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Individual activities as an integrated part of project work: an innovative approach to Project Oriented and Problem-Based Learning (POPBL)

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ABSTRACT: In this article, the authors describe and, on the basis of a recently conducted survey, evaluate a method to increase student learning through the introduction of an individual project using Project Oriented and Problem-Based Learning (POPBL) and team-based work. This can be achieved not just by adding individual activities outside, or parallel to, the project work, but by having individual activities embedded as an integrated part of the overall team-based project work. In what the authors have deemed *the extended project model*, students work individually during the solution phase of a project in an individual activity to be subsequently separately assessed. The results of the individually oriented project work form the platform for the final project work of the team. Students in each team are expected to evaluate individual solutions and select one solution to work on in the final phases of the team-based work. The extended project model also helps train students' abilities to evaluate various solutions of which one is their own, thereby learning how to assess their personal solutions against those of their peers, and thus to use objective evaluations to identify the overall best solution, or else develop a completely new solution model based on their new experiences. Furthermore, the problem of *free riders* can be resolved.

INTRODUCTION

There seems to be an apparent contradiction contained in the title of this paper in terms of focusing on individuality in project work. After all, Problem-Based Learning (PBL), by nature, is based on cooperation between individual students who each strive to achieve a synergy through the social construction of a project team in order to obtain higher learning goals, compared to what could otherwise be expected if they had carried out the work individually. However, in the authors' experience, it is possible to increase the learning outcomes of students by adding an individual project activity as an *integrated* part of students' team-based project work.

The background for considering this aspect of project work is twofold. The *first* reason derives from students' reaction to traditionally performed team-based project work at Aalborg University (AAU), Aalborg, Denmark. At the AAU, students generally perform one major project work over each semester during their entire study. Some students felt that – even though the Project Oriented and Problem-Based Learning (POPBL) method is highly valued by the student body as a whole, as well as surrounding industries and society – they needed to add some individual experiences into their training for solving problems. Students expressed a desire for a possible method to test themselves as individuals in *addition* to their training in social abilities. The *second* reason comes from international experiences where local legislation or administrative practices call for documented individual performance, even in project work. However, in this article, the authors focus only the implementation of the model and the achieved results at Aalborg University, even though the model is suitable for deployment in most project settings anywhere.

The Study Board for the School of Basic Studies of Science and Engineering in the Faculty of Science and Engineering at the AAU decided to develop a teaching and learning model that would *combine* the benefits of the socially constructed team-based project work with a *built-in individual project activity* – similar to a freshman year.

The overriding concern of the Study Board was that the individual activity needed to form an *integrated* part of the *complete process* of the second semester's project work. It should not merely be perceived as a traditional individual activity or a separate event isolated from the project work, as an annex to the main project work itself. Furthermore, it should be possible to develop and sustain the innovative and entrepreneurial competences of students based on their individual performance.

The commissioning of a new Study Guide for the 2002/2003 study included a new structure or model of the project work, which allowed for, and included, an *integrated individual activity* in the second semester's main project work. In this article, the authors describe the standard model, considerations for the proposed enriched model, the set-up and experiences based on a recent survey. This new model is called the *Extended Project Model.*

THE CURRENT STANDARD PROJECT MODEL

The second semester's original structure and the formal phases of the standard project model as performed at the AAU are shown in Figure 1. The typical formalised phases through a *standard* performed project work are detailed below.

The formal phases of the current standard project model (based on Ref. [1]) with regard to initiating the problem (the problem which initiates the project) are as follows (see also Figure 1):

a. Problem analysis;
b. Task formulation;
c. Problem delimitation;

d. Solution;
e. Discussion/conclusion;
f. Implementation (this is an *option* intended for a project work with a potential of actually testing their solution in a real setting, eg in an industrial process);
g. Reporting;
h. Examination/assessment [1].

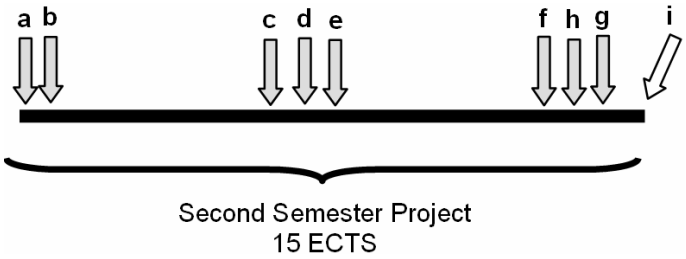

Figure 1: The approximate timeframe and relative duration for the phases during a semester with reference to the above list.

Figure 1 shows the approximate timeframe of the different phases typical for students' engineering education during the semester relative to each other. However, there is no specific time allocated for each phase, which means that some variations of the profiles between the different teams can be expected. Depending on how much time they spend on each activity, student teams begin the different phases at various times during the semester. In addition, depending on the nature of the problems, more time might be spent on *b* (problem analysis) in an analytically-oriented project, or more time might be spent on *e* (solution) in a solution-oriented project.

This variation is one of the benefits of project work, which means that students can focus on the various phases of a project that reflect their interests or the complexity or nature of the problems in the project and, accordingly, to their individual and team-based aspirations.

Beginning in 1974, the project model has continued to generally prove its effectiveness and students' graduating from Aalborg University are highly valued by employers for their high technical performance, as well as their personal and social competences and abilities to solve problems in teams – the latter matching the modern structure in industry and society. The data supporting this claim has been presented elsewhere [2].

WHY EXTEND A GOOD MODEL?

If a successful programme was already in place, then why even consider making a change? As mentioned in the introduction, students represented by members of the Technical Section (FAGTEK) of the Students' Organisation at Aalborg University expressed a desire to have the chance to test themselves as individuals in addition to performing socially and professionally in the relative *safety* of a team environment.

Aalborg University, which is a teaching and learning institution, is generally using the POPBL model. This model is based on the philosophy that an experience-based education provides better learning outcomes for students. The following has been affirmed:

> *The engineering programmes at Aalborg University are project-organized from the day the freshmen arrive until their graduation. In the programme, Aalborg University has grasped the opportunity to meet the voiced need for education to be more closely aligned to an engineering problem-solving approach* [3].

The specific aims for the second semester's project work in the first year programme are listed in Figure 2 [4].

Having fulfilled the second semester's project work, the student should be able to:

1. *Define relevant technical, scientific and contextual terms, and be able to describe the relevant technical/ scientific models, theories and/or methods for analysing the chosen problem area(s)*;
2. *Set up and prioritise demands for the project work whether it is an analytic oriented project or solution oriented project*;
3. *Make an assessment of the obtained results, their reliability and validity*;
4. *Process the chosen technical and scientific problem consecutively with relevant context and/or perspectives*;
5. *Perform methodical and consequent analysis of the results and draw conclusions based on the results obtained*;
6. *Manage project works in a systematic way to choose methods for obtaining knowledge in connection with problem analysis and problem handling*;
7. *Be able to make a critical evaluation of the relevance of the obtained knowledge in relation to the project work, including an evaluation of the suitability of the models, theories and/or methods*;
8. *Analyse personal learning processes and be able to identify strengths and weaknesses, and on the basis of this, consider continued study efforts*;
9. *Analyse the project team's organisation of the project work with a special focus on strengths and weaknesses, and from this, make suggestions to improve future teamwork activities, reflect on causes, and suggest how to solve possible team conflicts*;
10. *Communicate the results of the project work and the processes in a well structured and understandable way in written, graphical and oral forms*;
11. *Document the outcomes of the supporting project courses.*

Figure 2: The specific aims for the second semester's project work in the first year programme [4].

Given the above statement, there might be a potential conflict between the interests expressed by students, and the teaching and learning model, which is currently being practiced by the University. The dilemma between the learning gained by working in teams and learning gained from individual activities was the focus of the national evaluation of First Year Programmes in Denmark in 2001 [5].

In the final evaluation report, the evaluators focused on the balance between individual-based and team-based learning structures. The following was concluded:

> *A prioritising of individual elements in the study can reduce the positive effects of the team orientation both socially and professionally. A prioritising of the team organization will on the other hand limit the student's possibilities to be tested by and trained in individual performance, and it will reduce the transparency related to the qualifications of the graduates* [5] (authors' translation).

Because students wished to have the opportunity to test themselves as individuals, the Study Board explored the possibility of developing a model that – at least partially – could fulfil the wishes of the student body for individual activity, while also retaining the benefits offered by teamwork. It was in the Study Board's interest to facilitate and sustain a process whereby students' could learn to choose between the varieties of individually formed and created solutions in the process of teamwork, instead of merely working on one communally generated solution. Finally, the Study Board wished to investigate if individual activities could solve the problem often referred to as *free-riders*. That is, those students who are not participating equally in project work, but gain all the benefits of the assessment earned by the team in the project-based approach.

The objectives of the new programme were thus to:

- Develop students' individual performance skills;
- Train students to choose between different solutions in a team environment where individual solutions must be evaluated, tested and the overall best solution selected to be the one to be further developed for the rest of the project;
- Create an environment for potentially developing psycho-motor skills in a design process;
- Develop and sustain innovation skills;
- Develop and sustain entrepreneur skills;
- Develop and sustain a diversity in the number of possible solutions;
- Create personal solutions to a common problem;
- Deal with the *free-rider* problem, whereby students *hide* in teams without contributing to their team's best performance, thereby potentially creating internal team conflicts and fostering injustice in assessments.

The work of developing a new project model began with the overriding precondition that the positive effects of teamwork were to be retained, while also supporting individual activity in order to cater for the expressed wishes of the student body, and to strengthen the POPBL model pedagogically.

THE EXTENDED PROJECT MODEL

The formalised steps and specific aims are still kept as a standard to be followed throughout the project work. In addition to these steps, the introduction of new individual activities demanded that additional steps and aims that are related to the performance undertaken in the individual activity had to be considered.

The development of the new Study Guide for first year students resulted in the model shown in Figure 3, which illustrates the structure of the new second semester's extended or hybrid project work model. As managed in the model, the benefits of socially constructed project work are kept while, at the same time, an individual component is *integrated* in the project work model.

Besides focusing on individual performance, this part further supports students' development of social skills and abilities as the individual results form the basis for the continuation of the common project. The new extended model permits the preservation of the benefits of teamwork and allows to make it possible to take advantage of the benefits from individual activities as well, thereby creating a synergic effect generated by a combination of the two models.

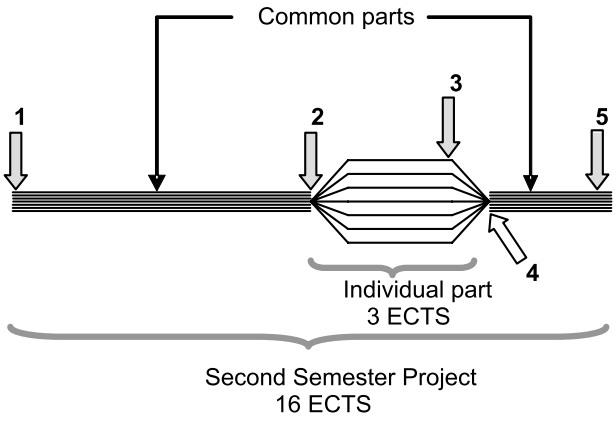

Figure 3: The extended project model (based on [1][4]).

The arrows and numbers in Figure 3 indicate the following:

- Mark 1: At the start of the semester, the objectives and aims for the complete project work are presented. With reference to Figure 1, the phases that students experience in this first common period are phases *a*, *b*, *c* and *d*;
- Mark 2: The team splits up and students work on their own for a period of three ECTS points. The work on the common project is put on hold during this time. The individual component covers parts of the solution marked *e* in Figure 1;
- Mark 3: At this point, students present their individually obtained results to team members and the supervisor, and the solution is open for evaluation and discussion. Students are evaluated on the bases of their individual proposals and are graded by a pass or a non-pass. In order to pass the complete project work at mark 5, the individual activity must be passed before the final examination;
- Mark 4: After the individual activity (at the arrow marked 4), students return to, and continue the work on, their common project in their respective teams. From this point on, the work is based on one or more of the solutions derived from the individual activity. However, team-members may also choose to continue with a completely new solution based on the experiences gained from the individual activities. The phases that the teams go through at this point are (*e*), *f*, *g* and *h* in Figure 1;
- Mark 5: At the end of the project period, students present their project report, a reflection document, and a summary of their individual activities. Each student is graded individually.

With regard to the European Credit Transfer System (ECTS), one year of full-time study is equivalent to 60 ECTS points, which represents 1,800 hours of study for each student. The extended project model covers some 16 ECTS points in total, of which the individual project part is allocated some three ECTS points.

The new model was established formally in 2002/2003, and the inclusion of an individual activity was set up as a possibility open for inclusion in the different programmes offered for the second semester. The first to implement this new possibility was the Architecture and Design programme. The following year, the Planning and Environmental Engineering programme also engaged this model.

A degree of hesitation in the adoption and implementation of the individual part in the project work was expected, as

changes are not easily made at institutions. Nevertheless, the Study Board promoted the use of the extended project model and more programmes are slowly beginning to see the benefits of the model. The Study Board will encourage the model to be implemented gradually in more programmes as positive results emerge and the benefits are proven by evaluations of the programme.

AIMS OF THE EXTENDED PROJECT MODEL

The main problem in the development of the new model was how to examine or assess the individual part of the project without interfering with the overall teaching and learning philosophy of POPBL at Aalborg University. Further, the individual activity had to be completed, assessed and passed in order to pass the final project examination. The systems under which first year students at the AAU presently study require that the group project is submitted in one final presentation accompanied by an individual oral examination. In contrast, the new individual activity, as a minimum, requires a presentation and a subsequent response to the results obtained, in order for assessors to be able to evaluate whether or not the individual activity should be allowed to pass.

In order to solve this problem, an additional activity was embedded in the end of the individual period, where students had to present their result to their teammates and supervisors. The results were tested publicly and responses given. If the quality of the activity was performed well, a pass was given from student peers and supervisors. If not, the student had to work on improvements and have those re-evaluated so as to be able to pass the final examination. If a student failed the individual activity, then the examination of the project work could not be passed either.

Since the individual activity forms part of the entire project work, it can – and should – be evaluated based on the relevant aims formulated for the entire project. Consequently, there is no need to set up additional aims that exclusively target the individual activity. On a practical level, the assessment could be based pragmatically on a matrix where the partial aims are listed and the demarcation boundaries for a passing performance are made clear. This would be a good guideline for students as a reference point for their work.

IMPLEMENTING THE EXTENDED PROJECT MODEL

The Study Board has followed the development and implementation of the Hybrid Project Model very carefully over the past three years since the initial implementation of the new model. So far, two of the possible 17 professional areas have been running the new model (Architecture & Design and Planning & Environmental Engineering). There are now considerations to implement it into the following programmes:

- Civil and Construction;
- Geography;
- Computer Science;
- Bio-Engineering and Chemistry;
- Medialogi;
- Industrial and Design Psychology.

When new educational areas enter the programme, it is generally based on an awareness of the positive results gained from colleagues. However, the supervisors are also, in some cases, the driving forces in entering the programme, as students' ability to generate a wider diversity of solutions, coupled with a high degree of creativity, engagement, innovation and entrepreneurship within the student body, are some of the characteristics that are typically in high demand by supervisors.

THE PLANNING & ENVIRONMENTAL ENGINEERING PROGRAMMES' IMPLEMENTATION OF THE EXTENDED PROJECT MODEL

The Planning & Environmental Engineering programme was the second programme to implement the extended project model, as it was thought that this project model could help students with their solution phases in their project work.

The current overall project theme for the second semester for the Planning & Environmental Engineering programme is *Urban Ecology*, with an explicit focus on small scale ecological solutions (ie the implementation of water or energy efficient and saving technologies, such as *green* roofs, solar cell plants, biological cleaning technologies, etc).

Although the current standard project model provides a good and suitable framework for students' project work, it was thought that the extended project work model could supplement and further the learning outcomes of students. This would be achieved by providing an added emphasis on supporting the solution-finding competences (and thus the creative and innovative skills) of students.

Students collectively work together on their project through the first four phases (*a* through *d* in Figure 1) of their project work. During these initial phases in the project work, students together collect and analyse data from relevant urban ecological cases, learn the basic ecological technologies, collect qualitative and/or quantitative data through surveys or interviews, and come up with a problem's formulation and delimitation (ie which parts of urban ecology and a technological solution strategy should be pursued). Students subsequently split up to pursue their individual solution strategy. In a project that is primarily concerned with the water consumption of a building block or blocks, students might, for instance, individually investigate different solutions for water saving, wastewater management or wastewater treatment.

Since students have to individually present and defend their individual solutions to their team peers, as well as their supervisors, in a subsequent evaluation sequence (step 3 in Figure 3), there is a great sense of personal commitment and pride that students demonstrate in their individual project work. This is accentuated since the different solutions (or parts of them) form the basis for the further development and refinement of the team's solution strategy and thus the continued project work.

A COMPUTER SCIENCE EXAMPLE OF AN EXTENDED PROJECT MODEL IMPLEMENTATION

As previously mentioned, interest in the Extended Project Model has been expressed by the Computer Science programme. The following serves as an example of *how* the extended project model could be implemented in a Computer Science programme.

In line with the Planning & Environmental Engineering programme, computer science students' work in teams on the first phases of the project before entering the solution phase,

where programming is an essential part of the solution (*e* in Figure 1). In this phase in their project work, students would be expected to have made specifications for the applicability of their program. The complete program would probably consist of several program parts, with one or more being chosen to serve as the basis for further programming in the subsequent individual phase of the project work. Students then work on their own, developing a possible solution based on an individual analysis. By choosing between possible solutions, a student writes his/her suggestion for the specific program component.

However, in this construction, there is always a risk that students of the team will help each other. *If* it becomes obvious that the so-called different individual solutions are generated by the same person and, as a consequence, are not solutions that can be attributed to individual students, then these students will encounter problems during their presentations and assessment of their individual activities. Ideally, different solutions to a sequence or a part of a program must be evaluated by the team and the *best* solution chosen for their continued teamwork. How they choose which solution should be used can be based on various criteria. It could be the fastest running program, the program that require the least storage capacity, the simplest programming, the one developed as an object, the most logical constructed, etc. Moreover, as stated previously, the team can decide to combine some of the solutions into one new program and continue their work.

The same principles can be applied in architectural activities where students might design a chair, an industrial product, a building, etc, or even work on a challenging theme, eg *vision* (what the eye sees).

Therefore, the extended project model can, in the authors' opinion, be put into service in most study programmes. It would only need some rethinking and re-planning to be able to find possible areas in which the individual activity could be performed. Indeed, the individual activity is very suitable for solving *practical problems*, as in most engineering problems, whereas it may be deficient when *theoretical problems* have to be solved. However, this hypothesis has not yet been challenged.

The benefits of the new model have been identified, based upon feedback from supervisors who have followed its use. The positive effects are as follows:

- More time is spent (in total) on the solution part compared to the time spent under the standard project model;
- Students progress further in the work performed after the individual part;
- Students are very proud of their own work and develop a high level of ownership of their own work;
- The individual activity provides students with a unique opportunity to excel in areas of expertise of their own choice;
- Students get the chance to test themselves independent of their teammates, which most students find exhilarating;
- Students' individual status in teams is tested, with their status adjusted according to their performance in the individual activity.

The not-so-positive effects that were detected by the supervisors were found to include the following:

- Students tended to be more stressed as they placed high standards on their performance and spent a lot of time on the task;
- It may be hard for students to overcome the change from the individual component to the team part in the further process of teamwork, as students developed very strong ownership feelings for their *own* solution;
- With small team sizes, eg three students, the effect of the model is perhaps limited, because small-team students work more individually and do not really function as a team (if teams are deliberately formed with smaller numbers, then the overall objectives would likely change as well) [6].

In addition, the Study Board noted that it could be hard to communicate about experiences gained in one environment to another, and between supervisors across different programme areas. The Study Board has to develop ways, in addition to already-existing coordinating meetings, to communicate and share experiences effectively and efficiently. This article is one way to make it known to others.

EVALUATION RESULTS FROM A SURVEY

At present, three streams of students from the *Planning & Environmental Engineering* have experienced the extended project work format. In May 2006, students from the 2nd, 4th and 6th semesters took part in a joint study tour to Berlin in Germany, with students from the 4th and 6th semesters taking part in a survey regarding their experiences of the extended project work. Out of a group of 26 students, 20 took part in the study tour, and all of them answered the questionnaire. This comprised 77% of the total number of students [7]. It is recognised that the sample *is* a small sample and it could have been influenced by the Hawthorne effect (wherein initial improvements in a process are caused by the obtrusive observation of that process).

The first question was *If you should compare your* personal workload *in the individual activity with the workload of the* standard *project work, how would you characterise the load?* Figure 4 shows the answers.

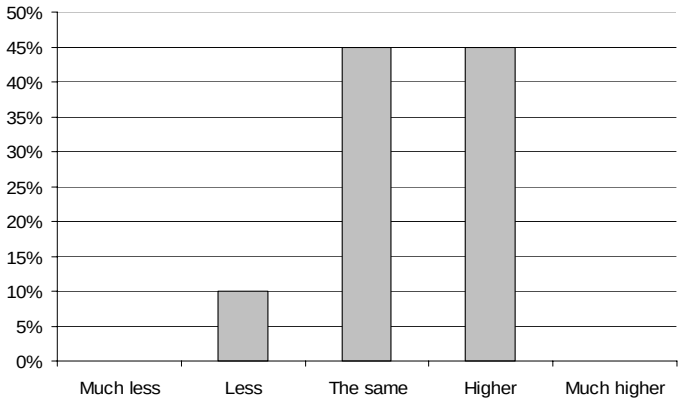

Figure 4: Personal workload compared with the traditional standard project work model [7].

It was found that 45% of the students surveyed felt that they had a higher workload, which is consistent with the feedback from the supervisors. However, the same percentage of students indicated that the workload of the extended project model was the same as for the workload of the standard project model.

The second question was *How would you estimate the* overall quality *of the project work seen in the perspective of having been through the individual activity compared to a project work without an integrated individual part?* Figure 5 shows the answers.

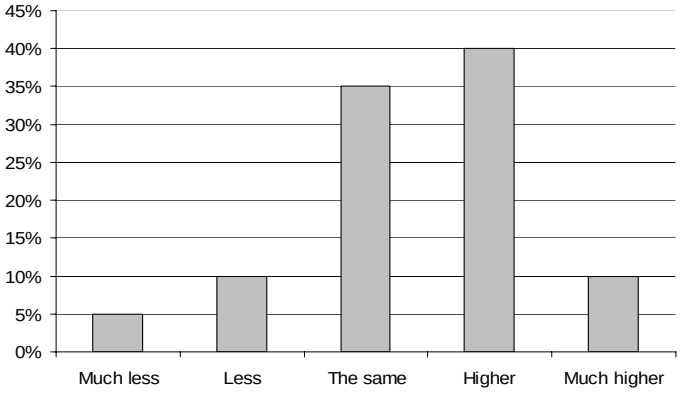

Figure 5: The overall quality of the project work compared with the traditional standard project work model [7].

It was found that 50% of the students felt that the quality of the total project work was higher (or much higher) in the extended project model compared to the standard project model – the latter model being the model that the students had followed in their third, fourth and fifth semesters.

The results from the third and fourth questions of the survey are shown together in Figure 6, as these questions concern the outcomes of professional competences (which are competences that are directly related to the profession) and the outcomes of the personal competences, respectively.

The questions asked were as follows *How would you characterise your* outcomes in the professional area *when comparing the second semester project with an individual activity, with the 4th and 6th semester projects without the individual activity?* and *The same, but for the* personal competences*?*

There was a slight tendency for professional competences to be less highly rated for the individual activity compared to the development of personal competences in the project work, which was significantly higher. The survey revealed that 75% of the students felt that they had developed higher or much higher personal competences by participating in the individual activity compared with their experiences from projects after the 2nd semester.

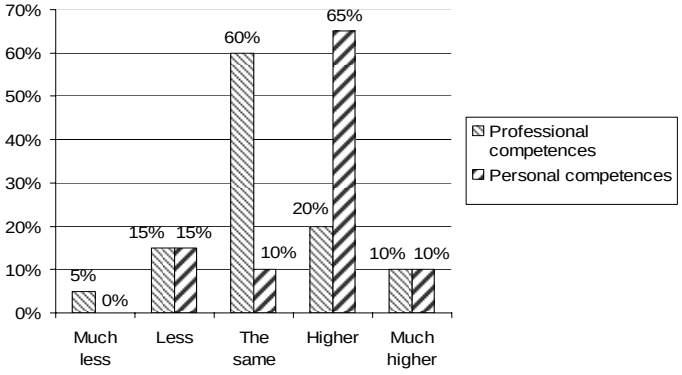

Figure 6: Outcomes of professional and personal competences compared with the traditional standard project work model [7].

Figure 7 also presents the results from two of the questions asked in the survey. These questions concerned students' experiences with the transitional phases of the extended project model. That is, the students' experiences when going from the group or team-based environment into the individual component and then returning from the individual period to the group or team-based project work.

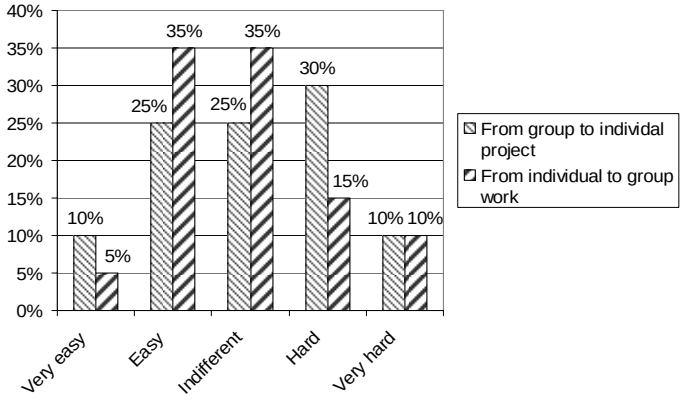

Figure 7: Students' experiences in the transition from the team-based project work to the individual work and vice versa [7].

The questions asked were *How did you experience* the transition *from the collective part* to the individual *part?* and *How did you experience the transition from the individual part* to the collective *part?*

Contrary to the aforementioned expectations of the supervisors, the numbers in Figure 7 show no clear indication that the students encountered difficulties when going from the group work to the individual component. While 40% felt it hard or very hard, it was found that 35% considered it easy or very easy.

The same mixed signals can be observed regarding the transition back into the team-based environment. It was found that 25% considered it hard or very hard to go back into the collective environment, whereas 40% of the students found the same transition easy.

So the overall impression is that the transition may not be as big a problem as many study managers and supervisors thought it would be, although between a third and a quarter of the students encountered some difficulties in the two transitional phases of the extended project model.

Figure 8 presents the results of the question *How would you characterise the* overall experience *of working individually with a problem as an integrated part of the total project?*

Here, the results are very clear, as 80% of the students stated that their overall experience with the extended project model had been good or very good. It is very clear that the students were pleased with the individual activity – a conclusion that is further supported by the answers to the next question, *Would you like to have an opportunity to have* more *activities which are individual later in the studies?*

The results of this latter question are shown in Figure 9, where about 95% of the students answered *yes* to the aforementioned question. This is a clear indication that the students would like to have more activities incorporated in their studies that are individually based.

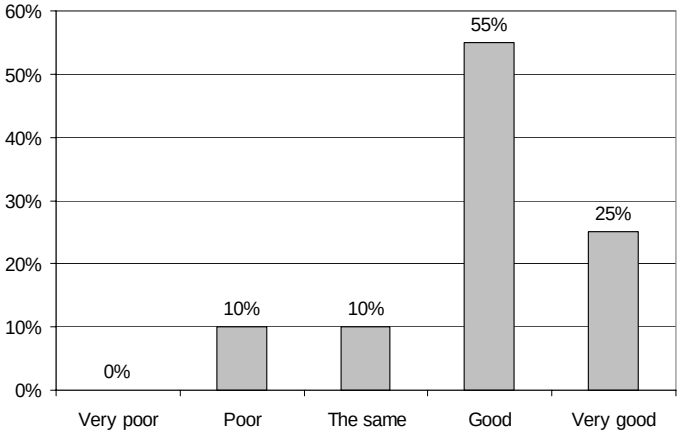

Figure 8: The overall experience of working individually with a problem as an integrated part of the total project [7].

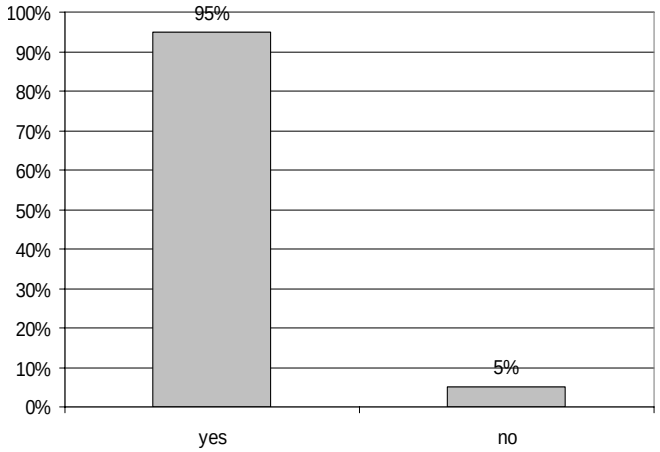

Figure 9: Results indicating that the students would like to have more activities that are individual later in their studies [7].

While the survey is a small survey, it does include a satisfactory proportion of answers and the students' experiences are spread over two to three years of study, which means that they have been able to make comparisons between the two main kinds of project models they have been exposed to at the AAU. A more detailed analysis of the students' response to the extended project model is underway by Kørnøv et al, and will be published later [6]. This more detailed investigation includes the qualitative answers in the form of comments to the activity. The present article only presents the quantitative data in an overall setting in order to give evidence to the extended project model's potential for wider use.

CONCLUDING REMARKS

The results from embedding an individual project work phase in a larger project-orientated and problem-based team-based project work model clearly indicate that the introduction of this type of individual activity in project work has the potential to be an excellent method to develop additional personal competences for students and, to a lesser extent, to further develop the professional competences for individuals, as well as for teams. The extended project model has certainly enriched the outcome of the total project work, as well as being a personal success for students. Based on students' assessments of their personal outcomes and the survey presented herein, they all felt that their learning improved by working as individuals and that they additionally had worked harder to generate personal solutions to their project's problems.

The individual activity also provided the grounds for students to test themselves outside the comfort zones of their teams. They all evaluated their experiences as being very useful and stated that it gave an additional value to their projects, as they were challenged to provide personal reflections related to the overall problem(s) of their project work [6]. Moreover, no *free riders* have been witnessed so far.

Surprisingly, there has been less evidence to support the fears of study managers and supervisors that students would experience significant problems concerning their transitional phases (going from team-based project work to individual project work and vice versa). However, this does not mean that the transitional phases do not present any sort of problem whatsoever, but the results from the survey clearly indicate that the majority of the students surveyed found these phases to be less of a challenge than expected by study managers and supervisors.

Finally, much to the pleasure of the Study Board, the data so far clearly supports the further development of the extended project model, both in an internal and external setting. There is also evidence to support the use of the extended project model internationally.

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