Developing process competencies in co-operation, learning and project management

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Abstract: *In this paper, an analysis of the development of the course, "Co-operation, Learning, and Project Management", for first year students in the Department of Engineering and Science at Aalborg University, Denmark will be presented. The objective of this course is to facilitate the students' learning of process competencies in connection with a PBL approach. The course includes theories and methods within the areas of co-operation, learning and project planning and supports the students' work with a process analysis prepared in connection with their project report. The objective of the process analysis is for the students to develop awareness of the work-and-learning processes, in order to become better project workers. Completion of the process analysis, which involves the student to document his/her reflections of the project process, has been a requirement in the Basic Study Program since 1982.*

Both the course and the process analysis have undergone major changes throughout time and this development has occurred in three phases: instruction; theory and on-reflection; experiments and portfolio. The quality of the students' process analysis has improved increasingly with the development of the course.

In this paper, we will analyse the development of the course and explain the theoretical ideas embedded in the third phase, in order to discuss the conditions for development. We have reached four conclusive conditions for this development: 1) students already have experiences with project work and group processes; 2) the project supervisors' support is necessary to create a reflective culture; 3) teachers involved in these courses are qualified in both the subject area and in the learning process competencies and 4) there is a team researching and developing this area. This development of methods cannot only be used in this specific context area, but it can also be used in staff development courses which is actually the case at the Centre for University Teaching and Learning, Aalborg University.

Keywords: *Development of process competencies; Reflection and experiments*

Introduction

Process competencies are an important part of the problem based and project organized engineering curriculum at Aalborg University. However, teaching and learning processing skills are not easy tasks. The learning of process competencies cannot be acquired purely through mental activities, such as a number of subject area competencies can. They are not analytical, technical, or scientific abilities but rather expressions of the individual's personal approach to learning and managing of the subject competencies along with a variety of other abilities, such as working co-operatively, communicating effectively, working independently, behavioural changes, planning and directing, and self-evaluation. They represent a metacognitive level of both action and knowledge. They represent a form of knowledge in action, which may be tacit, as it may be difficult to put into words.

Such skills can be very difficult to value, especially in an engineering culture characterized by technical knowledge. They can be hard to value, because it may be difficult for the learner to experience his or her own progression in the management of these skills. On the other hand, engineers at the university are much more aware of the necessity to achieve these skills, because e.g. co-operation, project management, communication etc. is recognized as core skills within engineering work. Compared to other subject areas at Aalborg University, engineering has progressed much more in the development of a curriculum within this area.

Teaching and supporting the learning of and reflection on these skills are important. They cannot just be achieved by organizing the students' learning environment. The PBL and the project work provide the basis for students "automatically" to acquire a number of process competencies. Research with master's students reveals that this is actually the case, with students taught in project-organized and problem-based programmes being evaluated by their employers as having an easier transition from the academic world to the business world than those with traditional educational backgrounds (Jensen & Wagner, 1990). Other studies indicate, however that assimilation of these personal competencies is restricted to a tacit level—in other words, the students do not appear capable of verbally articulating their own experiences in developing these skills (Kolmos, 1999). Students often choose to remain in the same project groups throughout several semesters, which provides a routine by working together within the same group. However this does not necessarily give them the competence to initiate and conduct a project in another group, because the experiences in tacit form are very context-dependent.

Definition of process competencies

Usually, in English educational research, the term "transferable skills" is used. In previous articles, we have used this term, but we are still not certain that this concept represents our intentions.

Our first concern is the term "transferable", as it refers to theories of transfer from one context area to another. Often the transferable skills are differentiated as either "generic transferable skills" or "personal transferable skills". "Generic transferable skills" are the subject-oriented methodological competencies, including methods, cross-functionality, creativity, problem-analysis and problem solving, while the "personal transferable skills" encompass communication, social behaviour, management, etc. Our concern is that the use of the transfer-metaphor implies that it is possible to transfer knowledge and skills from one context area to another without taking into regard the specific contextual culture. Our concern with

the transfer-research is that it is problematic talking about transfer of knowledge; it is much more about learning (Marton and Booth, 1997). Therefore one may use previous experiences and knowledge, whenever there is a new context, but it is misleading to say it is transfer – one has to reflect on one's own capability and experiences according to the new situation – and that is the transfer of learning. The process skills to use will differ, depending on the specific context, e.g. will co-operation in an engineering context demand other process skills than for example a human context? The culture will differ – and therefore one has to approach co-operation in two different ways.

Our second concern is that the skills concept can be interpreted as a more specific technical term. The development of skills for project management, co-operation and organizing the learning processes are all components of the process competencies. In English, it is a jungle to find the right concept for these skills. First, it is a question of using the concept of skills, competencies, and capabilities. In Danish, we would use the term competencies, as it represents the individual's potential capabilities and at the same time an integrated learning (Ellström, 1997). Ellström's concept of competence is broad and covers cognitive (typical subject area qualifications and skills), affective (motivation and emotion), psycho-motor skills, personal factors (self-perception and self-worth) as well as social factors (co-operation, communication, and management). All these elements are part of the competencies concept. The focus with the concept of process competencies is generally on the affective and social factors, and the process competencies are therefore part of the subject area competencies. They have to be regarded as an integrated process. They represent both technical skills as well as potential for personal development.

These competencies are essentially affective and social capabilities -in other words, they cannot be acquired solely through performance, but they are performed and should be evaluated in their practical context. Reflection is a method for linking performance and cognition, and therefore reflection of experiences is also a critical method of learning within this area.

In this article, we have chosen not to use the concept of transfer, however to use both competencies and skills.

A Story of Development

Since the establishment of Aalborg University in 1974, there has always been a course dealing with the practice of project work in the curriculum. We have studied the development of this course by use of students' evaluation of the courses during the time (Algreen-Ussing and Kolmos, 1996) analysis of students' process analysis, studies of course material, interviewing the lectures and using our own experiences as we have been actively involved in the course development (Kolmos and Rasmussen, 1994). This course has undergone major changes throughout time and this development has occurred in three phases: *instruction; theory and reflection-on-action; experiments, reflection-in-action and portfolio.*

Instruction
Throughout the 1970's and 80's, the scope of the process analysis was limited to a few pages, mostly written in the course of a half-days time after delivery of the project. The particular subjects, which were selected by the students were essentially random within the areas of project planning, project direction, cooperation, utilization of supervisors, the relationship between project and project unit courses – and the process analyses were at that point quite

meagre. The process analyses were generally not explicitly included in the project supervisors' agenda—leaving a great deal to the students' own initiative —and they were seldom given much attention in the final project exam.

Introductory courses for project work were also held during this period. In the 1980's, the project form was new for many students starting at Aalborg University, which necessitated an introduction to the special work form involved in both the model—and just as importantly, the work and-learning processes in the project. The courses were called, "Methods in Project Work (PA courses), and the basic literature was written with special emphasis on providing an introduction to the problem-oriented project work in the first year of the Basic Study Program in the Department of Engineering and Science (Algreen-Ussing & Fruensgaard, 1990). The primary focus of the course was to provide an introduction to make a project and to handle the project process. Therefore, it consisted of typical introductory lectures with presentation of the principles of the problem based project work and examples of, how the project work should be carried out; subsequently, accompanying assignments provided students with the opportunity to implement a number of the presented tools and methods. The teaching of the course was often quite difficult, in that the students perceived the material as either too abstract – or too basic. The course was sporadically supported by the project supervisor.

Theory and reflection-on-action
During the 1990's these courses underwent considerable development. Professor John Cowan served as a consultant for the basic educational programme and contributed to the further development of the course and the process analysis. On the basis of theories on reflection loops (Cowan, 1998), a plan was implemented for conducting a more fundamental assimilation of experiences shortly after the project delivery. In other words, once the project was delivered, a day was scheduled for the students to discuss their experiences with other project groups, in order to make the students more aware of their own experiences with the group process. Thereafter, the students were expected to conduct an analysis of their own experiences, which would in turn be incorporated into the final process analysis. In this model, it was still the supervisor's function to support the preparation of the project analysis, but it was further supported by the organised days for experience assimilation.

Further development of the course occurred at that point – not directly for the preparation of the project analysis, but to support the project process. At this point, the courses, referred to as the "PG-Courses" (project-and-group work), were on a far more theoretical level. The students' reaction to the content of the teaching was still that it was too basic or too abstract – basic because the specific advice seemed so self-evident (even though it perhaps was/is not self-evident at all) – and abstract because it was difficult for the students to relate the abstract learning theories to their own practices. Also far more students entering the university during the 1990's were experienced with the project model.

The developmental work which occurred at this point provided support in the area of the study plan development, within which three overriding, intermediate objectives for the basic educational programmes were formulated: technical subject matter, contextual subject matter and developing the project qualifications. In terms of the technical and contextual subject matter, it was determined that further congruence to Bloom's Taxonomy, which was selected as a shared reference framework for the description of the subject-depth should be sought. As an example of the emphasis on theory students should use Bloom's taxonomy to state their own learning aims related to their different specific learning goals. The quality of the process

analysis decreased, as the students nor the project supervisors were able to combine theory and practice. So the students did not really use the course content for their process analysis.

Experiments and portfolio
The third phase in the developmental work took place in 1999. At this time, the portfolio model was established as a fundamental new model. The novel aspect of the portfolio model was that the students were to gather documentation regarding their own project and learning process along the way. They could choose themselves, how they would organise the work with the process analysis – a great deal of good advice is given in the courses – but the most critical feature is that they experiment and gather documentation of their experiences. These experiments and the accompanying documentation constitute the foundation of a final reflection on the process, at which point the students would write their process analyses – which could also be referred to as their "public portfolio" (Kjær Andreasen & Kolmos, 1999).

The portfolio method is quite applicable for achieving the objectives of the on-going experimentation, documentation and reflection (Black et. al, 1994). In the "Co-operation, Learning and Project Direction" course (SLP), the overall objectives for the portfolio work are provided; in addition, there are a number of predetermined themes, to which the students are expected to relate. Specifically, students will be considering issues, such as project-management, organising of the work and learning processes, co-operation within the group and collaboration with the supervisors. From within these themes, students are expected to establish more specific goals for both the group as a whole and for the individual group members.

The defining of objects for the process portfolio is followed by arranging experiments and consequently documenting experiences with these experiments. For instance, the students may choose to conduct experiments with their project planning and direction in reference to maximising the effectiveness of their collaboration. This may be tested by completing their project plans one week at a time and after some time, to evaluate the effects of this method of planning. The student may conduct an individual learning test and thereafter analyse the group's co-operation – or the students may design communication diagrams over a period of time, in order to uncover their own patterns of cooperation. The SLP courses provide ideas for different types of experiments and considerable effort is initiated to make the methods operational, for the students to apply them themselves. Inspiration for the planning of the course content is derived from the classic literature in the field of group co-operation, as well as from newer approaches which provide both pragmatic and theoretical approaches to group work (Race, 2000; Jaques, 2000; Fallows & Steven, 2000).

Through these means, the courses were also more closely related to the process analysis during the course of the project process. The main reason for this being possible was that the students had more extensive experience with the project work form – in fact, only the minority of students experienced this teaching form to be completely new. The specific project model, which is practised at Aalborg University, is new to the students – but they do have experiences from similar processes – wherefore they can quickly adapt to this practice. Only the very first course is dedicated to the introductory aspects of the project model; otherwise, the courses contain a theoretical element including examples of the various practices and examples which document different aspects of their processes in various ways.

Similarly, much more focus is attributed to the individual in these phases, whereas previously, the courses were directed towards "the group" the courses were directed. This is where the

students show an interest in the subject, and their motivation to internalise the concepts, and becomes quite evident methods with respect to their position in the group. The co-operative group work is regarded as important in itself and the students recognize the importance of understanding their own individual perspectives, in order to fully understand the group. This is a way, in which to create much more reciprocal understanding in the group's dialogue.

The responsibility for the supervision related to the portfolio and the final preparation of the project analysis remains with the supervisor, but it is supported by those conducting the course. They will write a response to the completed project analysis, which is sent to all involved supervisors, external examiners, and peer groups associated with the project exam. This procedure gives the process analysis seriousness and a focus – thus, it becomes an explicit item on the exam agenda. The process analyses have clearly not only developed quantitatively – but also qualitatively, to the overall highest degree and with such an effect that it is given much more respect than previously (Kofoed and Kolmos, 2001). Our strategy for gaining respect in a cultural context has been through an increase of the subject level of the process analyses.

Reflection

During the second and third phase of the course development, we have used different methods of reflection. In the second phase, theory and reflection-on-action was based on Cowan's reflection loops (Cowan, 1998), in which an in-depth assimilation of experiences was completed after each project period. Cowan builds on Schön (1987) and Kolb (1984) and has developed the idea with much more in-depth reflection loops. Basically, the premise in this case is that relatively minor "in"-reflection always takes place, but it is necessary from time to time to stop and conduct a more thorough "on"-reflection. While the theory in principle is very attractive – the problem is that in practice, minor reflection loops diminish to nothing and the larger loops become some kind of "common-sense" which is not being facilitated by experts and/or is not occurring in a reflection-supported culture. The exchange of experience between similarly disposed individuals is not enough to reach a deeper recognition – even though this may occur in a supportive culture, where those expressing their opinions clearly provide support for conducting reflection with a process-oriented emphasis.

In reality, this was far from the case – on the contrary, supervisors abdicated their indirect responsibility within this area by pointing out that the process analysis should be written after delivery of the project. With the situation we found ourselves in with the course development, the expert strategy was doomed to fail beforehand. The experts themselves would either have needed to conduct the courses – which was a very expensive option – or else, the supervisors would have had this responsibility, which would have required post-education. Therefore the situation had to be re-evaluated. In order for the structured reflection-on-actions to reach deep learning, they had to be built up from a number of structured reflection-in-actions – in other words, it was assumed that the on-going process reflections had to be organised to a much higher degree.

From a theoretical standpoint, there is no doubt that these courses would have to be based on an experience-based pedagogy, as the process competencies are in fact an integrated part of the individual's world of experiences. The question really pertained more on, how we could get the experience-based competencies transformed into an innovative competence development which encompasses elements of the new competencies. Pedagogy based on

Concrete events/experiences

Common sense reflection

Active
experimentation

Horizontal - comparative reflection

Reflective
observation

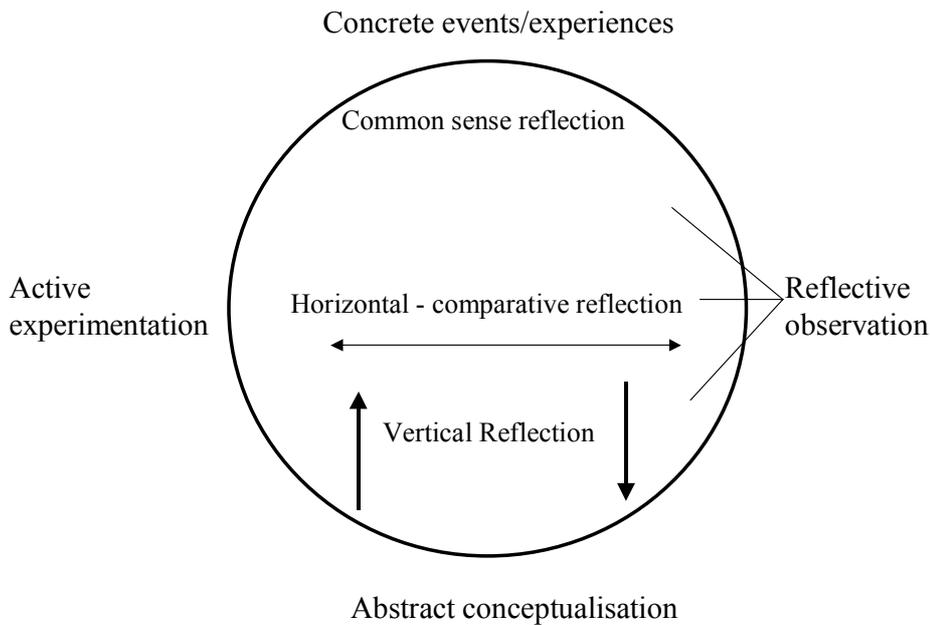Vertical Reflection

Abstract conceptualisation

Figure 1. Levels of reflection in the Kolb-circle

experiences runs the risk that it was founded on existing experiences – rendering it perhaps difficult to set the stage for innovation, creativity, and new ways of thinking.

Jennifer Moon (1999) defines reflection as "a form of mental processing with a purpose and/or an anticipated outcome that is applied to relatively complicated or unstructured ideas for which there is not an obvious solution". This is a broad definition, which is not very precise about reflection as a method, but which specifies that reflection deals with more complex thought sets which are not only simple considerations. Reflection enters as an element in the experience-based learning process proposed by Kolb (1984). It is a rational distanced and observed reflection in relation to the experiences. Reflection is a necessary link for a student to be able to develop his/her own concepts and abstract generalizations on the basis of experiences – and from these, to set the stage for new active experimentation. This description represents the logical progression with the "Kolb Circle" – but learning processes do not always take place in this manner. On the contrary, there is something chaotic within the learning processes which is not easily captured in a rational cognitive model – just as the reflection is not only deeply bound by events and experiences – but also to a high degree, active experimentation and conceptualisation.

If the student involved in experience-based learning is to develop a concept understanding, it is imperative that this learning is not restricted to only one type of experience, but instead, that it builds on several types of experiences which are analysed in relation to each other. These comparisons are in fact a critical step on the inductive road to conceptualisation.

Levels of reflection

As described in figure 1, we operate with three levels of reflection. On the common sense level, The first and foremost attention and focus is on the reflection—to gather the energy and to direct attention towards the processes, on which we have reflect. Next, there is documentation and description of the events and feelings/emotions - what happened and what is to be done? Mostly, this process occurs by individual reflections - and mostly this level is associated with reflection.

On the level of horizontal comparative reflection, learning occurs through variation and comparison of similarities. Therefore the analysis of various types of events and experiences aids in the reaching of clarity – it is through the contrasts and dualism that the particular characteristics emerge. For example, it is only through the intensifying colour contrasts of a deepening red that the colour red itself can be sensed.

Still, there is also the matter of setting the stage for new experiences (experiments) which are compared with previous experiences. The staging of new experiments is critical in the development of innovative processes. Otherwise, the building of experiences continues within a familiar framework of experiences. Peer-reflection is a significant method, in which an environment for comparing experiences is established, in order to provide the opportunity for reciprocal reflection of comparable experiences.

In the case of vertical reflection, further induction based on contrasts takes place with the purpose of gaining conceptual understanding and for concept construction. However, the opposite process may also occur, as our own concept construction is juxtaposed with existing concepts -in other words, deduction or validation of the concept development.

In terms of learning, the individual must be able to manage all of these processes – and they are all parts of the reflection methods. As mentioned, the different levels of reflection emerge from common sense to vertical abstraction, even though this is far from the way, in which it occurs in reality. In actual learning situations, it may just as well be the student who intuitively begin to construct concepts, for which examples will follow, as it may be the individual who starts to reflect on his/her own experiences. This is completely dependent on the individual style of learning. Therefore none of the three reflection levels are the highest – but they are different and all components are of a more fundamental and in-depth reflection.

Experiments

During the third phase of the course, the establishment of experiments became an important element to facilitate the learning of process competencies, especially the awareness of practice and the creation of innovative experiences (Kofoed et al, 2001). We are using the opposite of reflection in "Kolb's Circle" as this is regarded a necessary part of the learning and reflection processes.

The first advantage with experiments is that it is a conscious setting of the process where the students have to define objective, methods, time schedule etc. Some of the experiments that the students are carrying out, may have been done anyway – but the point is that the students are aware of what they are doing. In this way, experiments may give more awareness in the working processes.

The second advantage is that experiments are a method for creating innovative experiences - to provide the opportunity for setting the stage for creativity, new thinking, and innovation. In this context, it is crucial to facilitate the process, in order to take the known experience framework into account (Schön, 1983).

Throughout the course, the student is provided with small experiments embedded as exercises and over time, they are challenged to conduct tests in their groups and to reflect over the results in their portfolio. An example of these experiments could be a communication diagram, in which a group member or supervisor spends time (e.g. an hour) drawing a

diagram which depicts, how communication occurs in the group. Visualising communication provides a specific basis for discussion of the group's mode of communication which is generally not difficult for the students to reflect over on all three of the abstract levels, which in turn leads to potential solutions for extraneous communication. A possible solution could be to elect a chairperson—others could be to switch places or impose time allotments. The selected solution is then to set up a new experiment to be described and evaluated.

The experiments can contribute greatly to giving students the opportunity to –and be helped through facilitation – to be built on several types of experiences, analysed in relation to one another. Similarly, it is clear that reflection helped by reflection moves through all three levels. In one experiment – on the basis of their conscious knowledge that a pair of group members were extremely dominating—a group of students discovered ways to test several methods of communication and cooperation that demonstrated the groups' irrelevant communication and thereby showed that they had been "around Kolb's Circle". At the same time, their discussion shows that they reflect on all three levels, but that this occurs through iterations on the three levels. In the majority of cases, learning on the affective level will have occurred, in that the facilitated process has helped to change group members' behaviour—both the dominating and the non-dominating.

Premises for development of process competencies

In our analysis of the course development, we found four main issues that have been central. The experience from the course shows that the four elements are very important for achieving the learning goal. In our further development of the course these four premises will be taken much more into account.

The first one is the students knowledge and expectations. During the first phase in the late 80'ties, project work as a learning method was not known to students – so they needed much more specific guidelines for "how to do things..". Students' evaluation of the courses at that time indicated that they were satisfied with the practical approach, but theories on project work they regarded as banal or too abstract because they did not have any experiences to relate to. Today, the majority of our students have tried out project work during their primary and secondary school, and they enter into the university with some experiences. However, their experiences vary a lot, so in order to co-operate, they have to be much more aware of their former experiences compared to the new demands. The first parts of the CLP-course challenges exactly this and is supported by the documentation and the reflections in the process analysis – and because the students become aware of the differences in practice, they recognise to conceptualise their practice.

Furthermore, it is also important that the project supervisors support and value the development of these competencies, in order to create a much more reflective culture, but not all of them do. In all the phases of the course development, the commitment of the project supervisors have been a problem, so our only solution to that problem has been to select teaching methods where we were more independent of the supervisors commitment. In our analysis of the process analysis in the third phase, we find that students still complain about the lack of support from the supervisors and it seems as if there is a tendency that there is a correlation between the supervisors commitment and the level of content. The role of the supervisors and influence on the students project work has to be researched much more to give a scientific documented statement.

Teaching the course requires that teachers involved in these courses have knowledge about the project theme and qualification in both the subject area (technical knowledge) as well as in learning process competencies (project management, learning and group processes). It is important that the teachers are able to give specific examples in very specific matters, otherwise the students are not always able to identify themselves or to relate the course content to their own situation. Therefore, all lectures have to be double qualified knowing the content and theories on learning and process competencies.

The teachers can only become double qualified if they are closely connected to a team researching and developing this specific area. Development of process competencies must be research-based as well as other university subjects are research-based. There is a need for continuing development of concepts, theories, methods in order to avoid a common sense level. Therefore, we have created a close interaction between the Research Group on Higher Engineering Education and the CLP group. The relation between the two groups has always existed, but during the second and the third phase of development, more and more research has been addressed to issues in the CLP-courses.

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