Training in Concurrent Design

The Interplay of Theory, Practice, Reflection and Infrastructure

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***Abstract*— Concurrent Design is a rather complicated method, which on the one side require theoretical knowledge of how projects best should be carried out, while it on the other side requires practical training and experience in order to utilize the method in a good way. In this paper we present the main findings from a study where we followed two implementations of a Master's degree course of 15 ECTS within Concurrent Design, that includes both theoretical and practical training. The overall objective for the study was to understand how training within Concurrent Design should take place in the best possible way. Our findings suggest there should be an interplay between theoretical training, practical training, collective reflection among those involved, and utilization of an infrastructure which is also adapted to training purposes. The main contribution presented in this paper is the TPRI-Model for improved training in Concurrent Design where the interplay of Theory, Practice, Reflection and Infrastructure are discussed.**

Keywords*— *Concurrent Design; Training in Multidisciplinary Methods; Problem-Based Learning; Action Research

I. INTRODUCTION

Concurrent Design (CCD) is a methodological approach, which should contribute to solve multidisciplinary design problems in an effective and efficient way. If this approach is practiced properly, one can reduce the development time and save costs, while getting solutions of better quality. However, CCD is complicated and it requires a lot of training and practical experience before one can expect to achieve the desired benefits [1].

In 2014 our institute established a master's degree program in Computer Supported Cooperative Work and a core subject of this program is a course of 15 ECTS within CCD. In this course, students get training in the use of CCD, which should make them able to participate in CCD projects and contribute to the introduction of CCD in future organizations.

Before this study started, we have seen that training in CCD is crucial to achieve the desired benefits, also when the method is used in a professional context. We have tried different kinds of training, with different arrangements and duration, and with different kinds of learning material and activities. This has created the basis for the research question in this study, which is to figure out how the training in CCD should take place to achieve defined learning outcomes, the best possible way.

In this paper we present findings from an action research project that has been going on for two years, where we have followed two implementations of the Master's degree course in CCD. The action research process included instructional planning, course implementations, evaluation and justifications of the learning activities. As part of this process we have been through several action research cycles, made changes between each cycle, and tried out different training approaches.

Following this introduction is the Concurrent Design and the need for Improved Training section with a brief description about the background for the prevalence of CCD, as well as an explanation regarding how we understand this concept. Then, follows the Research Methodology section where we explain how the research was undertaken, how data collection has taken place and what research data the study is based on. Next, we introduce the TPRI-Model for Improved Training in Concurrent Design. The TPRI-Model is the main contribution of this study and an answer to the research question regarding how training in CCD should take place. This section is composed of sub-sections where we respectively discuss theoretical training, practical training, reflection among the participants, and infrastructure. Finally, we provide with a brief discussion and a summary of the main findings.

II. CONCURRENT DESIGN AND THE NEED FOR IMPROVED TRAINING

CCD builds on principles of a more comprehensive discipline, which is known as Concurrent Engineering. Concurrent Engineering deals with integrated product development with an emphasis on customer involvement and a well cooperating multidisciplinary team. The purpose is to avoid sequential office-to-office communication between experts representing different disciplines, if the tasks are interdependent and better solved in multidisciplinary teams working concurrently. The following definition of European origin reflects this: "Concurrent Engineering is a systematic approach to integrated product development that emphasizes the response to customer expectations. It embodies team values of co-operation, trust and sharing in such a manner that decision making is by consensus, involving all perspectives in parallel, from the beginning of the product life-cycle" [2, s. 329].

The American Institute for Defence Analysis wrote a comprehensive report on Concurrent Engineering in 1988. The background for this study was that the materials developed or purchased by the American Defence were very expensive, had a long development time, while it lacked the desired quality. The report concluded that Concurrent Engineering would result in improved product quality, at lower cost, and with less development time, and it included a discussion regarding what is required to implement concurrent methodologies [3]. Since then has Concurrent Engineering and integrated product development gradually developed to become a norm within certain industrial areas, for developing and introducing new products to the market [4],

Some practitioners do not mark the distinction between CCD and Concurrent Engineering, while others claim that CCD is the initial phases of the Concurrent Engineering process [5]. Additionally, we have the concept of a Concurrent Design Facility [2], [6], or a Collaborative Design Environment [7] which are environments for conducting CCD sessions. This is working sessions where all design team members from different disciplines meet concurrently, utilize appropriate software tools, and communicates regarding various aspects of the problem in question. A CCD session is realized as intensive and multidisciplinary collaboration, which is managed by a facilitator and lasts for approximately 3.5 hours. The overall goal for these sessions are to develop good and comprehensive solutions in the most efficient manner.

The authors behind this study belongs to a group of Norwegian university researchers that has worked with CCD in the past decade. Our interest for this method has partly been driven by the fact that several oil companies on the Norwegian continental shelf has implemented this way of work [1]. Furthermore, we have also found that the method can be used within other areas where multidisciplinary problem solving is required. CCD is a methodical approach, used to solve multidisciplinary design problems expediently. This is accomplished by establishing a multidisciplinary team that follows a process, including a set of CCD sessions, where specific design challenges are handled. The sessions are conducted in a facility, in which the team uses appropriate tools and benefits from an infrastructure supporting cooperation to develop comprehensive solutions [8].

However, our experience shows that it might be difficult to get desired results, the first time CCD is used with new participants in a project. New participants could claim that they see the usefulness of the method, but they do not always save time or resources, and they do not always get better results. Even though they claim they understand the method, it might be that they have missed important details to make it work optimal [9].

We find no other studies on how training in CCD should take place, but we find studies on training in Participatory Design [10], [11], studies on training in agile methods [12], or studies on training in project management [13]. The challenges of these studies have much in common with training in CCD since they also concern multidisciplinary problem solving with collaboration between different stakeholders, involvement of the customer, and stimulation to creative problem solving. Commonalities reported from these studies are that one must offer a mixture of lectures and tasks in order to provide a theoretical background, as well as practical experiences where students are able to try this out on real problems. This is in line with social constructivist learning theories [14], i.e. the students should become collaborative creators of knowledge, proactive problem solvers and critical thinkers, rather than simple knowledge recipients.

III. Research Methodology

The methodological approach used in this study is based on action research. This is a research approach that could be used in connection with the introduction of new artefacts in an organization [15]–[17], and we refer to training in CCD as an example of such an artefact. The overall objective for this study was to understand how training within Concurrent Design should take place and to document this for utilization in future training programs.

A. Research Environment and Participants

Agreements were established between the researchers, i.e. the tutors who was responsible for the training, and the clients, which in this case was master degree students who took a 15 ECTS course in Concurrent Design. The course was taken by 15 students in spring 2015 and 14 students in spring 2016. Since this research took place in connection with courses, there was no negotiations between the parties involved (tutors and students) regarding project approaches. The tutors established a schedule for both the project and the course activities, which the students dealt with. Each course was planned for one semester, with some lectures on various theoretical aspects of Concurrent Design, a smaller pilot project where students were able to test CCD in practice, and larger CCD pilot project in which the student performance also counted in the grade. Finally, students had to write a scientific report (essay) in which they reflected on the entire training in Concurrent Design. This report formed the main basis for the grade in the course.

Common to both course implementations was that we conducted two CCD pilot projects with 3 to 6 CCD sessions in each. Each CCD session had a duration of approximately 3 hours, and at the end of each session, we conducted evaluations. In addition, the students had to answer online questionnaires that referred to the training activities and students' understanding of key elements in CCD. There were conducted 4 questionnaires in 2015 and two questionnaires in 2016. In 2015 there were 15 students who took the CCD course and there were 12 students who answered the first 2 questionnaires and 13 students who answered the next two. In 2016 there were 14 students who took the course, there were 12 students who answered the first questionnaire, and 11 responded to the second questionnaire.

These questionnaires were conducted primarily to get an indication regarding how the students perceived the learning activities and their progress in relation to master CCD. A mix between free-response questions, multiple-choice questions, and rating questions with a 6 point Likert scale were used. In this way we obtained the respondents' views in relation to some selected areas (e.g. whether practical experience with CCD sessions also led to better understanding of the theoretical basis) while we also captured their general opinions by the use of free-response questions (e.g. to request the students discuss areas where this training can be improved, based on their experiences and what they have learned about CCD so far in the course).

The students were aware that all data from this course and the CCD pilot projects also was used for research purposes.

B. The Cyclical Action Research Process

Diagnosis to identify and define the problem is traditionally the start and the first phase of action research projects. In our study we went through this phase twice, i.e. once each year when the CCD course was implemented. This phase dealt with the planning of learning activities, including theory lectures and two CCD pilot projects. In connection with each pilot, we had to define a multidisciplinary problem that students should work to resolve. As part of this process we scheduled CCD sessions for the pilot, defined what results we aimed at, described the students' roles in the project, and the technical infrastructure to be used.

Before the training started we had prepared 9 lessons with theoretical material in CCD and we used one lecture (2 hours) for each lesson. We had hypothesized that the acquisition of theoretical knowledge is important to the success of practical CCD sessions. If the participants should be able to work effectively in CCD sessions, they should first have a theoretical basis and knowledge of how things should work.

Explicit learning is considered the most critical activity in action research and in this context are both practical outcomes and discovery of new knowledge central [17]. In this study we achieved learning through reflection since all CCD sessions were evaluated orally and the participants answered questionnaires which also included open and reflective questions.

C. Changes, Evaluations, and Learning Through Reflection

One of the important things with action research is to test out certain ways of work, uncover what is not working properly and try to change this at the next opportunity. In this project, we made several changes along the way, which were based on experiences we got during the course implementations and our desire to improve the training. For instance, we changed the design and functionality of the software tools used during the CCD pilots and we changed the pilot cases to make them better suited for training purposes. Accordingly, we changed the educational focus towards more attention to the CCD process itself and less to the final deliverables, with an increased amount of student reflection.

Although we know which theory should be included in the course, it is not trivial to determine how the theoretical training should take place. Consequently, we did major changes with respect to theoretical lectures from 2015 to 2016. In 2015 was all theory (9 lessons) lectured before the students got to try practical CCD sessions, while in 2016 we had only two theory lectures before students started their first practical pilot project. This resulted in some positive and interesting results, which we return to when we later in this article present the TPRI-Model for improved training in CCD and discuss the results. If we are to discuss this change in relation to pedagogical models, we claim we made a shift towards more social constructivism ([14] and more problem-oriented and project-based learning [18].

Evaluations took place during the course implementations with particular attention at the end of each pilot CCD project. We conducted an oral evaluation of the project and results gained, and we developed an online questionnaire for the participants. In this way the entire project team, including students, are involved in evaluations which in turn leads to changes and improvements that are implemented and tested by the next opportunity.

Improved Training in CCD represent the main objective of this study. In advance, we had extensive experience with CCD and a clear idea of how such projects should be implemented. Nevertheless, we want to better understand how the training should take place and the research methodology described in this section provides valuable research data that has been subject to qualitative data analysis and forming the basis of the findings we present in connection with the TPRI-Model for improved training in CCD.

IV. The TPRI-Model for Improved Training in Concurrent Design

The TPRI-Model for improved training in Concurrent Design is made up of what we in this study have identified as key elements for improved training in CCD, and in this section we discuss these items separately. However, there is also a connection between these elements and our experience suggests that motivation and commitment to learning is created in the interplay between theory, practical experience, reflection among the participants, and an infrastructure customized for training purposes.

A. A Theoretical Framework

To get the best results when using the CCD-method the participants in a CCD-project need a theoretical framework. Our experience suggests that the participants need a theoretical foundation to fully understand the CCD-method, which can be taught by thorough theoretical lectures. Our findings suggest that it is important to present the theory early in the CCD training, but some practical training should also be provided early in the training process. To optimize the CCD-training we have found that one should start building the theoretical framework early in the training and this framework will be stronger through practical experience and reflection. Based on our experiences from this study we suggest 4 main steps towards building a strong theoretical framework.

- Introduction to CCD theory – We recommend one or two lectures where the basics of the CCD-method is presented. In the introduction one should also tell the students what overall goals one would like to achieve by using the CCD method, i.e. save time, save money and get a result with better quality. We should also clarify expectations and let the students know what we expect from them in the upcoming CCD sessions in the first small-scale pilot.
- A small-scale practical CCD pilot project with two to four CCD sessions – So far, the students do not have the

proper theoretical skills to fully understand and use the CCD-method, and the students will most likely experience problems and challenges in their first CCD sessions in the collaboration room. Nevertheless, our experience suggests that the students benefit a lot just by coming into the collaboration room and get some practical experience. Although the students felt that the first case was challenging they reply that they understand the theory better and are more motivated to learn theory, once they have been through a practical case.

- Several theory lectures – Theory lectures focusing on the different important elements in the CCD-method, e.g. the people, the process, the tools, and the infrastructure. Here we present the rest of the theory and invite the students to reflect on the theory in relation to what they have experienced in the small-scale pilot. In these lectures they may find answer to some of the problems they experienced in the small-scale pilot. Our findings suggest it is useful to pinpoint the importance of the main elements in the theory to the students before they take part in the full-scale practical pilot. One should, to some extent pinpoint to the students what they should consider and be aware of, when they work in CCD sessions.
- Full-scale practical CCD pilot – At this stage in the CCD-training the students have been presented "all" the relevant theory. As part of the full-scale pilot it is also important to focus on theory and what makes the CCD-method work as intended. By continuously focusing on the theory, the students will see that a solid theoretical framework will help them perform better when using the CCD-method. The students will see that the theory can be a powerful tool when they work with many of the challenges in a multidisciplinary project using the CCD-method. In this part of the CCD-training the students claim it is positive to make them reflect on their practical experiences up against theory presented earlier in the CCD-training.

These four steps have shown that the students can build a strong theoretical framework and relevant knowledge for taking part in a project using the CCD method.

B. Practical experiences

We have learned that practical experience is crucial in understanding and learning the CCD-method. We see that the students need to have a substantial amount of practical training in CCD sessions before they fully understand the CCD method and can take part in truly effective multidisciplinary work. The need for practical experience, can be compared with learning to drive a car. You can read a lot of theory about how to drive, but you will not be a good driver unless you also have some practical experience.

Through this action research study, we found that the practical experience also makes the students see the need for, and the usefulness of, theoretical competence. Our experiences suggest it is effective to give the students some practical experience in CCD sessions in the beginning of the training after some introduction to theory. Practical experience makes the students more enthusiastic about what they can achieve by using the CCD method in projects. After the first CCD sessions some students claim that they understand what the CCD-method is all about. Even though this really is not the case we see that an early practical experience makes the students able to reflect on theory and what they are experiencing, when working further to master the CCD method.

1) The right multidisciplinary case

Our experiences suggest it is important to develop and choose a relevant and well prepared case for the practical training. This is important both in the small-scale and full-scale practical project. In both cases, the projects should not be too challenging when it comes to the final results and deliverables. The project must force the students to work together and be responsible for their respective expert roles. Therefore, we believe it is important to spend necessary time to come up with a project case that reflects the students' skills and interests.

2) Student involvement

Experiences from this action research study shows it is positive for the learning that the students get truly involved in the projects. We have seen that letting the students take part in the calibration of the project, before the first CCD session, can be very motivating. Calibration is about defining the project's focus areas, deliverables, roles of the different participants, activities that has to be carried out, and tools to be used for different purposes. Involving the students in calibration is best suited for the full-scale project in the TPRI-Model since this requires more experience and theoretical knowledge than the students have before the small-scale pilot.

By taking part in calibration, the students can help to set the goals and find the expert roles that needs to be involved in the project. Feedback from students shows that they felt more enthusiastic when they had some responsibility for sub-products, and CCD artefacts such as the action list and the decision list. Although the results from the project should not be too complicated, students' feedback tell us that the students are more involved and motivated if the projects contribute to the production of useful products and deliverables.

3) The process, versus results and deliverables

We propose that those who are responsible for the practical training should focus on the process leading towards the result, more than the results in itself. By focusing on the process and making the students reflect on the process, the learning has proved to be more effective. In a training situation one should not put all effort on reaching the final goal, forgetting to reflect on how we got there. The changes we made from year 1 to year 2 in this study, where we increasingly focused on the CCD process, indicates this.

4) Goals and preparations

One of the key elements in the CCD method is that all participants should be well prepared at all times, before, under and after the CCD sessions. Based on our own experience and feedback from the students we have seen that it is important to visualize the goals for each CCD session, as well as preparing documents that the students must read and work with before each CCD session. In this way we force the students to get into the project and project material before they take part in practical CCD sessions. Forcing the students to prepare, also reveals if someone haven`t done their upfront preparations. If this is the case on can let this be a subject for discussion and reflection among the students. Preparations before practical training in CCD session have proven to be just as important as preparation is in real life projects using the CCD method. We found that students who did not do the necessary preparation spoiled the situation for other students, and it was clearly demonstrated that other students were not satisfied with this.

5) The facilitator

Both experiences from previous projects and feedback from the students in this study shows that the role of the facilitator is very important in a practical training situation. The facilitator should not only have the traditional role of a CCD facilitator, but also be the person that take timeouts and make the students discuss and reflect when something comes up during the CCD sessions, that can help the students get a better understanding of the CCD method. This means that the facilitator need both CCD skills and the ability to be a tutor with pedagogical skills and experience.

During this action research study, we tried to let the students have the role of the facilitator in some CCD sessions in the full-scale pilot. Feedback from the students were that this was truly motivating and that they better understood the importance and role of the facilitator.

6) Mandatory attendance

To make CCD sessions work in general it is important that everyone is present. Our experience also suggests that to learn the method well, mandatory attendance to lectures and CCD sessions are necessary. The students who followed our courses said that it was positive and necessary that they had to attend all lectures and CCD sessions. Feedback from the students who missed one or more CCD session, showed that they had trouble getting into the project and fully understand the method because they missed central parts.

C. Reflection and evaluation

As part of this action research study, we have delivered the 15 credit course two times with master students. Feedback and evaluation from the first course showed that evaluation and reflection [19] was an important element to enhance the students understanding and learning. In the second course we focused even more on evaluation and reflection throughout the course, both in theoretical lectures and in practical CCD sessions. Our experiences and the reflection reports from the students, tell us that reflection is crucial to achieve efficient and effective training in CCD.

We also found that evaluation of the CCD sessions was very useful for the students, to help them focus on what went well and what went not so well in a CCD session. When the students reflect upon their experiences, they could adjust and make improvements before the next CCD session. We propose to use reflection both during and after CCD sessions and it is also useful as a tool in theoretical lectures.

Another interesting finding was that the students had a tendency to focus on positive experiences with the CCD-method when they evaluated and gave feedback. Because of this we suggest that one should try to make the students also come up with negative experiences from the CCD sessions. By looking at negative experiences, and reflect on them, one will most probably get a deeper understanding regarding why things did not go that well and how one can avoid such problems in the future.

To summarize, we claim that evaluation and reflection should not just be used randomly, but rather as a planned tool for better understanding and improved learning of the CCD method.

D. Infrastructure

To conduct training in a method such as CCD one need an infrastructure and some guidelines which defines how the infrastructure should to be used.

1) A Concurrent Design Facility

A key-element in CCD is to conduct CCD sessions which take place in a concurrent design facility, i.e. a collaboration room equipped with computer tools and other necessary equipment's to achieve optimal multidisciplinary collaboration between the participants in the room [6]. We believe it is important to use these kind of environments, also in an educational context, so that students' experience is most similar to real CCD projects.

When we conduct real CCD sessions, it is for example important to have access to food and drinks since the sessions are intensive and last for several hours without joint breaks. This was also offered to the students in this study and their feedback confirms that this was positive.

2) A suitable project portal and collaboration tools

In connection with the implementation of a CCD project, there is much information to be communicated. There will also be produced a lot of information during the process, and the participants need access to this information in order to solve the tasks in the best possible way.

In an educational context, where participants are inexperienced, it is especially important to communicate relevant information in a clear and orderly manner, so as to avoid misunderstandings among participants. In this study, we customized a web site where all project information was conveyed and we experienced that Microsoft SharePoint was a suitable tool in this context.

The lessons learned from this study tells us that it is appropriate to let students participate in the calibration process for the project case they are going to be a part of. This is much about establishing a common ground [20] for the project participants, where they do get a common understanding of topics such as the project's focus areas, deliverables, which roles that should be assigned to the different participants, which activities that must be carried out, and which tools to be used for different purposes. We found that the project portal acted as a convenient support tool in this regard, and the design of the portal has an impact on how well it works

In addition to the administrative support provided by a project portal, one should also define the collaboration tools to be used. Our experience suggests that participants achieve awareness and better teamwork if appropriate collaboration tool are used (e.g. co-writing with Google Docs), while they lose awareness and overview when they work more individually and with their own tools.

3) Alternative communication channels

In addition to the project portals established for each pilot, we experienced that the students, on their own initiative, used a dedicated Facebook group for communication regarding relevant topics in the project. The Facebook group was also used by the tutors, who experienced that students quickly became aware of the information that was conveyed through this channel. This tells us that one does not necessarily have to define all tools in advance, but rather invite the students to choose their own solutions. If one ensures to reflect on the selections that are made and how the tools support the collaboration process, we believe such an approach can provide enhanced learning.

V. Discussion

CCD is an integrated problem solving approach which can contribute with competitiveness in a market where customers demand for customized products with advanced features and high quality, while costs and time to market must decrease. However, it is demanding to achieve competitive advantage and there is little documented research on how concurrent methodologies can be utilized, in this regard [4].

The study's main contribution is the TPRI-Model for improved training in CCD which provides with a systematic review of several important factors that influence how training could be organized. Concurrent Design is a rather complicated method, which on the one side require theoretical knowledge of how projects best should be carried out, while it on the other side requires practical training and experience in order to utilize the method in a good way. This paper doesn`t focus in depth on the specific learning outcomes and syllabus related to the CCD-method, but rather the focus is on the key elements to succeed with CCD training. We have chosen to focus on training in CCD since good training always will be important to the success of implementing complex tasks. In general, we claim that training in CCD deals with development of professional expertise, and we can find several studies on how such training can take place, both in a workplace setting and at educational institutions [21]–[23].

Our findings suggest that there should be a balance between theoretical training, practical training, and collective reflection among those involved. In addition, it is important to establish an infrastructure for the training, which includes the physical learning environment and technological tools that support the participant's cooperation process. This led us the Theory, Practice, Reflection and Infrastructure Model (TPRI-Model) for improved training in CCD and we use this model to present and discuss how we should achieve improved training in CCD.

To get the right theoretical framework and necessary experience one will have to focus on all 4 elements in the TPRI-model. What we have found and presented in this paper is that the order of the elements is important. We have found that it is not wise to just start by going through all the theory in the beginning and then start to focus on practical experience. Experiences from this action research study suggest that one should mix theoretical and practical training, and also use reflection as a tool throughout the entire training.

Reflection is an important tool to train students in the CCD-method. By using reflection, we do not just notice what went good, and not so good, in a CCD session or a multidisciplinary project. Reflection helps us find the reason and understand why things went good or not so good. This is very important when we are using a complex and multidisciplinary method. Reflection should be used actively as a tool in both theoretical and practical training.

The last element in the TPRI model is named infrastructure. Similar to reflection, infrastructure is a tool. Training in the CCD-method will be more relevant and effective with access to the right infrastructure. The entire CCD-method depends on access to relevant infrastructure. The concurrent design facility is a key element when working in a project using the CCD-method. If we do not let the students get access to the relevant infrastructure and tools, they will use before, under and after CCD sessions, they will not get the best and most effective training. Again, we can compare this with learning people how to drive a car. By giving the theoretical training they get an idea of how they should drive a car. However, without the infrastructure and tools, i.e. a car and the roads, they will not be able to experience how it really is to drive the car. Similarly, access to infrastructure is necessary to give relevant training in the CCD-method.

The TPRI-Model is based on the experience gained after the first action research cycle (2014), the changes we made in the second cycle (2015) and what improvements this resulted.

- At first implementation, all the theoretical material were lectured before the practical sessions started, but it worked better to divide this. Therefore, the TPRI-model recommends: 1) a little basic theory, 2) practical session work, 3) more theoretical lectures, and 4) further practical work.
- At first implementation, we had a great focus on deliverables and less focus on the collaborative work process. Experience from this entails that the TPRI-Model focuses more on the implementation process and reflections regarding how the multidisciplinary work of the participants works in the process, rather than focusing too much on the final deliverables.
- The main infrastructure difference between the first and second cycles was that we developed an online project portal to convey all relevant project information before the second cycle. This resulted in the students getting a better overview of the project and what was expected of each individual, which in turn is the background for some of our recommendations regarding infrastructure in the TPRI-model.

Although this study is conducted at a university, we believe the results, i.e. the TPRI-Model for improved training in CCD, primarily should be used by companies that want to set themselves able to work efficiently and effectively, using CCD. The TPRI-Model for improved training in CCD represents a pedagogical approach that is referred as integrative pedagogics, where theory, practice and self-regulation is integrated [23].

When Tynjälä [23] presents the Intergrative Pedagogy Model (IPM), it is argued well that professional expertise consists of theoretical knowledge, practical knowledge and self-regulative knowledge which are closely integrated. It is explained in depth what characterizes these knowledge forms and how each in their own way, help in problem solving processes. The TPRI-Model has many similarities with IPM, but there are also some differences. We claim the TPRI-Model build further on IPM, in that we provide with concrete proposals on how theory, practice and reflection can be emphasized when the goal is training in CCD. We touch the interplay and balance between these components and we add a new dimension that deals with the infrastructure. One might think that the infrastructure is something that is just there, but our experience suggests that the infrastructure (a physical learning environment with appropriate tools) is essential and can make a positive contribution, while deficiency of a defined infrastructure can inhibit learning.

This paper and the TPRI-model focus on the overall elements that are important to make students or others thoroughly learn the CCD-method. The paper does not go into detail on important learning goals and learning outcomes when learning the CCD-method. The TPRI-model will not in itself make people experts in CCD without trainers who are skilled in CCD both in theory and practice. Going into learning details will require detailed information on how the CCD method is built up, and unfortunately we do not have enough space in such a paper.

The students will most likely experience problems and challenges in their first practical CCD sessions in a collaboration room. However, our finding suggest that this can make the students more interested and prepared for the upcoming theory lectures. These experiences can also be useful when learning other complex and multidisciplinary systems and models that require both theoretical knowledge and practical skills. Testing the TPRI-model on training in another complex and multidisciplinary model would therefore be interesting further work to see if it is possible to generalize optimal learning in comparable methods. In this context, it is relevant to mention the Stage Gate method [24] or the project management method PRINCE2 [25], which are used in other contexts at our institute. We have a hypothesis that training in these methods also preferably may be based on the principles from the TPRI model and we are motivated to explore this in future projects.

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