WHAT STUDENTS LEARN FROM IPD PROJECTS

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1 Introduction

This paper describes the results of an on-going investigation in the learning effects of integrated development projects at Fontys University of Applied Sciences. In three subsequent semesters the students were asked how they rated their competencies at the start of the project as well as at the end of it. The students voluntarily filled out a questionnaire. It was a remarkable outcome that a lot of students tended to give themselves lower ratings in the end. So at the end of the second semester a number of students were also interviewed in order to find out more about this. It appeared that if they met any difficulties in for instance communication or co-operation during the project, that they interpreted this as a decrease in competencies. This required a different interpretation of the outcomes of the questionnaires. This has already been reported by van Schenk Brill *et al.* 2006 [SCH-06]. In the third semester students were explicitly asked to mention an eventual increase in competencies and also a possible contribution for this effect. The investigations showed that co-operating in general and in multidisciplinary teams in particular, co-operating with companies and also working according to plans are the four objectives that are recognized mostly by the students. Only a few factors that actually contribute to, or block, the learning effects have been defined; these are subject of further investigation.

1.1 Fontys IPD projects

Since 1995 integrated product development projects (IPD projects) have been carried out at Fontys University of Applied Sciences (first described by Kollenburg *et al.* 1998 [KOL-98]). Unique about these educational projects is that groups of about six students, coming from various departments and sometimes even various countries, get an assignment from an (industrial) company. The assignment often consists of an investigation for a new product, including a market survey or the development of a prototype. The projects have to be carried out within one semester, taking about one day a week. During this semester, the group of students is guided both by a tutor from Fontys and a representative of the company (see e.g. [SCH-01]). The Fontys tutor used to coach both on the process in the project and on the contents. At the end of each semester all groups present their results in an official symposium for an audience of fellow students, tutors, company representatives and other interested partners. This all takes place in English in order to improve the students' language development.

1.2 Co-operation with secondary technical education

Since 2004 students from Fontys University have been linked to students from ROC (secondary technical education) that already work in practice, while still participating in training, as reported in [SCH-04]. Preferably the practical training of the ROC-students is done in the same company that offers an assignment for an IPD project. A tutor from Fontys, as well as a tutor from ROC coaches these groups of students. Purpose of that, is to mutually transfer the experience of the tutors from both parties to each other, and to improve their coaching competencies. By combining students from ROC and Fontys, multidisciplinary and multilevel groups have been formed. The projects, carried out in this way, are called know-how sharing projects. We shall refer to them as KHS projects. Actually, there exists a larger co-ordinating project, which made the experiments possible. This is funded by the government and aims to improve circulation of knowledge between educational institutes and small and medium enterprises (SMEs). This larger project is also called the KHS project. When we mention KHS projects in this paper we will refer to the IPD projects in which ROC students participate, which is the case in about 30% of all IPD projects. The authors of this paper are involved in the IPD and KHS projects as tutors.

1.3 Objects of investigation

We investigated the results of IPD projects with the purpose to determine the actual learning effects from multidisciplinary and multilevel projects. Also we wanted to discover other factors that might improve the learning effects. From this, conclusions can be taken for possible improvements and may-be for inspiration of other universities with our "model". We hope to answer the question: what are critical and essential things to ensure, when using such a learning environment for students? More about the purpose and the way the research was carried out can be found in the next chapters.

2 Research purpose

As in other European countries, in the Netherlands education changes to more competence-based training. Therefore competencies were also introduced in the IPD and KHS projects. This was described by Bakker *et al.* 2004 [BAK-04]. As a consequence the educational view on how to train young people to become young professionals has also changed. This resulted in a change for the IPD and KHS projects. We started integrating competencies into the projects, developed instruments with which we tried to improve self reflection (e.g. by peer assessments and self evaluation reports) and assessed students on the products they developed as well as on the process they needed for that. In short, we changed our behaviour from lecturing to coaching. By doing that, we hope the learning effects from the projects will increase. As this is no guarantee we wanted to retrieve what can be learning effects and what factors are positively influencing these learning effects. Especially we wondered whether these effects would be similar to the competencies as defined for the IPD projects and are there any differences between multilevel, multidisciplinary projects and "normal" projects? Besides we wanted to discover the factors that influence the learning effects.

3 Way of research

Our first step to find out the learning effects of IPD projects was to monitor student groups for one year, so during two separate periods with IPD projects. At the start of the first semester, students were asked to name the competencies they expected to learn by participating in the IPD project. Also, they were asked to estimate how good they already were on these competencies. As it concerned open questions the answers were quite broad but we were able to filter out about eight competencies that students expected to learn from the multilevel and multidisciplinary projects, which were named as the most important. We compared this to the answers given by the tutors. The seven most important competencies the tutors mentioned had an overlap of six with the ones named by the students. Also the learning aims that had been defined for IPD previously were considered. Nine competencies were derived for later surveys in the second phase. At the end of the first period the students were confronted with their own answers and now they were asked to estimate the level of their competences again. Only on three items an increase in competence level was reported, on two items the level was the same, but on three items even a decrease was noted! Two of these items concerned the co-operation with companies. This gave rise to our assumption that students rate themselves too high on this point, having too less experience for a realistic estimation. Also the numbers of students that indicated one of these competencies was sometimes too low to draw solid conclusions. On the comparable items the tutors however rated the student most of the time 10% lower than the students did for themselves and on the items with company co-operation even 20% lower. This brought us to pay more attention to the company related items in the next phase. A number of students that did not participate in the first survey filled out the forms the second time. Looking at the whole group the most important competencies mentioned in the second survey did not differ from the first ones. A second phase with a lightly different approach was needed.

The approach in the second phase was to use a questionnaire with the nine competencies that were derived in the previous semester. Students were asked to fill out the form once before they started their projects and once at the end. Both times, the question put to them, was: how do you rate yourself on the learning effects or competencies mentioned in this form? In the second survey the students that also participated in the first one got their forms with answers back so they could compare their level of competence with the original level. Now also a reference group was asked the same questions to rule out the learning effects that would have taken place anyway. That is to say when working during one semester on a project in a homogeneous group of students. In order to find an explanation for the decrease in learning effects and also to give us more insight in the way the learning effects were achieved, we interviewed some of the students at the end of the projects. In case the students had indicated a decrease in competence level in the questionnaire, they were asked for a possible explanation.

This way of research produced a lot of data. On one hand, when a student rated his or her competencies (on a scale from one to five) with a three at the start of the project, and a four at the end, he definitely learned something. On the other hand, when he or she rates their competencies at a two at the end, he or she also learned something! As mentioned before it could be that students underestimate the difficulties in working for real companies. This has been a main item for the interviews with the students. So the data are not as easy to interpret, as it may have seemed when the investigation started. This will be discussed later. The interviews gave us more insight, especially on the items where students indicated that their level had decreased. In most of the cases the students had not filled out the forms properly,

but wanted to express that a subject appeared to be more complex or difficult than it seemed at the very beginning of the project. Almost everyone admitted that they had learned a lot when things went wrong or were more difficult than expected. In some cases they indicated that their level had neither increased nor decreased because the particular item did not come up in their project. This led to a new approach for the last phase in the research. Now a questionnaire was prepared with again the nine competencies, but now the students had to report a possible increase and if so, a motivation of how this was achieved. As the response was low, no solid conclusions can be drawn, however trends might be discovered. Only on a few items increase in competencies were reported, but from the motivations a set of possible contributions to the learning effect could be derived.

4 Research results

4.1 First research phase

On the first inquiry, sent by e-mail to 70 students, a response of 35 students was gathered. They came up with 48 different learning effects. About ten of the effects were too specifically related to a particular project objective (e.g. learning how to make a web page using PHP). This is caused by the fact that the investigation could not start before the students had chosen their subject. Another 12 items were too unrealistic, too generally formulated and/or mentioned only once. So about 25 items remained to be considered. From those 25 we took eight items, enumerated in Table 1. In this table the items are given in order of the number of times they were mentioned, as indicated in the last column.

1	Co-operating in multidisciplinary teams (17)	17
2	Co-operating with companies (11)	11
3	Co-operating in general (8)	8
4	Working in projects (7)	7
5	Communication in general (6)	6
6	Communication with companies (4)	4
7	Practical experience (4)	4
8	Planning (3)	3

TABLE 1. Learning effects as identified by the students

The tutors came up with about the same items; only instead of *communication with companies* and *practical experience* they added *working on a realistic problem*. In the second inquiry, also using e-mail, about 20 of the students that had responded the first time responded again and about ten new students responded. We used separate mails for that; the students that responded the first time got their original answers, asking them to give the scores for their competence level right now (at the end of the project). The students that had not responded before were kindly asked to co-operate this time. In this second inquiry no new items came up and there was only a slight change in the number of times that the items were mentioned. Communication with companies (2) was mentioned less often; communication in general (3) more. Also the planning item (8) was mentioned more often. The scores of competence level on those items that the students rated themselves; both at the start of their project and at the end are depicted in figure 1. The item numbers in the graph correspond to the item numbers mentioned above. The score had to be given on a scale from one to five. The light grey strokes (indicated as IPD start) refer to the mean value of the score given by the students in

the first inquiry; the dark grey strokes (indicated as IPD end) refer to the mean value of the score given by the students in the second inquiry.
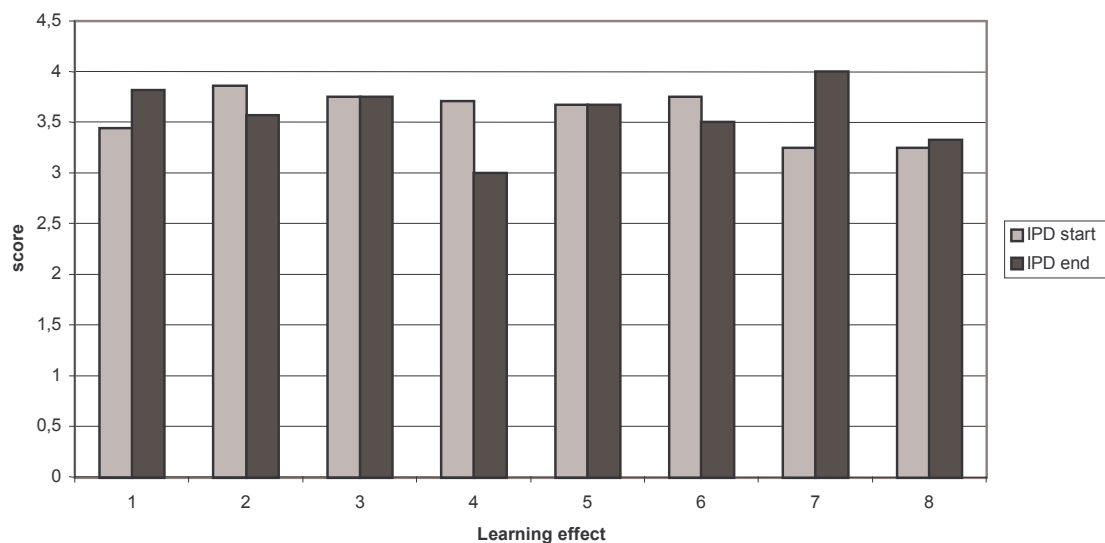

Figure 1. : Competence level scores in the first research phase

For each competence level an increase or at least no decrease would be expected. So the items two (co-operating with companies), four (project working) and six (communicating with companies) show remarkable results. Ignoring the answers of the ten new students showed no noticeable changes in the mean values of the scores; at least the items showing an increase or decrease still did so.

4.2   Second research phase

For the second phase (in the second semester) we had to decide what learning aspects we had to ask the students to give a score. Some of the aspects that came up in the first phase were, in our view, not specific for IPD projects. During the first phase there was an ongoing discussion on whatever we wanted the students to learn from the IPD projects. As an outcome of these discussions it was decided that working innovatively and thinking in solutions were important items for IPD projects. Also during this phase it became clear that for the next semester we would have more KHS projects, so more ROC students would participate in the projects. Therefore we decided to introduce an item on the co-operation between the Fontys students and the ROC students. At the end of the first semester it was decided that the students of our international course would participate in the next semester projects. Also some of the projects would be carried out again with our partner institutes abroad; students then have to work together using electronic communication means (reports on this can be found in [5] and [6]). So also an item about working with foreign students was introduced, no distinction was made between foreign students at our own institute and those abroad. Considering all this and the fact that the questionnaire should not be too long, we came to the learning effects the students had to score, given in Table 2.

1	Co-operating in general
2	Co-operating in multidisciplinary teams
3	Co-operating with companies
4	Working according to plan
5	Working innovatively
6	Thinking in solutions
7	Communicating in and about the project
8	Co-operating with other level students
9	Co-operating with foreign students

TABLE 2. Learning effects for questionnaire

The advantage of this list is that it makes it possible to ask for specific IPD/KHS related topics, the disadvantage however is that only four to five items could be compared with the results of the first phase. These items were collected on a form with a prepared table for the scores; so the students only had to indicate the appropriate score. The forms were distributed to the students by the tutor of their particular project. This resulted in 66 filled out forms (60% of the total). Also a reference group was asked the same questions in order to rule out the learning effects that would have taken place anyway. This concerned a number of projects in which students were working during one semester in a mono disciplinary and homogeneous group. We managed to find some projects that met those requirements. The students were of the same level; they could have chosen for an IPD project as well but preferred another project. In this way we could collect the answers of 14 students, too few to draw solid conclusions, but it gave an indication.

Some measures were taken in order to improve the percentage of response at the end of the projects. So it was decided to distribute the final questionnaire during the symposium, where all IPD projects were presented and where almost every participating student was present. Like with an inquiry for a fair or road show at the end of the symposium the forms could be handed in, which was rewarded with a small present (a 3D puzzle). In the opening speech the importance of participating in the questionnaire (and also in oral interviews later) was emphasized. This resulted in a response of 72 forms (65%). The approach was the same as in the first phase; the original answers of the students were copied into a new form and personally handed to the proper students. In the same way students who had not participated yet got a new form. Besides the nine learning effects a simple question was added to the form: are you willing and capable of participating in an oral interview? After processing the results it was concluded that those interviews were really necessary to explain the results of the questionnaires. In figure 2 these results are summarized compared to the scores that were originally given. It is striking that most values are lower at the end than at the start. Only the items five and six (working innovatively and thinking in solutions) showed an increase. The level of item one (co-operating in general) remained the same, like in the first phase. Also the items three (co-operating with companies) and seven (communicating) showed the same tendency in decreasing as the comparable items in the first phase inquiries. When we compare, however, only the scores of the students that participated in both the first and the second inquiry of this phase, the results are less dramatic. In that case only the items four (work according to plan), seven (communication) and nine (co-operating with foreign students) showed a fall back. Other ways of grouping the students gave no large differences in results. Separate groups were made for students working in projects together with foreign students in-house (from our international course), students that co-operated with students from institutes abroad (Finland, Morocco and the USA) and students working in KHS projects.
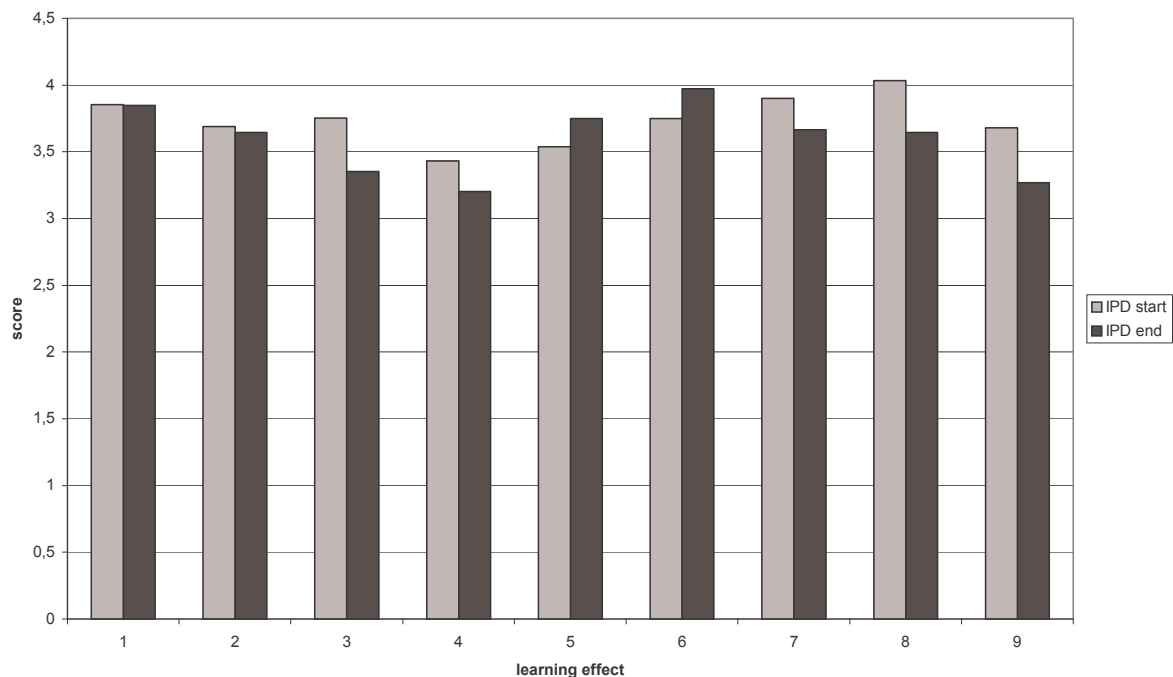
Figure 2. : Competence level scores at the start and the end of the second research phase

In the first two cases the results only showed some minor differences, but in the latter case there were some remarkable differences. On the items two (co-operating in multidisciplinary teams), eight (co-operating with other level students) and nine (co-operating with foreign students) they reported an increase in competence level, however on item six (thinking in solutions) a decrease. A possible explanation for this can be that about 30% of the students that filled out their form in this group were students from ROC.

Although the instructions on the forms were quite clear (in our view) the only explanation that came up to us was that the questions were still misinterpreted. Therefore the interviews were needed very hard. A number of 27 of the responding students (38%) were willing to be interviewed. After the final presentations, e-mail was used to make appointments and also a lot of the students were called on their mobile phone, the latter being a most successful way to arrange a meeting. (It should be noted that most of the students had to start their graduation work soon after the ending of the IPD projects.) Finally 18 interviews took place. For each item the students were asked for a reason why he or she thought that the competence level for this item had changed. Especially for the items where the students reported a fall back the reasons were discussed. About 60 to 70% of the students did not realise until the interview that they had increased on those items, in fact gained more experience instead of a fall back. Most of the reasons for giving a lower score were:

- the item did not come up to the expectations (it was more difficult than estimated)enumeration (dot)

- things within the project went not so well (either the students felt to have too little knowledge of a particular discipline or they blamed poor facilities, like too little availability of PCs or failing e-mail communication)

- at the start the item was estimated too high (caused by too little experience)

The items eight (co-operating with other level students) and nine (co-operating with foreign students) were only applicable for a restricted number of students. Only two of the interviewed Fontys students actually worked together with ROC students and reported neither a decrease nor an increase, as they were already familiar with that. Working with foreign students was the case for five of the interviewed students. Unfortunately none of the in-house foreign students was available for an interview, so only Dutch students were interviewed. The projects with foreign students gave rise to a number of problems. These were caused by:

- cultural differences

- communication difficulties (for almost all students involved, Dutch as well as foreign, English was not their native language)

- differences in background of studies (e.g. the students from the international course had learned quite a different way of project working than the students of the Dutch faculties)

- communicating by electronic means with institutes abroad (finding the right times and protocols)

Concerning the last problem the students blamed the fall back in learning effects also on poor facilities for this communication. At the end of the interviews almost all students admitted having learned at least something on this item. They could not or hardly indicate what things were positively influencing that.

To be able to adapt the gathered data from the questionnaires according to the results of the interviews it was decided to represent the data in another way. Therefore the number of times was counted, that the students' score was lower, equal or higher at the end of the project, compared to the start. Figure 3 shows this result.
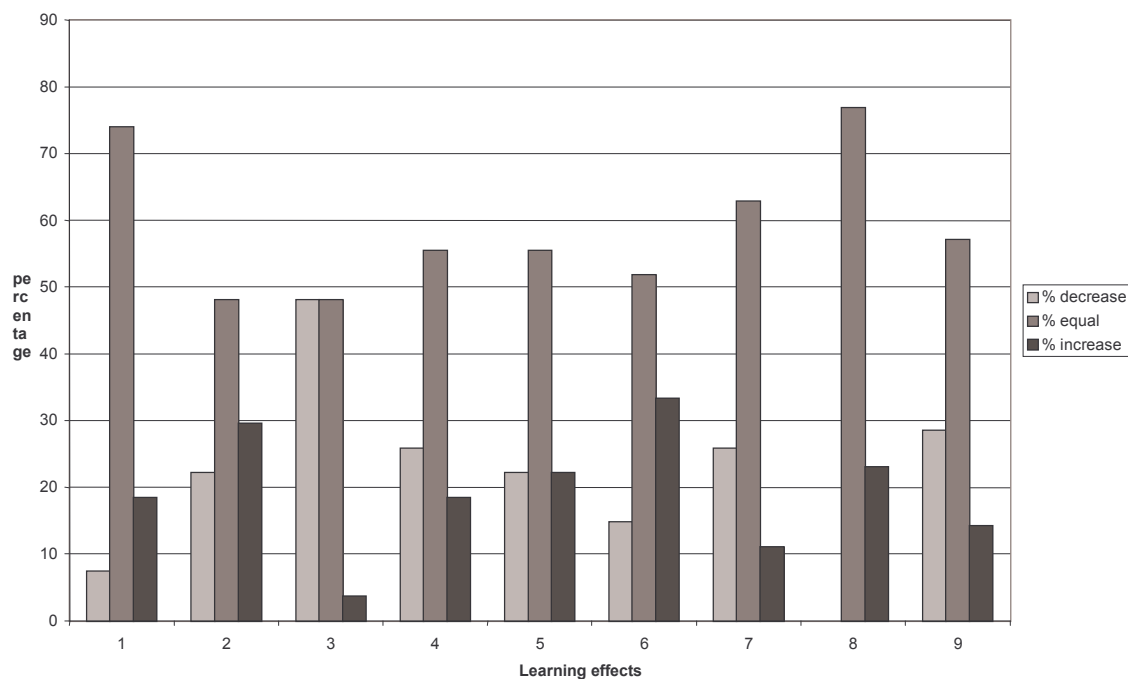

Figure 3. : Reported changes in competence levels

The light grey strokes (indicated as % decrease) refer to the number of times that a score given by the students at the end of the project is lower than the score given at the beginning, given as a percentage of the total. In a similar way to this the medium grey strokes (indicated as %equal) represent the number of times the students reported their score remained the same and the dark grey strokes (indicated as %increase) count the number of times that the students thought to have improved on that particular item. It would have been expected that those strokes would have dominated the graph; however this appears to be the case for the "equal strokes". Causes are of course the same as reasoned before. It was attempted to adapt this graph, using the data from the interviews. We are aware of the fact that the number of interviewed students was too little to perform real statistical processing, but wanted to have an impression that comes closer to the real situation than the one based on the original answers. From the 18 students only ten had filled out both questionnaire forms. For each item the number of times were counted that those students stated to have given a lower score that had to be equal or higher, and an equal score that had to be higher. These figures were used for the original counts to be recomputed. This resulted in the graph given in figure 4.
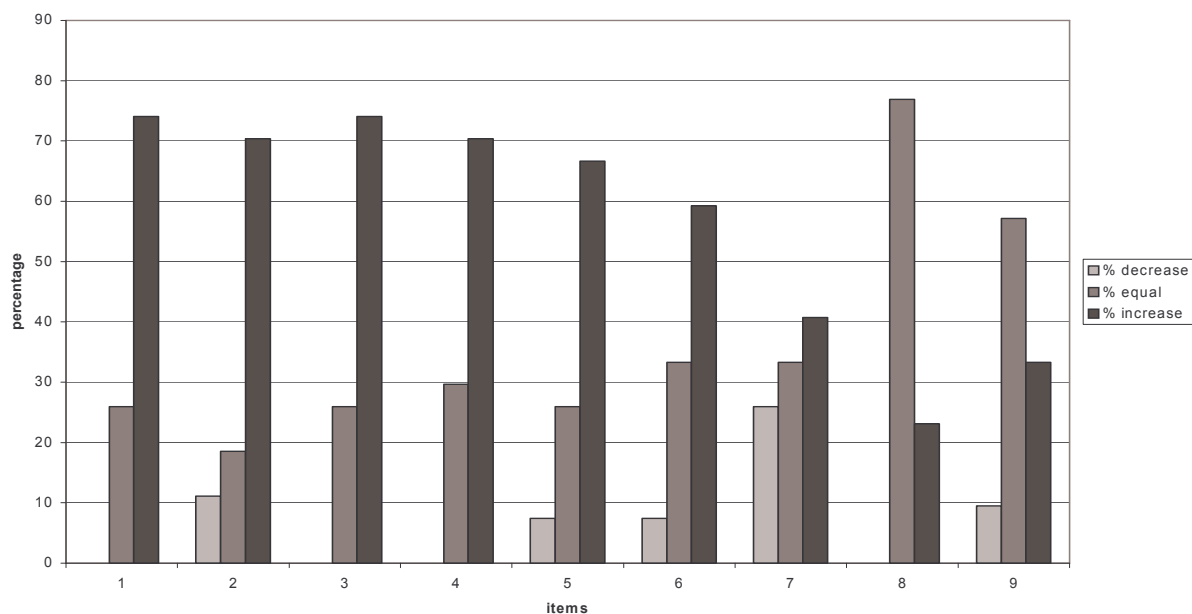

Figure 4. : Compensated changes in competence levels

The grey strokes have the same meaning as in figure 4. Although not so reliable, in this way the figures gave a much more expected view. An exception is formed by the items eight (co-operating with other level students) and nine (co-operating with foreign students), but only very few responding students had to deal with these items.

During the interviews the students were also asked to indicate what, in their view, the most important learning effects from the IPD projects were and from what aspects they actually had learned the most. The items that were named as most important include the following:

- communication (in general, as well as with companies)

- working together (in general, as well as multidisciplinary)

- responsibilities

The students learned the most from co-operating both in general, as well as in multidisciplinary projects.

Finally they were asked how learning effects of IPD could be improved. Besides a number of diverse and unrealistic answers, the most useful recommendations were:

- take care of a good match of required disciplines and participating students

- provide more and better facilities, specially to improve working together like more meeting rooms, better tuned schedules and better electronic facilities

- promote regular contacts between the company involved and the tutor or student group

Those recommendations will be taken into account in future projects.

4.3   Third research phase

This has only been a small preliminary investigation. At the end of the third semester the students were asked to complete a form on which the first eight learning effects from table two were stated. (Effect nine was not applicable this semester, as there were no foreign students involved.) Now they were instructed to only note a possible increase in competencies for the particular learning effects. As the number of responding students was only twelve no solid conclusions can be drawn from their answers. However a clear increase was indicated for the items three (co-operating with companies), five (working innovatively) and seven (communicating in and about the project). The students were also asked to give possible motivations for an increase in competences. The results are summarized in table 3.

1	Co-operating in general - right number of group members - to be complementary to each other
2	Co-operating in multidisciplinary teams - good tuning of schedules
3	Co-operating with companies - co-operative attitude of company - good reach ability of employees
4	Working according to plan - clear assignment - possibilities of own project contribution
5	Working innovatively - assignments concerning new products
6	Thinking in solutions - influence of other disciplines - presence of many problems
7	Communicating in and about the project - agreeing to communication protocol at the start - availability of modern communication means
8	Co-operating with other level students – N.A.
9	Co-operating with foreign students – N.A.

TABLE 3. Possible contributing factors to learning effects

5   Conclusion

We wanted to discover actual learning effects of IPD projects and which factors have positive influence on these learning effects. As an answer to the first part of this question we found the eight learning effects as given in table 1. Especially we wondered whether these effects would be similar to the competencies as defined for the IPD projects. Four competencies; *co-operating in multidisciplinary teams, co-operating with companies, co-operating in general and planning* were items both defined for our projects as well as mentioned regularly by the students. Also the students recognized other predefined learning effects as mentioned later in chapter four. This appeared from the answers in their questionnaires and the answers given in the interviews. For the second part of our question, what is of influence to the learning effects, a preliminary answer can be given. A number of factors, summarized from the latest questionnaires, are given in table 3. However these results have to be validated by more measurements. Complementary we wondered whether there are any changes visible by making the projects multilevel and multidisciplinary. It showed that in multilevel projects the items *co-operating in multidisciplinary teams, co-operating with other level students and co-operating with foreign students* increased more in competence level than in projects of one level (only Fontys students), however *thinking in solutions* showed a decrease. The response from the reference group was too little to be able to make a reliable comparison with our multidisciplinary projects and mono disciplinary projects.

6   Further research

Further research is needed on the factors that contribute to the learning aspects of IPD projects. The preliminary results can be used to design questionnaires in which the students can easily recognize such factors. Furthermore we would like to define a matrix of learning effects on the one hand and factors on the other hand, from which we can make some numerical computation of the influence of certain factors on the different learning effects. Still it is needed to find better ways of inquiry in order to get the students' actual level of competence and ways to show them that their competences really did improve. In order to find out more about the way students improve their competencies in IPD projects we will focus more on this aspect in interviews, e.g. ask students to draw story lines as suggested in [TAC-04]. In the future, when the projects will be assessed more strictly on the derived competencies, it will be able to get more feedback on this from the tutors. It might also be possible to determine on what aspects students learn the most and what are the reasons for that. Also more effort will be put in finding representative reference groups in order to find out what learning effects are unique for IPD projects and what learning effects appear in any project.

In the investigation, we used the help of numerous people, also of external consultants from the national Centre for the Innovation of Education and Training in the Netherlands (CINOP). CINOP is a consultancy organisation and expertise centre in the sectors General and Further Education, Vocational Education and Training, business management training and capacity building. In our case CINOP coaches the tutors in coaching the students, and works with us to improve instruments and procedures of coaching and assessing in the IPD and KHS projects. We like to thank Marlieke Ketelaars, one of the CINOP employees who worked together with is in the first two phases of the research. Also in the first phase we had the valuable support of Johan van der Sanden who died unexpectedly before the research could be completed. We deeply regret this. We are very grateful for the many and enthusiastic advices, based on his extensive experience, he gave us during the short period we worked together.

References

[BAK-04]   Bakker, R., van Kollenburg, P.A.M., 2004, *Competences of an engineer*, 5th Integrated Product Development Workshop IPD 2004, Schönebeck/Bad Salzelmen B. Magdeburg

[KOL-98]   Kollenburg, P. A. M. van, Punt, G., 1998. *Education in Concurrent Engineering is a Must,* 2nd International Symposium on Tools and Methods for Concurrent Engineering, Manchester.

[SCH-01]   Schenk Brill, D. van & Boots, P.J.H.M., 2001, *Engineering, Experiences with Industrial Co-education,* SEFI Annual Conf. Copenhagen: 103-104.

[SCH-04]   Schenk Brill, D. van & Kater, K., *New developments in Fontys IPD projects*, 5th Integrated Product Development Workshop IPD 2004, Schönebeck/Bad Salzelmen B. Magdeburg.

[SCH-06]   Schenk Brill, D. van & Kater, K., *Learning effects of Fontys product development projects*, SEFI Annual Conf. Uppsala, June-July 2006

[TAC-01]   Taconis, R., Plas, P. van der & Sanden, J. van der, *The development of professional competencies by educational assistant in school-based teacher education*, European Journal of Teacher Education, Vol 27, Nr 2, June 2004, 215-240

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