

Integrated assessment of disciplinary, personal and interpersonal skills - student perceptions of a novel learning experience

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Abstract

Integrated assessment of functional disciplinary knowledge and personal and interpersonal competence is discussed in the context of a final-year project course in a Masters programme in engineering. We state the rationale behind the course design and describe in detail the assessment system, where peer assessment and feedback are key elements. We then report from an investigation into students' perceptions of the learning experience in this course. Drawing on qualitative data from several cohorts of students, we interpret and discuss how students perceive the learning experience. We focus on some troublesome aspects related to the significant difference between the learning experiences in this course and in their previous courses. We illustrate with quotes how students' attitudes towards knowledge are challenged in several ways.

1. Introduction

As background, we present the general design and some of the thoughts behind a project-based final-year course in a mechanical engineering programme.

1.1 Description of the design-build course and the ideas behind it

The aim of the course is to provide an opportunity for students to practice in an authentic design-build project situation. Students spend a quarter of their time on the course during their last academic year in the vehicle engineering Masters programme. Groups of 10-15 students design, manufacture and test a technical system, typically an unorthodox vehicle, e.g. a solar powered aircraft. The task calls for students applying several previously studied subjects. It is large and complex enough to constitute a true challenge and necessitate efficient management of available resources in terms of knowledge, manpower and economy. The teachers avoid providing technical solutions since such are expected to come from the students. There are also multiple possible solutions to the problems they encounter implying that they find themselves in situations where they have to make decisions guided but not determined by their calculations. The project task is, both literally and figuratively, a vehicle to reach the learning objectives of the course. The intended learning outcomes of the course are presented to the students in the following way:

After completing the course the students should be able to

- work effectively in a project environment and understand mechanisms behind progress and difficulties in such a setting
- communicate in writing, orally and graphically
- analyse problems from a systems (holistic) perspective
- choose and use adequate engineering methods and tools
- handle technical problems which might be incompletely stated and subject to multiple constraints
- pursue own ideas and realise them practically

- assess the quality of work, performed by themselves and others

The intent with the course is obviously to stimulate and enhance higher-order learning (*creative, developmental*) rather than lower-order learning (*reproductive, adaptive*) (Ellström, 2001).

1.2 Experiential learning

The intended learning outcomes of the course could not be reached without creating the experiences. There are only a few principles, trade-offs and wisdoms that could be taught and learned as theoretical content, but at most to a reproductive level. And when it comes to teaching such principles, students quickly lose interest since they find it trivial and obvious. Learning is most powerful when students themselves can reflect on their own experiences. As one student reflects:

- You knew theories before, empty phrases. But now I have seen them in reality. These things are so easy to say. Like 'it doesn't matter how well you plan unless you follow it up'. I mean, you don't have to be a rocket scientist to realise that, everyone knows it. But it's one thing to know and another thing to apply, and we really got first-hand experience from applying it. It is so obvious, you can stop anyone on the street and they would say 'of course, everyone knows that'. But it is a completely different thing to experience it in reality. (2005)

We suggest that the nature of the intended learning outcomes calls for experiential learning. We allow the students to make their own experiences. We facilitate reflection on different activities in order to amplify students' interpretation and learning from what they have experienced. A consequence is that one cannot tell in advance exactly what the students will learn. We must accept that the learning outcomes vary since students will experience different situations and challenges and work on different things in their projects.

1.3 Integrated learning

Our assumption is that personal and interpersonal skills, and disciplinary knowledge, are interdependent and therefore should be learned together. We question the perception of for instance teamwork and communication as generic and transferable, which would imply that they can be learned and assessed separately and then applied regardless of the context. In our experience there is little foundation for that assumption, and furthermore, the intended learning outcomes in this course are qualitatively different from any generic aspects of those skills. *The teamwork and communication skills in this course are so strongly interwoven with the students' application of technical knowledge, that the two are inseparable.*

Take communication skills as an example. Here students should learn to communicate in ways that enable engineering. This means that they should learn to communicate technically with experts and laypersons, and grow confidence in expressing themselves within their field. They should learn to describe and present ideas and argue impartially for or against conceptual ideas and solutions. They should, by a computer or whiteboard, be able to develop ideas through collaborative sketching and engineering reasoning. In short they should develop the communication skills of engineers and start feeling natural about it. What must then be practised and assessed is authentic performance. Learning communication skills in theory is simply not appropriate if one aims at becoming a good practitioner. The same argument applies to the

learning outcomes regarding teamwork skills, project management and even to a certain extent to some technical learning outcomes.

1.4 Integrated learning - integrated assessment

Assessment is the most powerful tool we have to guide and support student learning. It is the assessment system rather than the espoused learning objectives that constitutes the real learning objectives to the students. At least to the students "*it is not the curriculum that shapes assessment, but assessment that shapes the curriculum*" (Brown & Knight, 1994). This means that the personal and interpersonal skills in the learning objectives must be given proper attention in the assessment system, as being legitimate and required learning outcomes of the course. As discussed above, the students are expected to develop contextualised skills. In order to fully communicate this intention to the students these skills must also be assessed in context. Our conclusion is that integrated learning calls for integrated assessment.

1.5 Development of the assessment method

Obviously, traditional assessment methods would not be appropriate here, as illustrated by the following circumstances

- the major part of the work is performed when the teachers are not present
- the course content varies from one year to another
- different students learn different things

Teachers are close to the students during seminars, meetings, presentations, tutoring, and project reports, and working documents are continuously read by the teachers. Still, the teachers can only see what the students are exposing to them. A student who is relatively quiet at meetings could be an exceptional team member in the everyday work. Therefore, it was natural to invite the students into the grading process. In the following the present assessment format and its implementation are discussed. The design of the assessment system has proven to be a very delicate matter. It was found that the students' perception of the assessment system depends less on how it is actually designed, but more on *how it is presented to them*. A lot of the exercises rely on the students' trust and confidence. If they feel that the teachers are sincere and considerate in their efforts to make the most of their learning experience and that they are willing to listen to critique and are serious about the quality of the assessment process, students are generally happy to both take part and contribute with suggestions of improvements.

2. The assessment system

2.1 Introducing the system

At the beginning of the course the students are introduced to the course objectives. They are instructed to gather a portfolio of evidence of all their efforts in the project, such as analysis, practical work, social engagement and administrative responsibilities. They are also asked to formulate their own personal goals with the course, in addition to the course objectives, along with which grade they are aiming for.

2.2 The first experience (mid-course)

At the middle of the course the students are exposed to the peer assessment for the first time but only as a tryout. The scheme is described chronologically in the following:

1. Each student writes a brief narrative about own work to date, with references to relevant outcomes. The narratives are distributed to all students in the group, who also have access to all referred material.
2. Each student writes feedback to all colleagues in the group and proposes a grade for each student based on the receiver's narrative and performance to date. The feedback is delivered to the receiver (via the teachers who check for rude or inconsiderate contents). The suggested grades are also forwarded to the receivers but only as averages from the group.
3. Each student writes a short reflective memo about the course, learning in relation to common and personal goals, performance and the received feedback.
4. Each student revisits own personal goals and revises them if needed.
5. The poll is discussed in a reflective group exercise chaired by the teachers.

The idea with the poll is to give the students an opportunity to test the peer assessment system and get formative feedback on how their efforts to date are received and valued by their peers. The suggested grades do not affect their final grades, but serve as an indication to the student.

2.3 The real launch (end-course)

Towards the end of the course the peer assessment system is launched for real. The scheme above is repeated but step 4 is excluded and a group discussion is conducted between steps 2 and 3 where the performance of each student is scrutinised. The discussion is chaired and moderated by the teachers and allows each student to comment on or explain her/his narrative. Then the student leaves the room for a short period while the teachers ask the remaining group to briefly comment on the case made by the absent student.

2.4 Final grading

Each student's final grade is eventually set by the teacher through a holistic judgement, taking into account

- the presented evidence (reports, hardware, etc) of the students achievements
- the feedback written by the student to others
- the feedback addressed to the student
- the student's reflection

While peer grading is a part of the assessment process, the final grades are set by the teachers. The presented evidence of student efforts is evaluated together with other collected data of the student's performance during the course and assessed with respect to the learning objectives in the course. The evaluation is performed independently by the teachers, before they meet and compare their opinions on the final grade of the student. The teachers' grades, and also the grades suggested by the peer students, are generally in agreement. In the cases of discrepancies between the teachers opinions a discussion and/or a second round of penetration of the portfolios settle the case.

3. Investigating student perceptions of the learning experience

3.1 Investigation

A great majority of the students reach the learning outcomes to an extensive degree, and most students praise the course lavishly. However, students' perception of this course is affected by their previous learning experiences (Prosser & Trigwell 1999). This course is different from students' previous experiences in their educational programme and we must appreciate the trouble the students may have with this novel experience. Course design must be informed by the full complexity of the student learning experience, and therefore a deeper investigation was made into the students' perceptions of the course.

Eight in-depth interviews were carried out (by Edström), three in 2004, and five in 2005. The interviews lasted 40-60 minutes and were recorded and transcribed. The investigation was also informed by the written reflective memos (mid-course and final), mentioned above.

While the students in general were extremely positive and showed remarkable insight and reflection, some aspects were identified as troublesome. We think of 'troublesome' either in the sense that the students themselves experience something as troublesome, or something we find troublesome from being at odds with our intentions. In the following we discuss the troublesome aspects, and illustrate them with quotes from the interviews.

3.2 The distinction between project task goals and learning objectives

While the *project task* is what drives *learning*, there can also be tension between the two. Sometimes it seems difficult for students to understand the distinction between reaching the task goals (building a product that flies or floats as required) and reaching the intended learning outcomes. Even for the students who recognise that there *is* a distinction, there is a limit to how deeply they understand the *implications* of it. In concrete situations they will mostly give precedence to the project task itself, often without even noticing that their preference is in conflict with learning. In the following we will show four examples where we think there is a learning/task conflict.

3.2.1 Example 1

The first example is intended to illustrate what we mean by a learning/task conflict. Rotating the project leadership is encouraged, in order to allow more students to try and learn from a project management experience. In 2005 the two teams decided to keep their respective project leaders for the entire project. One student gives no consideration to learning when mentioning this:

- We had the opportunity to switch to a new project leader after Christmas, but [...] We wanted the project to run as smoothly as possible.

Another student shows some understanding for the learning/task tension:

- [Changing the project leader] wouldn't have furthered the project. It could only have suffered. But if you completely drop [considerations for] the product - and maybe you should, actually - it might have furthered the course. It's hard to tell...you simply tend to put your focus on the product you are making.

In order to emphasize learning in coming years, rotation of project roles may be presented to the students as being standard procedure, not just an option.

3.2.2 Example 2

The students describe the feedback process as an effective learning activity. However, an obvious problem is that some students deliberately hold back on negative feedback in order to save the

group from dissonance, especially in the mid-course feedback exercise when they still have to work together for another semester.

- *Even if it may be wrong, it's easy to just give [the kind of feedback that is like] a pat on the shoulder, in order to keep the driving force in the group, the ambition.*
- You use the feedback to unite the group even more?
- *Yes, actually. And it may even work. (2005)*
- *In the [mid-course feedback exercise], I sat down and thought the matter over: should I be honest or should I favour the project? I favoured the project, because you can't... take [feedback] without it getting personal. (2004)*

Here, the conflict between learning objectives and project goals is obvious. As the feedback learning activity may threaten the project, it is in practice disarmed and the project task is given priority. This conflict is a difficult issue to resolve. One could force the students to prioritise the learning objectives harder, but that would also reduce their recognition of the project task and jeopardise a lot of the student motivation and effort triggered by their ambition so solve the task. One could also argue that their way of handling the issue is true, and ask why things should be made different in an educational exercise than in real life. The obvious reason is that the educational exercise is designed to prepare students for real situations, not to substitute them.

3.2.3 Example 3

This is a conversation where a student makes a suggestion on how to improve the course. When prodded by the interviewer, it turns out that the student's consideration was for the project task rather than for the learning outcomes.

- *In the beginning I think there should have been some technical seminars to give a faster start of the project. Technical specialists could have given a few lectures.*
- To help you see possible designs for instance?
- *Yes, technical solutions. And whom we could have contacted later with questions.*
- I wonder if you may risk [a learning outcome of the course]?
- *Yes, that is a risk. If they say 'this is what you should do' ... Yes, you are right.*
- But I can see that it's painful.
- *Yes, but maybe that is also what's good for you.*
- Though you think it would have been better with a more efficient start.
- *Yes, but that is perhaps because it had led to a better end result, I mean the boat. But maybe the learning wouldn't... (2005)*

We conclude that students may evaluate things biased by their focus on the result of the project task, and perhaps also their wish for a painless and enjoyable process. This means that students may not appreciate the relevance and worth of aspects of the course that are designed to promote learning.

3.2.4 Example 4

This example concerns the allurements of the course and students' motivation. Perhaps the reason why students focus on the project task is that the learning outcomes are simply not perceived to be as attractive as the design-build adventure itself:

- The focus of the majority is on the [vehicle]. A concrete technical goal, and you learn things around that, as positive side effects. A lot of us have said that for instance the feedback exercise was interesting. But if you promote a course saying that you will learn about communication and things, it will not attract as many students as if you say we will build a [vehicle] that will be extremely cool and receive a lot of attention. (2004)

The course succeeds in attracting and motivating students to take part in a demanding learning experience. Even if it was not the learning itself that attracted them, they are pleased with the outcome in the end. We are probably making unreasonable demands if we expect them to keep the learning aspect in the foreground on behalf of the project task itself. However, there are also examples where the students have showed dedication to the course goals and sacrificed some of the momentum in the project work from respect to specific course goals.

The conclusion regarding the conflicts between the project task and the learning objectives is not that the students need to be completely enlightened, and always forced to prioritise learning. It is important, though, that the teachers always consider, and occasionally help the students to recognise, the learning aspects of the course, especially when they risk to be in conflict with the project task goals.

3.3 Students' attitudes towards knowledge are challenged

It is the intent of the course to allow students to develop a more mature attitude towards knowledge (Perry 1999). The here anticipated view on knowledge could best be described as relativist: *Knowledge and values, including those of authorities, are contextual and relativistic.* This means that many students' attitudes towards knowledge are challenged in several ways. When the experiences of this course are seen through a dualist view on knowledge, they may be perceived as disappointing.

3.3.1 The right answer

Students often expose a right-or-wrong view on technical knowledge. In their previous courses there were always the right answers, a key in the back of the book, or the teacher verifying the quality of the solution. Students are accustomed to this feedback, and for many of them the verification is the culmination of the learning process.

There are two things to observe here. First of all, the teachers want the students to assume a more independent role and rely less on the teachers. It is, admittedly, hard to draw the line between a legitimate need for feedback and over-dependence of authority, and there is large variation between individuals. Secondly, in this course it is rarely possible to find *the* best solution. The objective is rather to come to one or a few feasible solutions and, in the latter case, pick the most promising one. The dualist (right-or-wrong) view on knowledge is very much challenged here. A more relativistic view on technology and engineering is necessary when creating a solution to a not previously solved problem.

The student in the following example feels let down because of lack of right answers from the teachers. It is interpreted merely as a way to make students work more, or work more independently. The student does not seem to realise that there is (also) another reason for the teachers' odd behaviour – there might not be any clear-cut right answers to give.

- They should have been more like teachers. We had to do all the hard work ourselves and we don't feel that we got as much help from the teachers as we could have had. [...] When

we went and asked them 'does this look alright', they tried to answer as vaguely as they could so you almost didn't know more than before you asked them. Just because they tried to make us solve things ourselves I think. (2005)

Half-way through the course another student expresses severe disappointment over the limitations of the group's calculations, and blames the teachers for not reducing the problem to something perfectly solvable:

- Not that these were the only calculations needed, but the only ones that could be made based on previous knowledge. All the calculations assuming kinematic equilibrium seem to give various degrees of unreasonable results. This is not just a pity and shame, but it is also terribly bad pedagogy now towards the end of an education. I would really have liked to see that some of the theory we have learnt was possible to use. We cannot even calculate the strength since everything is so tiny. (2005, mid-course written reflection)

Towards the end of the course other students reflect differently on the same experience.

- We started out with huge ambitions. We planned to put all these equations into [the software] and get a huge file. Then we would press 'play' and get the answers to all the mysteries in the universe and the meaning of life... [laughter]. But it didn't work... Everything else that we have studied, someone has always solved it before you. The teacher has gone through the problem and concluded that it can be solved. But now, there was no answer, and nobody has done it before you, as far as we knew. I think we learned a lot about limitations and complexity. [...] The apparent difference [to previous courses] is that there is no answer, there is nothing to compare your results against. (2005)

- The greatest thing I have learned from this course is humility. I'll approach similar tasks more humbly in the future. We thought we were better than we were. No, not better, but we have taken courses with well-defined problems, where there is an answer, the key. And that went well. But now you realised that as soon as you are confronted with reality, it's quite another story. (2005)

It is important to notice that no student will ever come to this course and state a personal learning objective such as "I want to develop a more mature view on knowledge". They simply do not miss the view on knowledge that they lack. It is difficult to acquire and appreciate knowledge that doesn't look and feel like one expects it to. A student who anticipates and values "truths" will see the world in black-and-white, looking for "truths", and often dismiss the most valuable learning outcomes. Thus, when they later reflect on whether they have attained their learning objectives, they may need support in recognising and appreciating the development that they have made, without specifically having formulated it as a personal goal.

3.3.2 Making decisions based on limited information

While it is seldom possible to calculate a single correct solution, the technical work still must lead to practical decisions. There comes a time when the calculations must be put aside and a decision be made, informed but not perfectly determined by the calculations. This is obvious in real design processes, but uncommon in educational situations. The situation is likely to be novel and almost traumatic for most students. An extreme case is the student who dismisses the application of technical knowledge altogether, as the calculations did not give the exact answers he expected.

- We could probably accomplish this project without any of our technical courses. We did a lot of calculations in the beginning, but they were very approximate. (2004)

In contrast, another student who reflects differently, on a similar experience:

- That was a bit of an 'aha'-experience. There were just a lot of unknowns and you had to... You couldn't find out... If you changed one thing everything else changed too, they all depended on each other. And I've never experienced that before. And to just decide on a few variables, based on nothing really, just some kind of... [puts a finger up in the air]. That was an interesting experience. (2005)

3.3.3 Recognising and appreciating application and synthesis of knowledge

Many of the students' previous courses focus on known and established relations and methods. This course, with its focus on synthesis, consolidation and application of sometimes quite fundamental technical knowledge differs from the way the students have previously seen knowledge being evaluated, for instance in exams. One student expresses a sophisticated view on the application of prior knowledge:

I think some [of my fellow students] feel that we haven't used much of our previous knowledge. Because it's not like exam tasks, it's not extremely difficult, but you have to think more widely. We are building this thing in parts that have to work together and as I see it that is pretty advanced [engineering]. And it is [application of knowledge from several other courses]. It's like if you learn how to tie knots. Here we use the simpler knots, but we apply them in difficult situations. In the previous courses I had to tie a lot of advanced knots, but I was never asked to use them. (2004)

In the beginning of the course, the students formulate their personal learning goals. Many hope to attain goals related to advanced calculations. We suspect that these goals are formulated using the view on knowledge acquired in previous disciplinary courses, while this course accentuates other types of challenges and knowledge. Even towards the end of the course they sometimes fail to see that their personal objectives were perhaps unrealistic considering the nature of the course, or they do not appreciate the sophistication of application and synthesis:

- My expectations on how much theory I was going to learn were not fulfilled. I can only speculate on the reasons for this. One explanation could be that very few theoretical lectures were given. This is not the whole truth, because I am also responsible to actively seek knowledge on my own. I can't really say why I haven't done that to the extent that I should. (2005, end-course written reflection)

- I had to give in on my goal of deeper knowledge within at least one technical area, in favour of my other goals that have dominated more than I imagined when I formulated them. (2005, end-course written reflection)

We want students to appreciate the value of what they have learned, at least towards the end of the course:

- [My friend] said he didn't learn much technical knowledge. He said 'I didn't learn a thing!' But then when we started discussing, it turned out that there is actually a whole lot that we have learned. (2004)

It was obvious from the remark above that a very essential insight was encountered merely by coincidence in an informal discussion between two students. This was one of the reasons behind the introduction of reflective exercises in the course.

4. Final remarks on the teacher's role

While the students' appreciation of the course is overwhelming, we have already shown in the quotes above that the students do not praise every aspect of the course and the teachers' performance. When students experience problems related to the troublesome aspects, they often indicate that the teachers should have saved them from the inconvenience. In the quotes above there are several examples: "*they should have been more like teachers*", "*there could have been lectures*", "*we had to do all the hard work ourselves*", "*terribly bad pedagogy*". It is clear that the students could interpret the troublesome aspects as failings of the teachers. This reaction is not surprising as the role of the teachers is one of the things that differs most in comparison to previous courses. For the intended learning in this course, it is however not always appropriate for the teacher to act in conformity with the expectations of the students. The teachers will not solve the problems for the students. The teachers will not be able to confirm that the students have found the right answer or the best solution to a problem. The teachers will not intervene when students experience anxiety and confusion in their creative processes. These are not design flaws of the course, but key learning opportunities and though they can sometimes be painful, the teachers have no intention to protect the students from them. Whether we feel the need for student acceptance or not, it is *sometimes* useful to explain our behaviour and motivate it from a learning perspective. This could be done in advance, in order to make the students more receptive, and after certain events as debriefing, in order to stimulate reflection.

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