on the project achievement when it comes to theory application in the projects.

A. Application of theory in the projects

The differences in project performance, in relation to the application of theory, are clear. The results in Table II show that the application of theory in the design process had medium quality during the course round of 2020. The points were slightly lower on questions Q2 and Q3, which specifically targeted the use of theory to ground choices made, and the understanding of the theoretical content utilized in the ongoing project work. In essence, these were the results that the teachers aimed to improve by introducing the new COI component. When comparing with the results shown in Table I the differences are largely related to all theory-related questions in the project evaluation form. We argue that the most important and interesting change is that the mean results in Q2 and Q3 not only increased by more than one point on the 1-5 scale but also were better than the results on Q1 and Q4 during the last course round. In essence, this clearly indicates that the students understood the theoretical content a lot better and also that they were a lot better at using theory to ground design and method choices in the project work. It also means that the students gained more related to these questions (+1.4 and +1.2, respectively), specifically aimed at measuring theory application than on the other questions (Q1; +0.5 and Q4; 0.7, respectively) which also included other aspects like the overall process and clarity of writing and referencing.

Together, the students were able to build an overall understanding of some of the most important concepts related to cognitive psychology and they could use this understanding to thoroughly ground the project work in a much better way than during the previous course round. Since there was a requirement to ground design and method choices theoretically also during the 2020 course round (when a few articles on the cognitive psychology subject were handed out to the students). This is also interesting to relate to the comment from one of the students on the research survey, that he/she learned more when engaging in critical discussions with peers. This also underlines the power of the community of inquiry set up, as do the results of the course evaluation survey related to the ability to apply and understand aspects of cognitive psychology.

When comparing the results on the last two columns in Table I and II we can see remarkable differences, which of course to a large extent explain the results related to the questions Q1-Q4. The students used around twice as many scientific sources in their blogs during the 2021 course round compared to the 2020 one. When it comes to sources related to cognitive psychology, the area targeted by the new COI component, we can see that the students used more than three times as many sources in 2021 than during the previous year. This is a big difference. That being said, it is important to note that the number of sources used varies a lot between the different groups. It is also of importance to note here that the students were encouraged to search for more literature related to cognitive psychology during the 2020 course round, but

none of the groups did that. During 2021, on the other hand, several groups used a few additional sources on cognitive psychology that had not been covered in the individual literature studies. Another clear difference, which also underlines the effect of strengthening the handling of theory during the 2021 course round, was of course that the students elaborated on the theoretical aspects, as well as the concept of cognitive psychology itself, a lot more than during the previous course round. That many more points (sometimes several per referenced article) related to the chosen theoretical aspects were also elaborated in the project blogs is also clearly in favor of the implemented CoI approach.

B. Application of the community of inquiry in the course

Our aim with this paper is to provide instructional strategies, theoretical and practical implications. We have already presented the new component used in 2021, as well as the results of the implementation. To be able to discuss how it contributed to the outcomes identified we will now compare the instructions given to the students to show the concrete differences that gave this immense effect. In 2020, the instructions to the students for the week with cognitive psychology was that each student in a project group should choose at least one of the scientific articles uploaded by the teacher. The student should read the paper individually and follow this instruction: "It is important that this is properly prepared, as all items are important either directly for the design or motivation to the chosen design. Everyone must also prepare suggestions on how the group can apply the points in the article read as you continue to work on your design solutions". The instructions for the seminar were: "During the first hour, the members of each project group present the article they have read to the other members. Set aside 7-8 minutes per presentation. It is important that notes are kept during all presentations, as all material can be used either directly in your design or in the discussion around it. During the second hour, the groups discuss further how the theoretical material can be applied in their specific case." The instructions for the follow-up work after the seminar was: "Now you can go back to your project blog and see where you can further strengthen your arguments with the help of the theory raised during the seminar (old blog posts can always be opened and edited). You will also work forward with the refinement of your design proposals, based on what you learned during the seminar". In the re-evaluation of the final project blogs for this year, it became clear that we had limited the students' possibilities for learning this subject by our chosen strategy. We only demanded the students to read one article each and we provided them with the articles. This created no scientific inquiry. We also only asked them to discuss in their own group and we did not assess their work and efforts in any way. The students were encouraged to search for additional literature related to cognitive psychology, but as stated earlier no one did that.

The main differences in 2021 were that this year, the individual assignment (the literature review) was assessed, and the students were not asked to read an article provided by us (the teachers), instead, they were asked to dig a little deeper into one specific aspect of cognitive psychology. Each student should: "... use three different scientific sources, which are not part of the course material". Furthermore: "In groups of five students, all members should choose different topics to cover all of the areas. If you are less than five students in a group, you should cover as many topics as you are group members. In this case, you should also take care to cover the

rest of the topics as a group, since all topics are of importance for the project work". The instructions at the seminar were the same for both years. The strategy to make sure that the students worked according to a scientific inquiry method and performed the work in a community elaborating on the aspects peer-to-peer explains thus the difference. Our implementation worked because of the combination of cognitive, social, and teaching presence. *The cognitive* by making the students more prepared individually. According to the theory, consideration of different perspectives teaches ways of reasoning that enhance critical thinking [10]. This was achieved by letting the students read several articles before the seminar and making them find different sources on their own. That created an individual inquiry before the inquiry in the community (the project groups). *The social* by the collaborative learning environment, and *teaching* by the way we designed the assignment. Returning to the metaphor previously described, the blind men and the elephant, we can see that making sure that each member of the community contributed with their perspective and then letting the community work with the different perspectives together led to a deep understanding of cognitive psychology as a subject, not just individual perspectives of it, which was the outcome previous year. From this experience, we agree with the statement that it is the process of inquiry that is most important, but the teacher facilitates discussion and scaffolds appropriate forms of participation in the community [10].

The pandemic has changed character, some say it is over, but it will probably have an impact on education for a while longer, and online learning will likely be held to a higher extent in the future than before the pandemic. That makes it relevant to evaluate strategies that can contribute to a better learning environment for the students in online education. We have clearly shown that CoI works in practice.

C. Method discussion, limitations, and future research

Before re-analyzing the project blogs, we had a sense that the new component had had a great impact on learning outcomes and the feeling that the students had learned a lot more than the previous year. But since a year had passed, we did not know for sure. After the re-evaluation, it became very clear that the difference was substantial. That, of course, led us to think if the difference could be explained by some other parameters as well? However, we concluded that there is no other probable explanation than the implemented component. Both years, the course was held online because of the pandemic. Furthermore, it was the same teachers and the same digital environment, so the outcome is, most likely, due to the implementation of the component. One thing to take into consideration though is that the students were more used to online learning and that could have impacted the results. However, we feel that it is unlikely that this would have had such an impact.

The limitations of this study are that we did not examine all project blogs. In the future, it could be interesting to look at all blogs from both years again and also to look at more aspects, for instance, how many perspectives of cognitive psychology the students address. It could also be interesting to follow up this study by comparing the results with a year when the course is not online, for example, the upcoming course this spring (2022). Interesting as well could be to ask someone that has not taken part in the course to do the analysis and comparison to eliminate the possibility that we are affected in any way. This risk is, however, very low since we have had

clear criteria for our assessment and comparisons, but to make sure that there is no bias in any way.

Another limitation of the study is that we have not performed a significance analysis on our data. The reason is that we only re-evaluated half of the project blogs for two of the teachers in the course (the authors of this paper) which makes up a third of the projects in total. In a future extension of the study, it would be of interest to do a significance analysis on the total number of projects.

VII. CONCLUSIONS

We have shown that through the use of community of inquiry, it is possible to build an online learning environment that makes it possible for students to achieve deep knowledge about a complex theoretical subject. If designed with care, community of inquiry can remove common limitations in online education. In this paper, we asked the question: “How can a course component aiming at deep knowledge creation be designed and implemented using CoI?”. One possible answer, derived from our study is, to facilitate for students to first individually investigate a subject through applying a scientific inquiry and then, in a community build an overall understanding based upon the different individual inquiries through critical discourse. One important practice recommendation is therefore to work with complex issues in a way that facilitates this. We have shown that it works well for designing a course component, our results exceeded our expectations. For future research, it would be interesting to work in this way in a bigger picture, in an entire course, or even study program. One can suspect that more education will be held online in the future as a consequence of the pandemic. Therefore, future pedagogical practice, as well as research,

should focus on this. Especially when designing educational settings for complex theoretical content.

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