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Hands-on Learning of Cooperation Technology:

Combining Knowledge Construction and Reflection

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***Abstract*—Project work is becoming an important part of university education aiming at preparing students for team-based activities in a workplace. However, cooperation problems are common in the learning process. The major purpose of the study presented in this paper is to address these challenges by designing a Cooperation Technology course and studying its outcomes. We applied social constructivist and reflective learning approaches and used various cooperation technologies in the course as platforms for project work. The practical tasks were designed to let the students experience different types of collaboration in different technological settings. The students were actively creating their knowledge constructing shared artifacts and constantly reflecting on their experience. Based on study data, we analyze collaborative workflows in and between student groups, use of technological ecologies, and the outcomes of their work. As a result, we provide a set of implications for combining social constructivist and reflective learning approaches in course design.**

Keywords- Cooperation technology, Course design, Collaboration, Social constructivism, Reflective learning

I. INTRODUCTION

Engineering is not a solitary endeavor, but it requires complex and varied forms of cooperation. Participants of the collaborative activities often have different backgrounds, schedules, level of engagement, and interest in a specific project. On the one hand, this may facilitate a creative process and innovative ideas through "the symmetry of ignorance" [1]. On the other hand, cooperation problems are rather common and often lead to frustrations and disruptions in the learning process.

Cooperation can be supported with a varied set of tools that we will hereafter refer to with the generic term *cooperation technology*. Knowledge of cooperation technology is becoming recognized as an important part of engineering education, providing competencies to understand the cooperation needs of different working contexts and the impact that these technologies can have on work practices.

Learning cooperation technology presents a number of challenges. First, the needs of users are rather varied. Cooperation might take place in small groups or larger communities of interest or practice [2], it might involve co-located or distributed actors, it might happen in the context of well pre-defined organizational procedures or be more creative and unstructured, and it might involve rather homogeneous workers or require bringing together people with very different competencies and interests. Generally, any working setting involves multiple forms of cooperation at different stages of any given work practice. Second, the set of cooperation technologies to choose from is equally large, ranging from dedicated tools for specific work procedures to generic social media. Some systems are dedicated to supporting cooperation, while in other cases the support is integrated in other systems; some systems require strong organizational commitment, while others are lightweight and can be easily adopted by small groups.

In our educational and research practice, we investigate how to teach cooperation technology to engineering students. Our aim is to promote an understanding of cooperation needs and technological support that can help students in their future working places in selecting and using different technologies in an appropriate way.

Cooperation Technology course at our university is mainly intended for computer engineers, but it is open to students from other engineering programs. It must therefore be tailored to students who might be interested in the design of new cooperation technology, but also to students who are interested only in its use and impact. The course has been completely revised this year, moving from a rather traditional course with lectures and a final written exam, to a course that integrates lectures with a group project. The course has been re-organized upon consideration of two main pedagogical approaches. *Social constructivist* approach proposes that learners co-construct their environment and understanding together with their peers [3]. *Reflective learning* approach implies that students learn by reflecting on relevant experiences [4]. Specifically, the main goal of the group project is to experience collaboration mediated by technology and reflect on how it evolves and how collaboration, and consequently requirements for technological support, changes depending on the characteristics of the work.

In the paper, we present and discuss the outcomes of our experience with the course. In particular, we discuss how students established and supported their cooperation, how they overcame breakdowns, how they used specific tools, and how these tools influenced cooperation.

II. STUDY SETTINGS

The course is taught in the autumn semester, over a period of 13 weeks, and it is mainly intended for fourth year students at the Master level. The course counts for 7.5 ETCS. Students receive a final grade A–F (Fail): 70% based on the group project and 30% on an individual essay. In autumn 2012, 31 students attended the course, working in seven groups of 3–5 members. Students had the possibility to choose their team members, but not all used this possibility and some of the groups were put together randomly. Traditional lectures throughout the semester were used for introducing core concepts and examples of existing tools. This basic knowledge is intended as a conceptual tool to be used and extended in the group project.

A. *Group project: overall design*

The group project was composed of three tasks. Following a *social constructivist approach*, each task was designed to promote the collaborative construction of new knowledge on cooperation technology. Each task was designed to require different forms of cooperation, either face-to-face or mediated by technology. In this way, students gained first-hand experience of cooperation and how technology can promote or hinder it. Following the *reflective learning approach*, we aimed at promoting rethinking of this experience to learn from it. To this aim, after each task students had to deliver not only created artifacts conveying the acquired knowledge, but also reflection notes. A template was provided for the notes of each task to scaffold the reflection process, pointing out specific issues to consider, e.g. the flow of work during the task and how it was affected by the technology used, how different technology influenced cooperation, and the tradeoff between creativity and efficiency. The notes were written collaboratively in groups, so that the students had to discuss their experience

The three tasks were designed to involve different forms of cooperation, considering collaboration and learning on two levels – group and community. In this perspective, a student group is a subject within a *learning community*, which, in turn, could be thought of as shared histories of participation and learning [2]. The results of activities performed by students is an artifact, a reification of experience [2] that is shared with other community members, e.g. through presentations.

B. *Course Activities*

For *Task 1* students had to create a handbook containing a description of at least 10 tools for cooperation. To avoid a simple cut & paste from existing sources, students were required to specify a clear purpose for their handbook (context of use, intended readers, selection criteria), and describe the overall organization of the entries and their internal structuring. There was no restriction on the tools that each group could use to support internal cooperation and on the final format of the handbook.

The groups were required to present their handbooks to their peers and a few visitors during a virtual seminar in vAcademia 3D virtual world (http://vacademia.com/). This technology has been chosen for this course as: first – it offers the opportunity to experience different forms of cooperation and mediation, and second – being unfamiliar and complex, it forces discussion on appropriate use of technologies, critical thinking, and reflective learning [5]. 3D virtual worlds are known for providing wide opportunities for collaborative work, wide opportunities for simulating environments for conducting meetings, performances, and role playing [6].

During the creation of the handbook, students experienced group cooperation, both face-to-face and supported by technology. The preparation and delivery of the presentation required cooperation in a technological environment that was unfamiliar to all the students. The presentation involved not only group work, but it was also an experience of (technology-mediated) cooperation within a learning community, with each group sharing their knowledge with others and engaging in discussions.

In *Task 2*, the students had to use a mobile application called LingoBee (http://simola.org/lingobee/), designed as a crowd-sourced cloud-based repository for situated mobile language learning. Task 2 was to produce (a) a dictionary of Norwegian terms and phrases that might be useful for e.g., a newcomer to town, and (b) a glossary of terms related to cooperation technology. For (a), students had to create entries individually in an open dictionary and then comment on and improve other entries and rank the best ones. For (b), each group had to create an initial draft of the entries in a corpus visible only to the group. After this first phase, all the entries were made public and groups had to comment on other groups' entries and then revise their contributions based on the feedbacks that they received.

The cooperation required in Task 2 was rather complex, including cooperation within groups, across groups, and within a learning community. Collecting entries for the Norwegian dictionary could also potentially lead to cooperation with the local community.

The two sub-tasks were also rather different. Given the nature of the intended outcomes, we expected students to use the mobile functionalities more extensively during the first part of the task, possibly exploring the city as an arena for learning. The production of the glossary could instead be compiled consulting the syllabus or Internet sources. It should be noted that while sub-task (a) represented a typical scenario of usage for LingoBee, sub-task (b) was purposefully designed to stretch the usage boundaries of the tool. For example, the feedback capabilities of LingoBee (adding to an existing entry, commenting, and ranking) were not presented explicitly to the students when the tool was introduced to them. Therefore, the students needed to do it using another tool. Since providing feedback was done across groups, reaching an agreement was expected to be challenging.

Summarizing, Task 2 was designed to provide direct experience of different forms of cooperation, mobility and how it affects cooperation and tool usage, and breakdowns in the flow of work caused by inappropriate support in the tool.

As for *Task 3*, the students were participating in a Joint European Course that was designed and conducted by CoCreat project (http://www.cocreat.eu/). The course lasted

five weeks and brought 68 students from three universities: Tallinn University, (Estonia), University of Oulu (Finland), and our University – in a virtual space. Study process has been structured with the ideas of collaborative and problem-based learning, social constructivism, and technology-enhanced learning. For our students this was intended as an occasion for putting at work the knowledge gained during the two previous tasks. By cooperating with students with different backgrounds, they were expected to meaningfully and creatively apply this knowledge in a domain, i.e. education, that was outside their area of expertise.

During the course, larger international groups were formed from local groups. All the course activities were conducted distantly posing an additional challenge for the students. Working with international peers, the students shared competences and developed practical skills.

The joint activity consisted of several tasks aiming at creating a multimedia book. Each international group of students worked on one media chapter. The book has seven chapters. Each of them is entitled by a Technology-Enhanced Learning challenge designed by CoCreat partners and consists of a deliberate solution to it developed by the students. The resultant handbook was intended to be an open resource, and it is now available at http://cocreat.purot.net/.

TABLE I. PRACTICAL ACTIVITIES OF THE COURSE

	Task 1	**Task 2**	**Task 3**
Course activities	Collaborative writing + presentation in vAcademia	Creating a language dictionary + a glossary	Collaborative writing + f2f presentation / Adobe Connect
Types of collaboration	Local group	Local group + local community	Local group + international
Assigned technology	vAcademia	LingoBee	Adobe Connect, Purot Wiki, Prezi
Main outcome	Handbook of cooperation tools	Language dictionary + glossary of terms	Online media handbook on ed. tech.

C. *Data Sources and Analysis*

The data were collected from the direct observation of students' activities online and their recordings, the virtual artifacts the students created, and user feedback in the form of questionnaires, group reflection notes, semi-structured interviews, and individual essays. Most of the results presented in this paper are based on the reflection notes.

For analyzing the data from the student reflection notes and essays, we use the constant comparative method [7] that was originally developed for the use in grounded theory methodology and is now applied more widely as a method of analysis in qualitative research.

III. STUDY RESULTS: COLLABORATION

A. *Tasks and Outcomes*

The main part of Task 1 was clear for all the groups, except for few minor imperceptions. The resultant handbooks of tools were evaluated by the course staff and met expectations, with some of the groups making a considerable effort in identifying the needs of the intended target group and searching for tools outside the most common ones. Some groups focused too much on the layout, but generally, the handbooks showed satisfactory knowledge of existing tools and demonstrated a considerable increment of the knowledge that as course staff we tried to convey through the lectures.

The presentation in vAcademia was perceived in the beginning as an unnecessary complication, but most of the groups reflected that after watching all the presentations, they could see the cooperation potential of this technology and valued their experience. Six out of seven groups used at least three features that are unique for 3D virtual worlds.

Four groups reflected on being puzzled by Task 2, which resulted in the reduced efficiency. The entries created for Task 2 (a) contain some typical Norwegian terms and phrases for students and in general, such as "fruktkort" (fruit subscription at the university shop) and "dugnad" (voluntary work). Several of the entries had contributions from more than one student, indicating collaboration and some entries were contributed outside of the university campus implying mobility. LingoBee's multimedia capabilities were used for some entries where the users included photos to illustrate the terms. The cloud-based repository is available from http://simola.org/lingobee/index.php?gid=28.

For Task 2 (b), the entries of the glossary are mostly rather superficial, with poor grounding in the recommended readings or in state-of-the art knowledge in CSCW. The length and layout limitations in LingoBee (which was designed to capture language-related contents through text and multimedia) on lengthy textual descriptions could have prompted synthesis and focus on content rather than layout. However, these limitations have rather acted as an inhibitor, with students complaining about the limited space and difficulties in formatting.

For most of the groups, we can note a considerable improvement after the entries were revised based on peer reviews.

Different parts of Task 3 were misunderstood by most of the groups, primarily because of the international students involved. Only one group extensively reflected on the missing community support, but at least five groups found a way to solve it (mostly incorporating additional tools) based on the direct observation and the interviews.

The resultant media handbook chapters were satisfactory. The main misunderstandings of the task were that students from Finland must lead, as their competence was more theoretical, and that the technological part of the chapter can be made as an attachment to the main part. However, expert evaluators were satisfied with the results after their comments were addressed. Students themselves were also rather happy with the outcomes of the project in terms of both the resultant chapters and cooperation experience.

B. *Cooperation on the Group Level*

Six groups out of seven identified their group level collaboration as successful or at least satisfactory. Three groups discussed that the main contributing factors were good atmosphere, knowing each other beforehand, and having similar motivation levels.

– *The group has worked really good together, and we all had the same goal for this course. We have all put in approximately the same amount of effort.*

Three other groups emphasized planning and extensive use of online tools for increasing efficiency.

– *[…] belonging to different study programs, we have relied heavily on using online cooperation tools.*

– *That decision [to use Google Drive, Doodle] enhanced the overall effectiveness of the collaborative effort […] and every active member respected the deadlines.*

The students did not identify many challenges for cooperation on the group level. The most common challenge was the differences in time schedules of the group members. It was discussed by four groups.

– *Two of the group members were abroad during the work on task 1 and this introduced some challenges regarding coordination and collaboration.*

– *As everyone has had a lot to do outside of this project, it has been problematic to schedule meetings and find time to work on the task.*

The second common challenge was the difference in motivation levels. It was mentioned by two groups.

– *Collaboration is always a bit tricky when you are in a new group with random people. You don't know each other's working styles, rhythms, motivations, and interests.*

– *The level of ambition and initiative is highly divergent, leading to a certain degree of unfriendly atmosphere in the team. Someone has put a lot more energy into it, and has been working towards maintaining an overview and pushing the other members.*

Finally, small local groups were much easier to coordinate than any activities between local groups or on the international level. None of the groups reflected on group-related challenges in the in Task 3, as it seemed easier.

– *The cooperation between the group members was much easier than on the community level. […] The communication was more personal and interactive between the group members and that was not the case on the community level.*

C. Cooperation on the Community Level

On a number of occasions, the students have emphasized the advantage of working with people with different backgrounds (symmetry of ignorance [1]) for creativity and generally the success of the project. This was especially prominent on the community level when collaborating with international students in Task 3, as the Norwegian and Estonian students had a technical background while their Finnish counterparts – pedagogical. Four groups explicitly stated that this type of collaboration benefited both learning about cooperation and the outcome of the project.

– *In the end we managed to work together and meet each other's expectations. We merged our understanding of technology and their understanding about learning.*

This enabled the students to expand their possibilities.

– *We […] were able to complete a far more complicated task than we would have been able to by ourselves. Through working with students with very different expertise than us, we were able to gain insight in to another way of looking at our field of study.*

The cultural differences provided enough source of diversity, encouraging students to learn.

– *To create a good environment for collaboration between different cultures and locations, we had to be open minded and tolerant regarding alternative ways of doing things, communicating and ways to interpret observations.*

Despite the extensive positive feedback, collaboration on the community level imposed a number of challenges. The students mentioned such challenges 14% more often than benefits in the reflection notes for Task 2 and 135% more often reflecting on Task 3. This includes educational and cultural background diversity, lack of shared understanding and other aspects.

– *Since the teams were from different fields of work, we had different understanding for the same topics so it was sometimes a challenge to explain to each other our points of view and to make a unanimous decision which way to go.*

Impersonal communication made collaboration on the community level more difficult, as little effort was applied to establish connections and social capital. This was partly addressed by course staff, but still was a serious barrier for the students.

– *[We] did not get the same feeling of team spirit and group cohesiveness with the internationally distributed group as the local group. Without social interaction in the same way as local teams we did not get the same feeling of responsibility. […] This resulted in less effectiveness and less motivation for the task.*

Working locally, many groups used face-to-face meetings especially in the beginning of the project work, as a means for social interaction and building trust. Inability to apply this in Task 3 imposed another serious challenge.

– *Although there are tremendous opportunities for both effective and creative work in distributed work, it does demand a bit more effort and time to achieve. The main reason for this is that it takes longer to get to know each other in the starting process.*

In many cases, the students failed to establish fruitful communication and shared understanding, adopting a simplified approach to negotiation of meaning.

– *Having only one person from each country meet online over Skype and then informing the rest locally was quite efficient […]. However it was not helpful when it came to knitting the groups closer together and making the participants feel more connected to the project.*

Challenges in coordinating activities between the groups in Task 2 were explicitly identified by three groups.

– *Coordinating feedback between the groups was hard because there was no natural leader involved. No one wanted to take responsibility for coordinating the groups.*

When working with international students, the students experienced even more challenges, as six groups out of seven explicitly identified them in the reflection notes.

– *From Finland and from Norway some people took the responsibility of dividing tasks and making groups but overall a clear feeling of responsibility was missed.*

D. Reflection on Learning Cooperation

We did not ask the students directly how much they learned about cooperation, but most of the groups provided positive feedback on Task 3.

– *I think all of us would cope better with this type of situation today, and we are probably more open minded when going into a collaboration process with people we do not know compared to what we were before.*

The experience of using new tools, both assigned and selected by the groups, was closely related to learning cooperation.

– *Using all the new tools together with all the other people on the group was exciting and challenging […]. We have learned a lot about working in large groups that are not located at the same place.*

IV. Study Results: Technology

A. Reflection on the Assigned Tools

1) Task 1: vAcademia

The students were not given any restrictions on the tools to apply for achieving the main objective of Task 1. However, they were required to use vAcademia for presenting the results of their work.

The direct observation of the activities in vAcademia showed that in the beginning the students struggled with the new type of cooperation platform and did not know its affordances. The data from the pre-questionnaire shows that 54% of students expected a 3D virtual world to be easy to use, but this number was slightly lower in the post-questionnaire. Four groups provided feedback on the use of vAcademia in the reflection notes. Only one of them found the platform easy to use from the very beginning. However, the complexity of vAcademia is partly perceived, as two groups reflected that found it easier to use and could see possible benefits after the virtual seminar.

– *I was a bit skeptical about the presentation in Virtual Academia, but it was really fun, and I think we did good.[…] I was positively surprised at not only our own but the other groups' presentations, and am pleased to have experienced this digital format of group meetings*

At the same time, many technical problems that hinder and distract collaboration were identified for vAcademia.

2) Task 2: LingoBee

For Task 2, the students were given a strict requirement for using a specific tool – LingoBee. However, they were free to use any additional tools. LingoBee was also a new tool for all the students, and four groups reflected that the tool was challenging to learn.

All the groups stated that LingoBee was not fully suited for the task.

– *What confused us with Lingobee was that we did feel that the application and its interface did not match with the requirements for the TASK 2, especially in part (b).*

However, two groups found creative or practical solutions to this.

– *The usage of the Lingobee tool has shaped the cooperation between the group members in many ways. This tool made monitoring the work progress easier and was good replacement for Google Drive.*

Three other groups reflected that they found some other tools to replace the missing functionality, while the two remaining groups simplified the task to fit it into the tool.

– *[Email] was used to tell the other group members when an entry was submitted, keeping the group aware and updated. It is also easier to write an entry on a computer, […] and then they were copied from the mail on the phone and into Lingobee.*

– *We found Lingobee to be to be quite an easy program, actually too easy for our use. It was quite difficult actually to make a good delivery in this program.*

3) Task 3: Purot Wiki, Adobe Connect, and Prezi

The students were given three tools in Task 3. Apart from delivering the results and the first and final meetings, they could incorporate any other tools, discussing it with their international peers. The reflection upon Purot wiki varied greatly, but all the groups found both advantages and limitations. Three groups learnt to use the tool and mitigate its limitations, while four others preferred to use familiar alternative tools and insert polished pieces into Purot wiki.

All the groups also found both advantages and limitations of Adobe Connect. In a similar manner, five groups used it as the main synchronous communication tool (although, only two groups were satisfied), while two groups switched to more familiar alternative solutions.

Prezi was a new tool for all Norwegian students. Five groups explicitly reflected on its advantages, especially the possibilities to work online and make dynamic presentations. Two of these groups also found several limitations, and only one group provided a purely negative reflection. None of the groups went for alternatives.

Finally, while most of the groups reflected on challenges in international cooperation, only one group mentioned that a tool was missing in this task – a tool for community support.

– *There was no use of e-calendars, blogs, or anything that was shared by all group members other than the Cocreat page.*

B. The Use and Reflection on the Additional Tools

All the groups used several additional tools in all the tasks. First, most of the groups (6, 6, 7 for tasks 1, 2, 3 correspondingly) used Google Drive/Documents, as all the tasks required to write collaboratively. This tool was familiar for all the students and described as the most appropriate when no tool was assigned. It replaced the missing functionality of the assigned tools or used instead of them.

Most of the other additional tools were incorporated to support the collaborative process. They included Facebook (4, 2, 4), Skype (4, 2, 3), email (3, 3, 2), and Doodle (3, 0, 3). In most cases, the students explained the use of these tools by the fact that they are more reliable, all or most of the group members are already using them, and they know how to use them efficiently.

C. Reflection on Learning Cooperation Technology

Most of the groups stated that they incorporated familiar tools in their group technological ecologies. Students stated

that they could start using such tools right away and work more efficiently.

– *[…] instead of striving and possibly spending lots of time to find what might have been the most efficient or most exciting tools for the job at hand, we found it easier to use tools that we were already familiar with.*

However, students often mentioned that using familiar tools, although contributing to the work done, did not necessarily lead to creative solutions, learning, or change.

– *Our tools were familiar, with […] little overhead and high productivity level. However, for the sake of learning more about cooperation technology, it is possible that we would have benefited from using more unorthodox tools.*

Two groups explicitly noted that the assigned tools (being unfamiliar, challenging, and different) contributed to the increased understanding of the course topics and facilitated learning.

– *Wikispaces and vAcademia […] required us to think differently than when we use more familiar tools, and although we did not always enjoy using them […], we believe that it taught us even more about how distributed collaboration works […].*

V. Discussion and Implications

Based on the results of the study, the combination of social constructivist and reflective learning approaches worked well as most of the students benefited from both collaborative knowledge creation and reflection on their (positive and negative) experience.

However, we identified a number of challenges of such combination. From the social constructivism perspective, providing the students with the most suitable tools and letting them focus on the assignment would have the most positive effect. This means that cooperation breakdowns that we designed following the reflective learning approach reduced this effect to some degree. The results demonstrated that this was the case especially for less motivated students.

At the same time, from the reflective learning perspective, it was justified to give the students challenging and slightly inappropriate tools. This would cause breakdowns that acted as triggers of reflection and learning. However, the breakdowns did not always work as intended, as less motivated students tended to use them as a barrier they did not want to overcome. Therefore, the breakdowns have to be designed carefully.

For example, the breakdown we designed for Task 1 – giving the students a too complex tool, worked well. The results show that all the groups overcame it and most reflected either gaining useful experience or learning. The breakdown for Task 2 – providing a tool with inappropriate functionality, worked only for highly motivated groups and degraded the less motivated ones. The breakdown that (partly not intentionally) occurred during Task 3 – limited community support, worked well from the reflective learning perspective, as most of the groups reported positive learning experience. However, this breakdown significantly limited the collaborative knowledge construction process, as the results demonstrate.

We argue that there are tradeoffs between making knowledge construction as smooth as possible and letting students go through multiple experiences, creating triggers to promote reflection. Breakdowns can, to a certain extent, act as such triggers, but there is a risk that they disrupt the construction of knowledge without leading to reflection. If the breakdowns are too difficult to overcome, they may slow down or even stop the process. At the same time, if they are too easy, they may only create unnecessary disruption.

The scaffolding mechanisms that we have put in place to address this risk (structured reflection notes) were successful only for the most motivated groups. Therefore, we need to develop better mechanisms that scaffold not only the reflection process, but also the cooperation process.

VI. Conclusion and Future Work

The course design we implemented and presented in this paper provided implications for combining social constructivist and reflective learning approaches in technology-mediated educational context. The implications are empirically based and can benefit courses that are grounded in theoretical approaches we applied and provide a new perspective on technology-enhanced learning.

We are planning to continue our research into teaching cooperation technology. In the next semester, we will try to balance collaboration and technological challenges more accurately with the prospective team work outcomes for student groups with different motivation levels.

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