Lessons from the Collaborative Innovation Networks Seminar

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Abstract: This paper describes lessons learned from teaching a distributed virtual course on Collaborative Innovation Networks (COINs) over the last 12 years at five different sites located in four different time zones. The course teaches students how to leverage virtual collaborative creativity in the Internet age by making best use of e-mail, social media, and the Web. In this paper we extend 6 principles of teamwork by Richard Hackman (2011) to the virtual realm.

Keywords: Collaborative Innovation Networks, COINs, distributed virtual teams, social network analysis

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1. Introduction – Collaborative Innovation Networks (COINs) seminar overview

This paper describes a course to teach students how to leverage virtual collaborative creativity in the Internet age. In particular this course helps students understand and apply the dynamics of online communication using e-mail, social media, and the Web. This is done using online social network analysis with help of our own tool Condor (Gloor et al 2004). Our course is unique in that it teaches a self-directed style of learning though *competitive collaboration*. While there is competition among teams and among team members for the best grades and ideas, the key is to collaborate. We strive to reward the individuals and teams who contribute most to the success of the entire class. Every team member is expected to step up and assume responsibility for the results of their teamwork.

The goals of this paper are two-fold: First to present our experiences collected over 12 years teaching this course on virtual teaming, collaboration and innovation. Second, to investigate whether Hackman's (2011) six conditions for successful teams apply to our virtual teams, and finally to extend these conditions for building *real* virtual teams with shared aims, suitable norms of conduct, with the right collaboration tools, and the right type of coaching for virtual collaboration.

For the last 12 years the authors have been involved in teaching a distributed seminar where student teams with participants from MIT / US, Illinois Institute of Technology[1] / US, Aalto University / Finland, University of Cologne / Germany, and University of Bamberg / Germany, collaborated as virtual distributed teams, tackling problems of social media analysis and other COINs-related issues. The students' backgrounds vary from computer science and industrial engineering majors at Aalto, to design and finance students at Illinois and from MBA students to information systems students in Germany. Thus, the disciplinary backgrounds of the students vary quite a lot. Majority of students are Master's students, while some a few are already doing their doctoral studies.

[1] Initially this group of design students came from Savannah College of Art and Design/US, since 2014 they participate from IIT.

For most sites, the course consists of a several day introductory block course taught on-site, followed by four months of virtual collaboration by distributed student teams. The virtual collaboration projects are divided into iterations of one to three weeks. The first iteration is one week long to encourage teams to get up working quickly. The rest of the iterations are two to three weeks long. At the end of each iteration each team presents the results of the last iteration and the plans for the next iteration in a virtual meeting. Most virtual meetings are for the whole course, all sites connected to the meeting. One or two meetings are team specific with one team at the time presenting to teachers only. Iterations both force the teams to work constantly on their projects, as well as give them a chance to receive feedback from the teachers and fellow students. At the end of the last iteration the students give a bit longer final presentation on the whole project. After that they still have some time to finalize their final seminar paper reporting their whole project. Due to differing semesters at different continents, the US students officially finish the course after the first four iterations, but students may still continue working in the projects. We encourage the best teams to improve their seminar papers to conference papers.

There are two focal points of the course that set it apart from similar courses on virtual teaming, namely a focus on teaching *collaboration*, and *innovation*, two skills prized in today's knowledge-based economy, but commonly considered difficult to teach (Beane 2005). In the COINs seminar, the concept of COINs is focused not only on students learning from each other in teams similar to Communities of Practice (Lave & Wenger 1991; Wenger 1998), but also with an explicit goal to collaboratively innovate to create something radically new (Gloor 2006). A key part of innovation through COINs is to teach students the rewards of intrinsic motivation, based on the motivation pyramid "money > power > glory > love > wisdom" introduced in the genome of collective intelligence (Malone et al. 2009). The motivation pyramid is key for the self-organizing emergence-based style of collaboration through rotating leadership practiced in this course. For example, we prioritize giving students the freedom to choose the subject they like for their teamwork over enforcing the location-based group structure rules. We try to teach them that they should not be motivated by extrinsic motivation – getting a good grade – but by choosing a topic that they love, which in turn, because they are more motivated to do good work, will also lead to a good grade.

A problem that we discovered is that there is a wide range of students, from unmotivated students who just take the seminar to fulfill a requirement, to students who go to great lengths to take the seminar, intentionally traveling from remote locations, and spending far more hours on their team projects than they would be required. Because of the interdisciplinary nature of the course we also see a wide range of technical expertise among the students, some of whom have a strong computer-related and programming background and others who may be competent users of off-the-shelf software, but have no experience in working with proprietary software programs. These students can easily become unmotivated if they do not have fast access to help in working through questions and problems that they encounter. We found that having unmotivated students and highly motivated students in the same team has a high risk to demotivate the motivated students.

Our solution is to offer a wide selection of topics, from very basic ones – for instance "Coolhunting for a brand on the Web" to highly demanding ones – "building a pair of eye tracking glasses including software from scratch" which far surpasses the minimum number of hours requested from the students to work for the seminar. Based on the principle "birds of a feather flock together" this leads to highly motivated teams selecting demanding tasks, and low motivated student teams choosing an "easy" topic. But even intrinsically motivated students need recognition for their hard work, which they get at the virtual status meeting, where good work is pointed out by the instructors and recorded in Webex. Initially the teachers were far more indiscriminant with praise, but over time we found that giving praise more sparingly, an honest critique telling what is good, and also telling what is not good, was far more motivating for the students.

Besides teaching collaborative skills, we also try to teach in the course how to innovate. Innovation means applying solutions from outside the problem domain to come up with radically new ways in how things are done. In the course, we encourage students to reach out to external people and to learn from areas outside their problem domain to develop novel solutions. Having a diverse mix of students' disciplines and backgrounds on the teams ensures that there are multiple approaches to generating new ideas. As one of the key topics taught in the course is coolhunting for new topics (Gloor & Cooper 2007) we encourage students to coolhunt on the Internet for new and innovative ways to tackle their research problem. Additionally, we ask students to reach out to previous year participants, to learn from them, and keep them engaged in ongoing projects as external advisors. This works

particularly well for multi-year projects, where subsequent teams of students continue to work for multiple semesters to advance knowledge on facets of particularly complex problems.

In the remainder of this paper we present how we have taught students collaborative teamwork in globally distributed and multi-disciplinary teams. We show what the teamwork looks like based on a visualization of their social networks collected through the e-mail communication of the students, periodical surveys and interviews conducted with students after the course is finished. We compare our results to six conditions that foster team effectiveness presented by Hackman (2011) and investigate if these six conditions apply to our virtual teams.

2. Background on Virtual Teaming

Based on a study aimed at understanding how to design and lead diverse teams within the U.S. intelligence community, Hackman (2011) notes both the potential benefits derived from team work as well as the multitude of challenges that teams inevitably face, especially those comprised of members from diverse disciplinary backgrounds and skill levels. Recognizing that it is not possible to link effective team performance to any single cause, Hackman argues instead that "it takes a set of conditions, operating together, to help a team move onto a track of ever increasing competence as a performing unit." (pg. 21) These conditions are operationalized in the following six conditions for team effectiveness (Hackman 2011: 167-169) that were applied as a benchmark for COINs seminar global virtual teams (GVTs).

1. *The team is a real team, with a bounded set of people.*
2. *The team's purpose is challenging and consequential, with desired end states clearly stated, but the means to execute largely left to the team.*
3. *The team has the right number and mix of members.*
4. *The team has clear norms of conduct that promote full utilization of team members' capabilities.*
5. *The team's organizational context provides the material, technical, and informational supports that the team needs to accomplish its work, as well as recognition and reinforcement of good team performance.*
6. *The team receives competent, well-timed coaching to help team members work through problems and exploit emerging opportunities.*

Through a survey to examine how intelligence team leaders allocated their time in working with teams (Hackman & O'Connor, 2004) Hackman and his colleague found that leaders spent most of their time *in properly structuring the work itself,* suggesting that "by the time members actually get down to work, the conditions that most powerfully shape team behavior have already been established." (Hackman, 2011: 170-171) The second most important factor that made the difference in team behavior and performance was *the team launch* followed by the interaction between the leader and the team during the course of the work. Hackman refers to this break out as the 60-30-10 rule: 60% of the leader-influenced performance of a team depends on the degree to which the six enabling conditions are put in place through the preparation and pre-work of the leader (in our case, the teacher); 30% of the team performance depends on the launch execution; and 10% depends on what the leader does once the team is underway. Therefore, according to Hackman, the most important job of the team leader (or teacher) "is to get the [six] enabling conditions in place, to launch the team well, and only then to help team members take the greatest possible advantage of their favorable performance circumstances." (pg. 22)

Our experience over years of teaching the course confirms Hackman's 60-30-10 rule and guides how we allocate our time and attention as teachers and team mentors. We work collectively to coordinate tasks and responsibilities prior to the start of the seminar to ensure that Hackman's six conditions are met. Planning the launch of the global virtual team projects is given considerable attention. Finally, each student team is assigned a faculty leader/mentor, but the students are also encouraged to reach out to any faculty leader that they wish.

In the section that follows we describe the methods that were used to collect and analyze data to investigate whether Hackman's six conditions apply to our virtual teams.

3. Method of Analysis

Data collection

The scope of the exemplary data analysis described in this section is the latest instance of our COINS seminar starting in fall 2014 and ending in spring 2015. In total the teamwork period lasted four months divided into six iterations. We had 44 students from five sites and four diverse disciples (computer science, business, design, sociology), located in three countries and forming ten teams each distributed to two to three sites. We collected data by mixed

methods: surveys, interviews and emails. Next, we will explain in more detail the data collection from each of these sources.

Surveys

Prior to the teamwork project start, the students filled out a background questionnaire with questions on their prior experiences on teamwork and course topics, as well as their expectations for the course. The teamwork period was divided into six iterations. At the end of each iteration, students filled out a questionnaire on their view of the project and team success, trust (Spreitzer and Mishra, 1999), teamwork quality (Hoegl and Gemuenden, 2001; Hoegl, Weinkauf, and Gemuenden, 2004) and the main challenges and best successes experienced during the latest iteration. After the course ended, the students were asked to fill out the end-of-the-course survey, where they were asked to evaluate their learning during the course, to describe the successes and challenges they had experienced during their project work, to evaluate the contribution of their fellow team members, to give advice to the students taking this course next year, and to give feedback on the course, as well give suggestions on how to improve the course further. In addition, after each virtual meeting students and teachers were asked to rank the presentations. Teachers also graded each presentation.

Interviews

After the course ended we interviewed altogether nine students, at least one from each of the five sites. Participation in the interview was voluntary. The length of the interviews ranged from ½ hour to one hour. The interviews were performed by two of the teachers, five interviews were done face-to-face and four through Skype. All the interviews were tape recorded and transcribed by a professional transcription company. The interviews were semi-structured and conversational. We asked the students questions on three topics: 1) working and communicating in a globally distributed, multi-disciplinary group; 2) learning during the course; and 3) suggestions for improving the course.

Email collection

We collected all email communication during the teamwork period by asking the students cc: all their messages to a team-specific dummy email folder.

4. Results - Virtual Mirror of Communication

One of the key concepts we are using to increase communication is "virtual mirroring". Looking at the communication behavior of the teams by mining their e-mail archive with social media analysis tool Condor (Gloor & Zhao 2004), we are able to track the health of the social life of a team (Gloor et. al 2012). "Mirroring" the communication patterns back to the team members creates awareness and allows them to correct and improve their communication behavior.

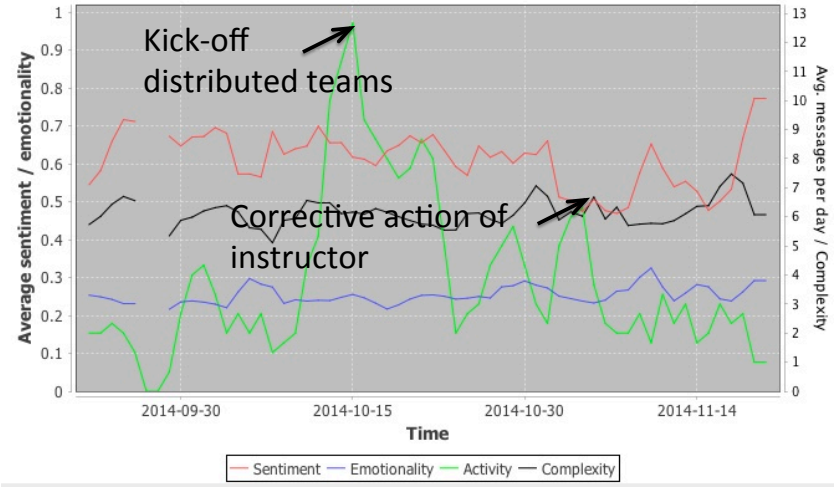

Figure 1. Activity, sentiment, and emotionality Sept 21 to November 19, 2014 of COINs14 course

Figures 1 and 2 illustrate sentiment and centralities over the first two months of the seminar. Sentiment is measured by using a bag of words approach in Condor developed through machine learning (Broennimann 2014). Note how the sentiment over time in figure 1 is going down. We have found that this is a sign of a healthy culture, as team members are changing from a supportive communication style, which is mostly positive, to a more honest language that mentions both positive and negative issues as they come up. There is also a drop in overall sentiment after the main instructor used some plain language to realign project priorities and work habits of the team members.

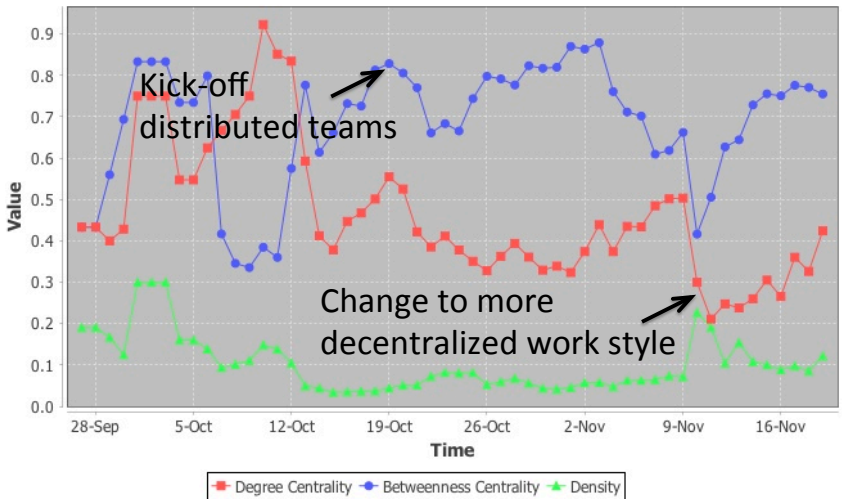

Figure 2. Group betweenness centrality, degree and density Sept 21 to November 19, 2014

Figure 2 illustrates the drop in group betweenness centrality (Wassermann & Faust 1994) after November 12, with the mode of teamwork shifting from being dominated by the main instructor with high centrality to a mode where teams are working more independently denoted by low group betweenness centrality. The same effect is also illustrated in the social networking snapshots shown in figure 3. The top of figure 3 illustrates the initial buildup of the team, where team members join the group after having attended the local introductory block courses. The middle of figure 3 shows the full network with the teams clustered together. The bottom of figure 3 illustrates a more independent work style where the centrality of the main instructor goes down after week 7, while team members start working more autonomously.

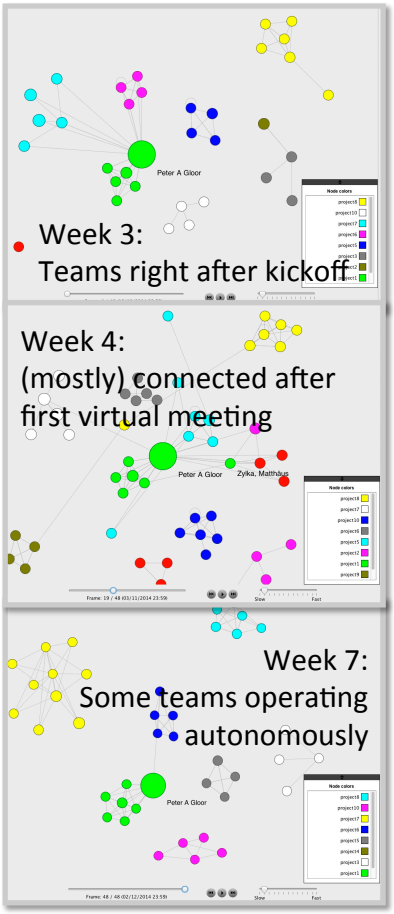

Figure 3: social network created from e-mail of main instructor of COINs14 seminar.

Figure 4 shows the message volume over the duration of the entire seminar. As can be clearly seen, activity spikes consistently immediately before a project status meeting, clearly illustrating the need for these meetings. When we started the COIN seminar 12 years ago, we conducted only three to four meetings for the entire duration of the one-semester seminar, which lead to huge spikes in activity. Seven years ago, based on activity charts like the one in figure 4, we greatly increased the frequency of these meetings. Since then students are complaining about the frequency of these meetings, which are currently done in roughly bi-weekly intervals. However, while most students told us they would prefer using the meeting time to work on their projects, the activity chart tells another story: they just don't do anything until just the one or two days before the meeting. Also, members of the most highly performing teams, both by teacher and peer ratings, told us they appreciate these meetings, as they are an excellent learning opportunity to see how other teams are tackling similar tasks. Therefore, we think this is one of the instances where teachers have to override short-term feedback of students for the students' long-term benefit to optimize their learning experience.

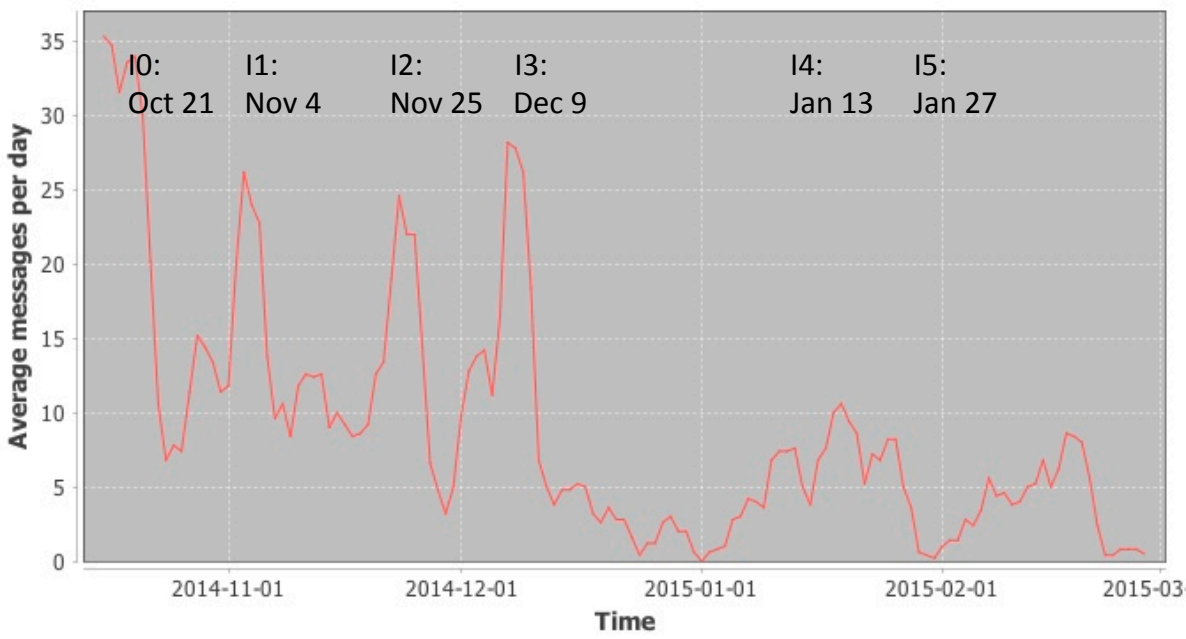

Figure 4: Activity of the group mailbox

Figure 5 shows the temporal social surface of the COIN seminar e-mail network from figure 4 (Gloor 2005). The x-axis shows days, the y-axis actors, and the z-axis betweenness. The temporal social surface confirms the evolution of the network structure in figure 3, with the teacher in the first half of the course being highly central – the dark "peak" in the rear left with up to 0.9 betweenness. In the second half of the course, the dark peak reduces its height by 70%, indicating that there is no longer any actor with dominant betweenness, rather a small group of people all have betweeness of 0.1 to 0.2, sharing leadership in their respective teams.

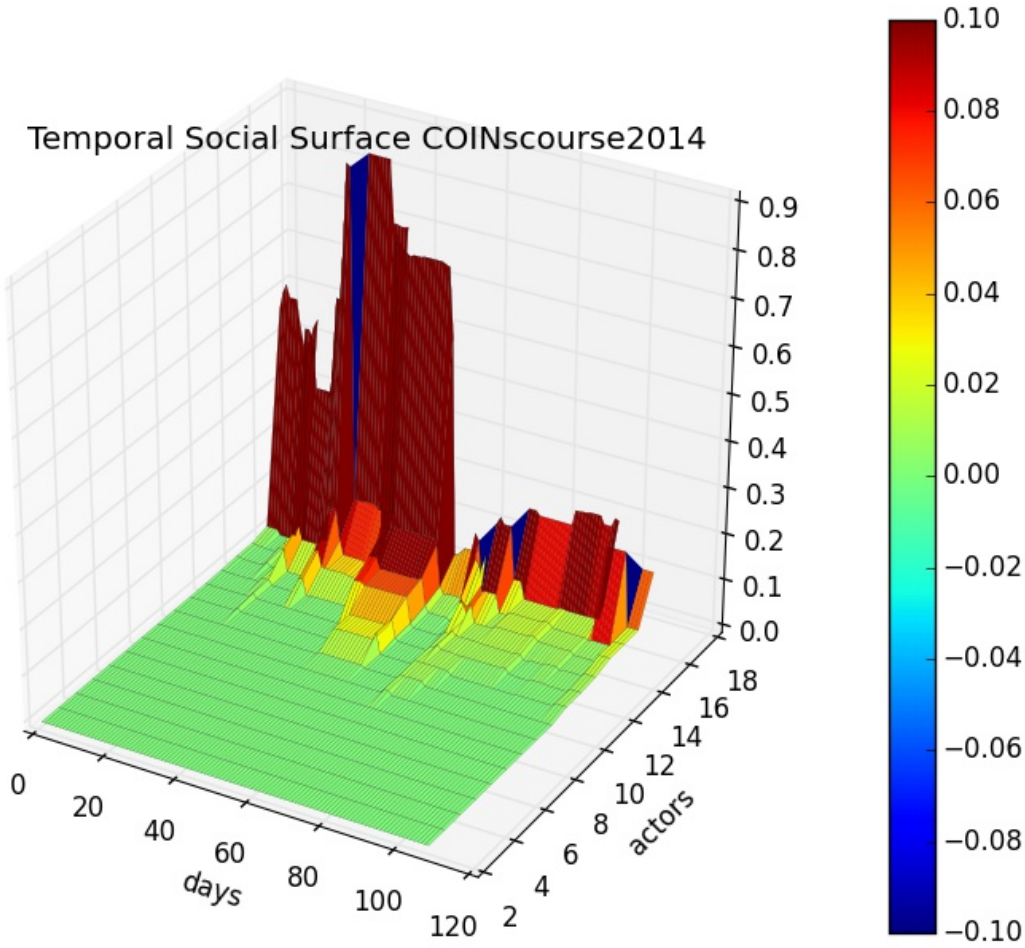

Figure 5: Temporal Social Surface of group mailbox

5. Results – Trust and Teamwork

We complemented the virtual mirror with a series of surveys at the end of each iteration. Through the surveys we were particularly interested to explore the role of trust, and how it could be built quickly[2] in distributed virtual teams with participants from different cultures (Finnish, German, US, Chinese, and Indian). In the survey, trust is measured through questions assessing openness to new experiences, concern for others, reliability, and competence.

[2] The initial type of trust formed by new team members is referred to as "swift trust." Swift trust is described as "presumptive" since team members have no prior working relationship on which trust could be based. For a discussion of trust and swift trust see (Robert, et al. 2009).

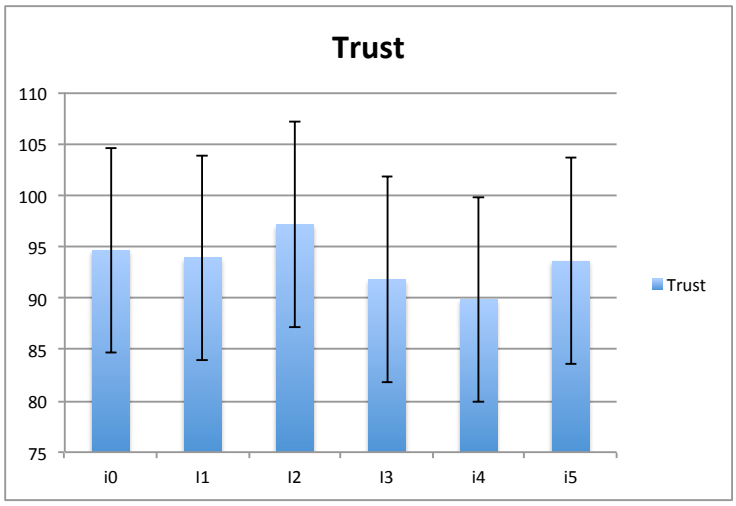

Figure 6. Evolution of trust from iteration 0 to iteration 5

As figure 6 illustrates, teams give advance trust, but then, as time progresses, trust falls from one iteration to the next. There is a positive effect on trust in iterations 2 and 5 right before the mid-term and the final presentations. We speculate that trust seems to run in parallel with the intensity of collaboration. There seems to be some correlation between the progression of e-mail activity, which is shown in figure 4, and the evolution of trust shown in figure 6.

Next, we looked at co-located and remote trust. All teams had participants from at least two locations, with the largest groups of participants coming from University of Cologne and Illinois Institute of Technology (IIT). The IIT students concluded their participation in the course after the presentation for iteration four in early December 2014.

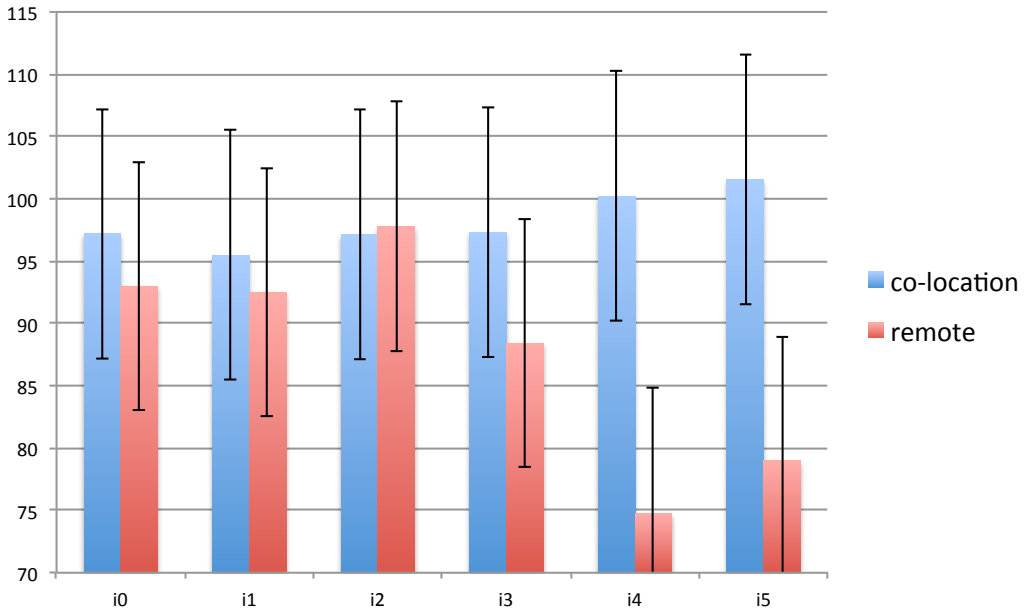

Figure 7. Co-located and remote trust over the 6 iterations

Figure 7 illustrates the increase in trust among team members working together at the same location, and the decrease in remote trust over time between team members collaborating over long distance. Similar to figure 6 we see again a positive pre-presentation effect in iteration 2 and 5, but overall remote trust drops decisively over time. It seems that long periods of silence, be it via e-mail or chat, rapidly destroy distributed trust. One insight from figure 7 for the course organizers is that to build trust in distributed teams, they need to work under a heavy workload and experience pressure, so they are forced to intensively collaborate. Another insight related to building and maintaining trust among team members is managing expectations by providing advanced communication about semester schedules, holidays, test periods or other events that would impact a student's participation on the team.

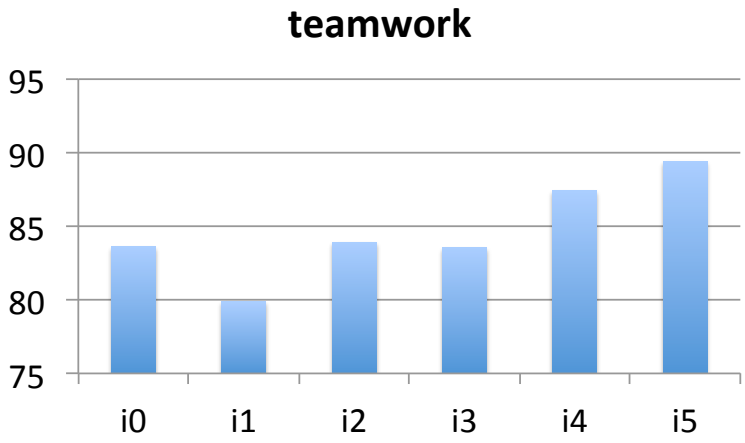

Figure 8. Self-rating of teamwork quality over the six iterations

Figure 8 shows the self-reported rating of teamwork quality for each student aggregated over time for each iteration. Self-reported quality of teamwork is going up as time progresses, but it seems this comes mostly from increased trust and collaboration among co-located team members. This is confirmed in figure 9, where the students with co-located team members at Aalto/Helsinki, and Cologne report the highest teamwork quality. The MIT and Bamberg students, who were mostly in teams where there was just one member from this location, rate their teamwork experience much lower. The IIT students might be a special case, as they were made up of two populations, design students and business students, with little interaction besides this class. The IIT students also had much bigger difficulties using the social media analysis tool Condor that is an essential building block of the course. Students from IIT learned Condor through videos and the user manual; students from Cologne and Aalto/Helsinki received face-to-face training on Condor by the lead instructor. Finally, as this was the first year that the course was taught at IIT there were no prior peer experiences of the seminar to guide students' expectations.

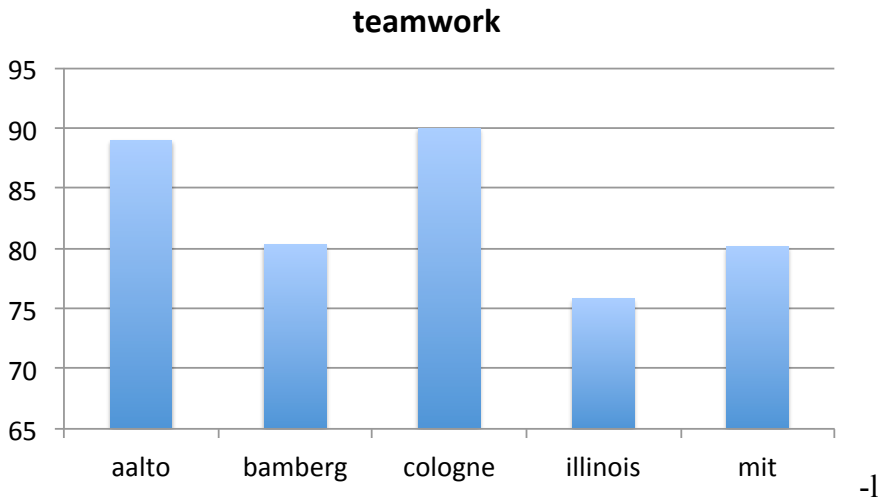

Figure 9. Peer-rating of teamwork quality at different locations

Figure 10 shows the evolution of peer-reported quality of Teamwork at different locations. Aalto and Cologne again consistently report a high quality of teamwork, which might come from the interaction with other co-located team members. Illinois again reports the lowest quality of teamwork, while the teamwork quality of the smaller student populations at MIT and Bamberg seems to be fluctuating wildly over time.

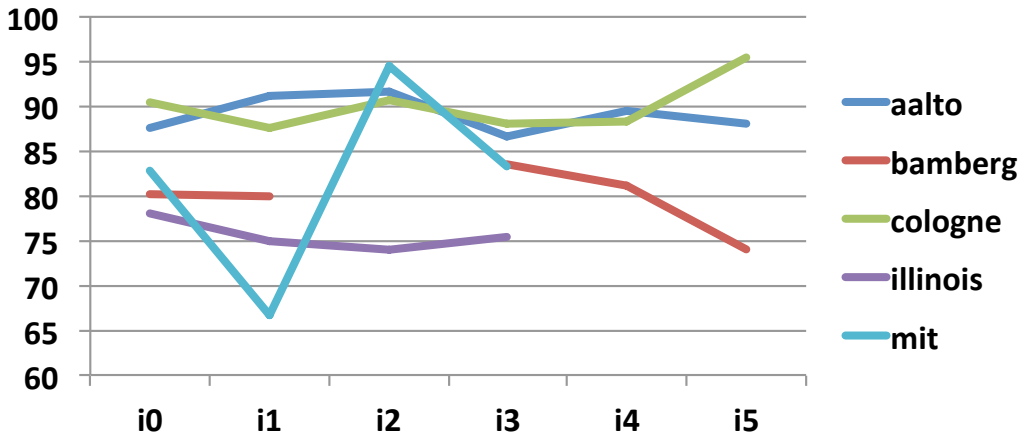

Figure 10. Evolution of teamwork quality ratings at different locations

Note that this rating comes both from team members in Cologne rating their experience with team members at the other sites as well as rating their experience with team members in Cologne. On the other hand we can see that the students in Illinois give low marks for teamwork quality even though they as well have several co-located colleagues in Illinois. Thus, the similarly large number of participants at the same location in Cologne leads to a higher overall rating.

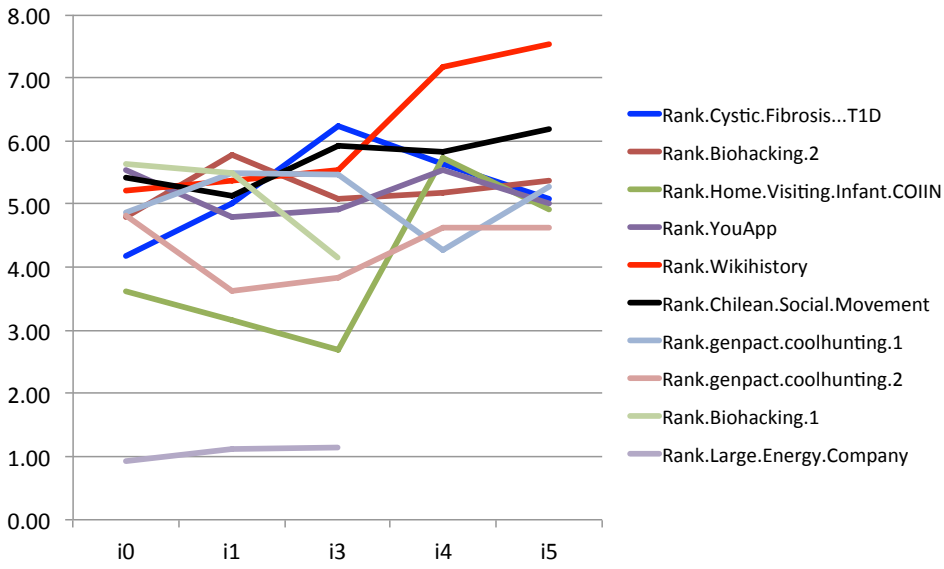

Figure 11. Force-peer ranking of the different teams over time

The final rating analysis shows the averaged results of a force-peer ranking, where all students were asked at each iteration to rank the status presentations given by the teams from best to worst. The “wikihistory” team shows the best trajectory, starting out in the top group, and becoming the undisputed leader over time. This also leads to the effect that all the other

teams converge somewhere in the middle. We found that the teams where there were small groups of high-performing students (“wikihistory”, “Chilean Social Movement”) did better than teams with one strong undisputed leader (“Cystic Fibrosis”). The results from teams with no recognizable leaders were ranked the lowest by their peers (“Home Visiting”, “YouApp”).

In addition we also correlated the sentiment calculated from the e-mail body of the collected student mailboxes with trust reported in the surveys. We found significant negative correlation (R=-0.477, significant on the 0.05 level, N=38). This means that the more negative the e-mails exchanged between team members are, the lower is their mutual trust. Just using Condor to track the change in sentiment in the e-mail discussion among team members can thus be used as an early warning sign for a decrease in trust and quality of teamwork.

6. Results - Lessons for Managing Virtual Teams

In this section we will look at Hackman's (2011) six enabling conditions for effective teams and compare them to our findings. The enabling conditions are: 1) creating a real team, 2) specifying a compelling direction or purpose for the team, 3) putting the right number of the right people on the team, 4) specifying clear norms of conduct for team behavior, 5) providing a supportive organizational context, and 6) making competent team-focused coaching available to the team.

During our COINS course we aim to teach our multi-disciplinary and globally distributed student teams how to work efficiently in teams. They learn by doing, i.e., by solving challenging problems in teams, while receiving guidance both from the teachers and project clients. As our teams have many similarities to the teams Hackman studied, we found it highly interesting to compare whether the Hackman's six conditions apply to our virtual teams. The similarities we recognized between the intelligence teams that Hackman studied and our teams are the following: 1) teams are multi-disciplinary, 2) team members are skilled professionals in their area, 3) most team members have not worked together before, and 4) teams might be distributed.

Next, we will discuss each of the Hackman's six conditions and compare them to our findings.

1. Create a real team.

According to Hackman a real team consists of a *bounded set of people*, which makes it clear to all team members who belongs to the team and who does not. Team members work together *interdependently* to achieve a common goal for which they have *collective accountability*. Finally, the teams are stable enough to give members a possibility to learn to work together. Hackman compares "work teams" and "coacting groups" and finds that real work teams are much more effective than coacting groups, in which coactors are merely performing their own tasks in parallel. According to Hackman the main reason explaining this difference was that real work teams engaged much more in peer coaching, i.e., teaching and learning from each other, than coacting groups did.

Each of our student teams forms a clearly bounded team, as members are selected in the beginning. Each team works for a common goal for which they are collectively accountable, i.e., their work is always presented and graded as the achievement of the whole team, both in our bi-weekly virtual meetings, as well as with respect to the final paper. Thus, of the three criteria of real teams by Hackman, boundedness and collective accountability our teams achieved easily. However, the third one, working interdependently has required more attention, as team members typically try to just divide tasks among themselves, especially due to the global distribution, and then work independently and finally quickly put all together for the presentation. We have taken several measures to encourage students to actually collaborate, as it has been clear to us that those teams that truly collaborate achieve the best and most innovative results.

Right from the beginning we encourage our virtual teams to build "real teams". We encourage them to spend enough team-building time using Web conferencing with the camera turned on, where members take time to get acquainted with each other. Students have commented that this is one of their major learning and they advise the future students: "*Use time to get to know other team members in order to create shared understanding and knowledge about each other, this will help you work together later on*."

We also recommend that the students discuss in the beginning what kinds of knowledge each member can bring to the project, what kinds of tasks each would like to work with and what new skills they would like to learn during the project, as one of the students puts it: *"First they need to know about their own strengths and their weaknesses, and they have to talk about it right before they want to start their project. […] We can actually share our feelings and our rationale about how we choose this project and how we think that we can contribute to this project."*

We noticed during the early years that technically skilled engineering students in particular did not understand how design students could benefit the project. After we teachers started emphasizing that the teams should discuss the skill differences, the student reactions have changed drastically: nowadays many students mention that the best experience during the whole course was working with people from multiple disciplines!

Students commented that the best success during the project was *"Different views on certain topics due to partly different backgrounds of group members", "Learn something different from different angle and way of thinking".*

2. Specifying a compelling direction or purpose for the team

According to Hackman, a compelling purpose energizes the team members, orients them towards their common objective and engages their talents. A good purpose is *clear* and concrete, so *challenging* that members need to stretch to accomplish it, and finally achieving the purpose has clear *consequences* for other people or for major organizational objectives. All three attributes - clarity, challenge and consequentiality - are needed for a good purpose. Hackman emphasizes that team leaders should help the team to specify the *ends* to achieve, but leave the *means* for the team to decide. Hackman suggests that one possibility to specifying the purpose is to give a team as the first and the most important task to together develop a statement of the teams' main goals and purposes. This is important also for professional teams who are well able to specify the purpose by themselves, but might need a little encouragement to take time and really agree on what they are about to accomplish. Hackman adds that a direct relationship between the team and the customer for whom the work is being done is highly motivating as that enables the team to receive direct feedback.

For our student teams, we have aimed to set clear and challenging project goals, for instance finding new trends for Cystic Fibrosis in social media, but leave it up to the teams to self-organize and decide on tools and methods to accomplish their goals. Students have liked our challenging topics: *"Having a truly inspiring topic keeps you motivated", "[The best in the course was that] I got to work in the domain that I'm really motivated about."*

In addition to being challenging, our topics are quite broad and open, i.e., the team has several possibilities to accomplish their task within the time allowed. Thus, the teams need to define by themselves the specific scope for the project and agree on that with the customer. This way, we give the team a possibility to influence on the project scope based on the members' own interests and thus create a topic that is truly interesting to them.

The first task for the newly formed student teams is to specify the purpose and scope for their project and how they plan to achieve it. They have less than week to do this, before presenting the goals and steps to everybody, teachers and other teams, in a common virtual meeting.

The flip side of the coin of the challenging purpose is that finding a suitable scope is often not trivial. Students have commented that this step is actually the most difficult one in the whole project: *"The first couple of weeks are the hardest to get going"*. Often the team needed to scope down the project compared to their original goals: *"There were a lot of tasks we wanted to do for the paper or the project, but we soon noticed that we wouldn't have time for all of it. We figured out we should find the most important parts for the project […] we had to do some selection."* Many students are used to fully defined goals; our approach of requiring the students to participate in forming the final goal might not be what they had expected: *"The goal of the project was not as clear as I expected."*

The process to achieve the goals is mainly left for the teams to figure out. However, we strongly recommend that they have at least 1-2 weekly virtual meetings involving the whole team. Moreover, they need to present what they have achieved during the previous two to three week iteration and what they plan to do during the next iteration in our bi-weekly virtual meeting for all teams. There they will also receive comments both from the teachers and other students.

Our topics are consequential, i.e., most topics have customers and end users that are really going to use what teams produce. Often teams even have direct contact to the customers. Students have appreciated this possibility: *"It was very helpful to have the client meet directly with team members to sort out the objectives of the project"*.

3. Putting the right number of the right people on the team

Hackman suggests that a well-composed team has both the right number of people — a slightly understaffed team is best — and a suitable mix of members having both the needed skills for the task, as well as collaborative skills. He states that the greater the diversity in member's training and disciplinary backgrounds the greater the potential for individual and team learning. On the other hand, greater diversity poses a greater challenge to the team in terms of communication across members' various training and disciplinary backgrounds.[3] The members should be neither so similar that they duplicate one another's resources, nor so different that they cannot communicate and coordinate well.

We found that having teams composed of members from two to three locations, ideally with two members co-located works best. This leads to a total team size of four to six. If the number of team members at one location is more than two, they easily form a sub-team that starts meeting and making decisions without involving the members from other sites, especially if a large single-site sub-team collaborates with a single team member from another site, this single person is easily forgotten in communication.

To match team member's skills to the ones needed for each topic, we provide students with information on what skills each topic requires, to help them select topics that fit their skill profile. The final selection of team members is done by the teachers based both on the student's own choices, finding a good balance of global distribution and getting a suitable number of team members.

However, we have difficulty taking the collaborative skills of the future team members mentioned by Hackman into account when forming teams. As we need to accept all students in the course, the teams have a good possibility to practice their teamwork skills. Differing personalities and cultural differences have sometimes caused clashes in teams, which in the worst case may lead to a member leaving the team. Especially, written communication between globally distributed team members is susceptible to create these kinds of clashes, and bad for helping to solve them. Fortunately, these kinds of clashes are not common.

[3] For a discussion regarding the effects of homophily and hetrophily on communication within teams see Everett Rogers *Diffusion of Innovation* (2003: 304).

Even though collaborating with people from different backgrounds has been challenging, especially in the beginning, students have greatly appreciated the experience. As the best success in the whole project, students mentioned: *"Different views on certain topics due to partly different backgrounds of group members", "Getting different perspectives on the same topic and putting together our ideas based on these."* Some students felt that the most useful skills learned during the project were: "*The skill to organize diversity in a team and the skill of communicating effectively in a global virtual team."*

4. Specifying clear norms of conduct for team behavior

Hackman states that the norms of conduct are shared agreements among team members about which behaviors are valued in a team and which are not. Hackman emphasizes norms that help teams to identify and effectively use the members' knowledge, skills and experience. He suggests that norms that support learning and experimentation help create a climate of psychological safety, making it easier, e.g., to ask for help. Norms that promote helping and sharing among team members are also important. Finally, Hackman mentions that teams that need to rely on electronic communication, and thus have a more challenging environment to coordinate their activities, might need norms for communication.

We have noticed that promoting frequent communication and rapid problem solving are particularly valuable to virtual teams. Therefore, we give our students a few pieces of advice when they start the projects. We encourage them to communicate often and answer questions fast, preferably to have two regular meetings per week, to prefer synchronous communication when possible, to let the other team members know in advance when they have time to work and when they do not (e.g. exams or travels), to promise to other team members only what they can deliver, and finally, to tell other team members about any problems and ask for help right away. We ask the students to use this advice as a basis when creating their own norms.

After the first iteration, we ask the students to present the project goals, a brief project plan, and their way of working. When discussing their way of working, communication related norms (e.g. answering emails within the same day) are often mentioned.

During their projects, we ask the students to use a technique called "virtual mirroring". After the first few weeks working on the project, the student teams analyze their own communication by doing social network analysis of their written communication (emails and chats). With this, we aim to both encourage them to communicate actively and to improve their communication behavior based on the analysis. The students have found frequent communication and initial face-to-face video meetings very important: "*I think having two meetings every week is really, really important. […] You need to have high level of communication frequency, in order to get things in the project going smoothly. Initially, it is very important to have a look at the other person's faces, so you can remember who they are.*"

Even though we do our best to prepare the students, creating and using the norms and collaborating in a real distributed multi-disciplinary team has been challenging for the student teams. Despite our well-intentioned attempts at teaching them positive norms, many teams still learn through trial-and-error. Having collaboration challenges and then solving them form an important learning experience for the students. Many of them actually mention after the course that the most important learning for them was global collaboration: *"[The most valuable thing was] just to have a team containing global team members", "I learned to work with students in other countries and other cultures".*

5. Providing a supportive organizational context.

A team should have the resources it needs to accomplish its tasks also from outside of the own team. Hackman lists four aspects of a team's context to be especially consequential: 1) the *information* needed to accomplish its work, 2) *educational and technical* resources to supplement the team members own knowledge and skills, 3) *material resources* that the team needs to carry out its work, and 4) *external recognition and reinforcement* of excellent team performance.

Our course starts with an initial block during which students are familiarized with the tools, methods and terminology needed in the projects. These include basic concepts, tools and methods of social network analysis. This helps create similar background knowledge for everybody, which makes collaboration easier later on. The initial block lasts a few days and is taught by one of the instructors who travels to all sites to teach face-to-face, giving the students a point of contact that they all know and trust. Unfortunately, sometimes we have

not been able to arrange this visit to all sites, relying on the local instructor at times. Students have found it important to have at least some common knowledge and experience: *"It is much more convenient for people to come to a group project when they know, they have the same knowledge."*

After each iteration students receive feedback from the teachers. In addition, all teams have a mentor, as well as a customer from whom they receive feedback. The frequent iterations with virtual presentations by each team provide both structure and support for students to work in teams: *"What worked well for the course would be the presentations every two weeks. […] I think we didn't slack off because of those presentations, and we were able to maintain some sense of urgency because we knew there was some concrete deliverable […] It made it much easier to plan our goals for every week."* The feedback in the virtual meetings is seen important: *"It's good time for us to learn the other group's work and [teacher] will give us comments about our work […] I think it's very good."* Feedback from the customer is highly valued as well, and students were hoping for even more frequent feedback from the customers. However, we have noticed that students are maybe a bit too timid to contact the customer as often as they would find it useful.

6. Making competent team-focused coaching available to the team

As the last condition Hackman takes up well-timed team coaching, which should increase the chances that a team succeeds. According to him the best coaching results are achieved when coaching interventions focus on the actual work the team is performing: coordination of member effort, performance strategies the team is using, and the degree to which the team is using its members' knowledge and skills. He suggests in paying attention to the timing of the coaching, as different kind of coaching is needed at different phases of the team life cycle. Even though Hackman mainly emphasized the team leader's role as a coach, he also suggests actively involving team members to help in coaching, e.g., in the form of one-to-one coaching of fellow team members.

In our course each team has a mentor, a member of the teaching staff, to guide the team. Mainly the mentor helps the team to define a suitable scope for the project, gives feedback on any results and answers questions. The mentor tries to respond to requests from teams within the same day, and also assists when students experience technical difficulties. While the mentor makes her or himself available, teams often try to muddle through, reluctant to call on

their team mentor for help especially if the mentor is someone they do not know. Learning how and when ask for help and assistance is an important lesson in the course.

In contrast to Hackman's model, our teams do not have named leaders. In some teams an experienced person might take a leading role, but quite often the leadership role changed naturally in different phases of the project, when different persons took more responsibility at their turn: *"Sometimes I think it was [a team member] from Chicago who had a leading role […] sometimes I had this leading role. It depended on who did what work from week to week […] we had circulation in there."* In some teams we noticed that experienced team members took the role of a peer coach: *"Initially it is very important to have some kind of mentor figure to force people into setting the schedule and setting their workload. […] I would say I was the person."* Experienced team members also helped less experienced, e.g., technical students taught the design students how to use the analysis tools.

Do the Hackman's six conditions apply to our virtual teams?

As presented in the previous section the six enabling conditions for effective teamwork that Hackman suggested seem to match surprisingly well with what happened during our course projects. Hackman's intelligence teams are also multi-disciplinary and they can be distributed, but most often they did not seem to be globally distributed, like our teams are. Most intelligence teams seem to also have a possibility to meet face-to-face, which our teams do not have. Thus, our teams have a more challenging set-up due to global distribution and lack of face-to-face meeting possibility.

The most notable differences that were observed in our teams compared to what Hackman suggests are the following.

1) Real team: Hackman states that members should work interdependently, however, students typically try to split the work into pieces that they can do independently, which does not foster teamwork. Moreover, building a real virtual team requires extra effort in the beginning.
2) Compelling purpose: According to Hackman, the goal of the team should be clear. In our case, however, teams found it challenging to define a clear goal due to the exploratory nature of several of our projects.
3) Right people: We found it difficult to perfectly match student backgrounds and topics due to the limited number of students, all of which need to be placed in teams.

Furthermore, we did not take into account personalities, teamwork skills or cultural differences. However, one of the main goals of the course is to practice teamwork skills. Students indeed have challenges when practicing to work together, but report that they learn a lot, and appreciate the diversity in the teams.

4) Norms of conduct: Student teams create communication norms, but typically no norms for other aspects of multi-discipline, cross-cultural collaboration. Misunderstandings and challenges arise due to global distribution, differing backgrounds of the students, and different cultures. However, we try to create a climate of psychological safety, making it easy to ask for and to offer help.
5) Supportive context: Even though the "organizational context" is missing, the course context is intentionally built so as to provide a supportive context for the teams. Furthermore, we provide a short initial block to create similar background knowledge. Teams typically receive quick and supportive customer feedback and answers to any questions.
6) Coaching: We see coaching as important, but differ in our view of the role of the team coach. Hackman sees the coach mainly as a team leader, whereas our teams are egalitarian and do not have a named leader. In our teams, coaching comes mainly from outside, from the teachers, but also from other team members. Egalitarian teams have become more common in the industry, e.g., in agile software development, and we think it is important to teach students how to work in such teams.

How to extend Hackman's six conditions to build real virtual teams?

Our final goals was to discuss how Hackman's six conditions could be extended for building *real virtual teams* with shared aims, suitable norms of conduct, with the right collaboration tools, and the right type of coaching for virtual collaboration. Based on our experiences during the 12 years of teaching virtual team collaboration we would suggest the following additions:

1) Real virtual team: Regarding the Hackman's first condition (real team), building a real virtual team requires considerable extra effort in the beginning of the project compared to collocated teams, especially to get to know each other and to build trust. Thus, in the beginning virtual teams should invest heavily in getting to know each other, e.g. by arranging and team building exercises over videoconference (in case face-to-face meeting is not an option), as well as getting to know each other's backgrounds, motivations and special knowledge that each can bring into the project.

If this is not done properly, the team cannot become a real team, but will turn into a coacting group that just splits tasks among each other and finally combines the end results, which does not bring out the full potential of the team.

2) Psychological safety and agreeing on communication practices: Regarding Hackman's fourth condition (norms of conduct), creating a psychologically safe environment and agreeing on communication practices rose up as especially important for virtual teams. In virtual teams we would recommend creating an environment where both work progress and communication is transparent all the time to all team members and asking questions and for help is seen as positive and is encouraged. In a virtual team it might easily happen that a team member is fighting alone with some problem for a long time, without other team members noticing that, whereas in a collocated team these kinds of problems are easier to notice. In addition, agreeing on common communication practices is much more important for a virtual team, as communication in virtual settings always requires extra effort and the usage of electronic communication channels.
3) Collaboration tools: Regarding Hackman's fifth condition (supportive context) we would add the importance of a good set of collaboration tools that a virtual team needs to have for different kinds of communication and collaboration purposes, e.g., videoconference and a shared repository, as well as common software tools for performing the work. Organization can do much to support virtual teams, e.g., arrange easily accessible videoconference facilities, or in the best case a continuously open videoconference connection between the sites with screens at team members' premises.
4) Coaching virtual teams: Quite often, virtual teams are made of strong individuals collaborating passionately together for a common purpose or a goal without an appointed leader. This was the case in our project teams as well. Thus, a leader that also coaches the team might not exist in a virtual team, even though Hackman's sixth condition (coaching) suggests that. However, the need for coaching does exist. The team members can of course coach and mentor each other, but an external coach, such as we had, is certainly beneficial, as well, to reach the full potential of the team.

7. Looking Ahead: Applications and Relevance of the COINs Seminar

The COINs seminar has undergone continuous improvement over the 12 years of its existence. For example, advances in technology that enable virtual teamwork and

collaboration has required updating of the format of our bi-weekly virtual "All-hands" meetings. Recent studies of collaborative work and collective intelligence have also influenced the format and content of the seminar. Perhaps most importantly, the students today are very different than the students who participated in the seminar several years ago. They are adept users of social media, technologies and devices that did not exist when the COINs seminar was launched. As much as our current students are different from those from previous years, we find that the benefits for students of the seminar have remained consistent.

For students, the benefits derived from participation in the COINs seminar are multifold. For example, learning to successfully navigate within global virtual teams challenges~~,~~ students to articulate and demonstrate their respective disciplinary contributions in multicultural and multiple disciplinary settings, and prepares them for situations they will encounter in their careers. Client-based projects require that students establish ways of working together to identify and frame problems, apply multiple research methods and develop a range of solutions that address the client's needs. Working in a multiple discipline team introduces students to new perspectives and work practices, using both 'off-the-shelf' and proprietary software tools. Opportunities to apply network perspectives in research are increasing rapidly across many fields. We are convinced that the COINs seminar teaches students fundamental skills to succeed and prosper as collaborative innovators in today's globally networked world.

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