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CASE INTEGRATED DESIGN SKILLS & KNOWLEDGE

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ABSTRACT
Learning how to create physical products that are either functional, producible, profitable, sustainable and valuable involves both intensive practice and acquire broad knowledge and skills.
Concerning the latter, most industrial design education programmes offer comparable, separate learning courses in sketching, 3D-CAD, production and materials, engineering & construction, ergonomics, business & economics and design.
Most programmes rely on offering design projects into which all mentioned knowledge & skills are supposed to be integrated into well designed products.
In the Industrial Design Engineering (IDE) course of Rotterdam University of Applied Science, we have become aware of a noticeable gap between the learning of fragmented subjects and the application into real-life design projects.
In the programme we have been experimenting with integrating adjacent subjects into integrated assignments, but students somehow lost the previously learned knowledge and skills when asked to apply into real-life projects.
As of academic year, 2018-19 we have chosen to fully integrate all basic design engineering knowledge and skills into a coherent programme of practice-based, yet simplified design cases, in order to increase direct applicability in real life design projects.
Furthermore, integrating several subjects into design cases is expected to deepen a higher-level of conceptual knowledge, enhance motivation, class attendance and pass rates. Working with integrated design cases might diminish competition between several parallel classes and assignments.
In our paper we describe the aims, theoretical foundation and practice of the educational and organisational measures taken. The effects taken are assessed, based on analysis of student, teacher and learning outcomes evaluations.

Keywords: Integrated learning, knowledge and skills, formative strategies, assessment as learning

1 AIMS FOR THE ACADEMIC YEAR 2018-19

For the academic year 2018-19 the Industrial Design Engineering department has developed a new line of courses (referred to as cases) for the knowledge and skills subjects within the curriculum. These cases include all knowledge and skills needed to design a product; sketching, 3D-CAD, production and materials, engineering & construction, ergonomics, business & economics and design. Our primary goal for the new cases was to integrate fragmented knowledge and skills students were taught prior to the academic year 2018-19 and apply these knowledge and skills in a more integrated manner. A deeper and higher-level of conceptual knowledge would be achieved in this new setup of cases and would also increase direct applicability in real life design projects [5]. A case also focuses on more practice-based assignments with just-in-time theory, online (flipped) lessons and feedback that can directly be used and applied by students, as outlined by Merriënboer and Kirschner [3] and Dochy [2].
The structured time schedule students experience during the case week with clear assignments, classes, workshops and feedback from different teachers would also enhance motivation and class attendance. In order to successfully carry out the cases, teachers have to intensively collaborate as a team and calibrate accordingly.
The advisory report on study success by Klatter, Theeuwen, Veen, Visser, and Wassenaar [6] shows that teambuilding, learning communities and integrating different subjects in courses are important

contributing factors to study success. The landscape of the profession for Industrial Design Engineers is changing. The lessons and theory we taught 10 years ago are not all that relevant anymore, and students today demand a different approach to get them to learn successfully and therefore innovation and change is important in education. In the past the Industrial Design Engineering department saw big differences in pass rates, attendance and motivation for courses that were complex in theory; like construction theory, maths etc. and courses that were practice based like 3D CAD, modelling and sketching. The 'hard to learn' courses were often experienced by students as having the highest priority, while the 'nice to do' courses took the second place. Also, these courses all had their separate assignments and subjects that were not interrelated. By combining and integrating the different courses into one knowledge and skills course line (cases), it diminishes competition between several parallel courses.

2 THEORETICAL FOUNDATION OF THE CASES

For several years the department of Industrial Design Engineering focused on assessment as learning according to Dochy's theory [2]. First it was integrated into the project courses, with a clear time schedule during the week with several organised moments of feedback by different teachers. By intensively guiding students and providing them with the right feedback at the right time, students guide themselves towards the end assessment. Teachers followed the whole learning process of the students, so the end assessment is not a moment of truth. The end assessment is a summary of all the students results and progressions they made during the course.

The assessment as learning theory has been fully integrated within the knowledge and skills class line for the academic year 2018-19. By scheduling teachers just in time students follow lessons and workshops that are applied directly. Students feel the urgency to apply the information they are getting during the week and also need the feedback from teachers to successfully complete their assignment.

The direct application of knowledge and skills in a meaningful assignment also enhances student's intrinsic motivation, autonomy and freedom of choice as mentioned by Ryan and Deci [1].

Within the development of the new course line (cases) for the academic year 2018-19 the structure and build up was used as shown in figure 1. The first semester consists of basic isolated and plain assignments and build up in complexity in the second semester. The third semester (second year) is stressing the integration and application of the different subjects and the fourth semester is about combining the previously learned information in a more contextualised and authentic assignment. This model give teachers a tool and insight in how to design the new case setup and develop the new course line.

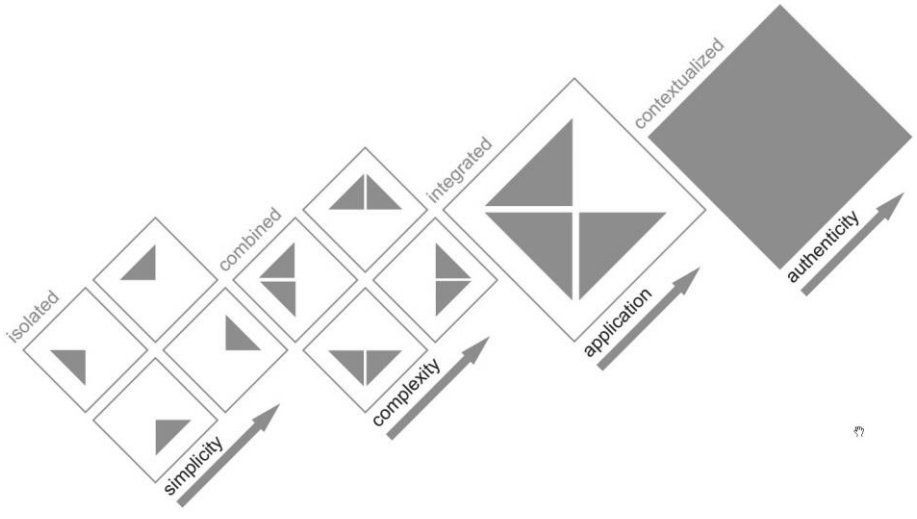

Figure 1. Design Skills Transfer model 2018 (Bekker, Hulst, 2018)

3 PRACTICE OF THE EDUCATIONAL AND ORGANISATIONAL MEASURES

The redesign and development of the new course line of knowledge and skills 2018-19 was done by a team of 10 teachers. All teachers taught different types of courses in the prior years with different knowledge and skills. The knowledge and skills for the courses were selected by the whole group of

teachers and then divided into smaller working groups who developed the course for the specific semester. In total 9 new courses had to be developed from the 2018-19 academic year on and are still continuing. The whole process of the development started in April 2018. Due to the short deadline, careful calibration and planning during the whole development process with all the teachers involved was crucial to develop the course with the right aims and goals.
Every course consists of a team of 4-5 teachers who each have their own role and expertise during the course. Expertise in the specific criteria of the course in not always needed for the teacher in order to take part in the lessons, workshops and feedback during the course. Teachers therefore also learn from other teachers, just like students do, in order to exchange information and expertise [6]. This broadens the landscape for innovative teaching methods considerably and enhances deep learning.

4 NEWLY DEVELOPED ASSESSMENT STRUCTURE

With the redesign of the course line in 2018-19 the structure and planning of the assessments is divided into weekly formative (not graded) feedback moments and one summative (graded) assessment at the end. In this setup students get feedback during the practice of the course and progress is monitored weekly. This eliminates working for the deadline as students have to build up their assignments weekly as outlined by Dochy [2]. The redesign also focuses on clear assignments with clear examples for students to work to. In this course line students see all the different knowledge and skills of the assignment come together, so they can apply them in a more contextualised and meaningful way as mentioned by Merriënboer [3].
The assessment committee of Industrial Design Engineering collaborate with the course developers. The criteria for the courses are written with a holistic approach, instead of detailing every aspect of the course (case). The details of the course are discussed during weekly formative feedback moments. Students of Industrial Design and Engineering tend to focus more on the details instead of the whole assignment and students see the list of criteria as a guided list of 'things to do' instead of focussing on the assignment itself. Also checking this list of detailed criteria by teachers takes a lot of time and calibration and focuses less on the learning progress of the student itself.
In earlier first semester courses within the academic year 2018-19 teachers had to calibrate after all the students work had been seen, but direct feedback to the student was not possible due to limited time. Also, the setup for the formative assessment of the courses in the third semester were very elaborate and took a lot of time of both student and teacher, and all had to be repeated in the summative assessment.
The courses that followed focused on assessing within one day by 2 to 4 teachers, as the progress of the student had been monitored weekly through formative feedback moments. This shortens the assessment time considerably and is more satisfying for student and teacher. Also, the aim is more on flexibility and efficiency for both student and teacher.

5 EFFECTS OF THE MEASURES BASED ON ANALYSIS OF EVALUATION

In the academic year 2018-19 courses are evaluated four times a year and are organised by the Educational Committee within the Industrial Design Engineering department. This committee checks the quality and practise of the course taught each semester and involves a group of 15 students who represent their group (class) and year (first year; 4 students, second year; 4 students, third year; 4 students and fourth year; 3 students) and 2 to 4 teachers involved per course. Students had to prepare the evaluation by interviewing their own group of students based on 4 questions phrased by the Educational Committee.

5.1 Summary of evaluation of cases KV110, 120, 130 (1st year)

For the first-year students noticed the feedback of different teachers was not always clear and the same, but the diversity of teachers worked very well according to students.
The criteria for the assignments were not always clear for students, though written very detailed, which students in the 1st year appreciate.
Communication and time table planning were not always clear due to several locations where this information was found and due to the effort of teachers stressing more service and overview for students.
Students also expected more depth in the theory within the assignments, though the knowledge and skills are now divided over the three cases (KV110, 120, 130).

More feedback on assignment end results was expected but due to planning there was not enough time in between the cases to organise this.
Students say they can logically apply the learned knowledge and skills into real-life projects.

5.2 Summary of evaluation of case KVA30 (2nd year)

Students say the case content is very usable and apply them directly, they understand the importance for the profession.
Subjects of cases are diverse with clear assignments and clear planning of the assessments.
Students notice a proper connection with projects and appreciate the workshop sessions on different locations of the University.
Some first year students notice insufficient theoretical depth in learning theory. This is less the case for second year students.
Also, the teachers are often insufficiently calibrated according to the students and communication is not always clear.
Second grade students appreciate the integrated approach significantly higher compared to the classic approach as experienced in the former year.

Table 1. Case overview 2018-19

KV110	KV120	KV130	KVA30
Semester 1 (yr. 1)	Semester 1 (yr. 1)	Semester 1 (yr. 1)	Semester 3 (yr. 2)
5EC	5EC	3EC	15EC
Students participated: 89 Pass rate: 90%	Students participated: 88 Pass rate: 87%	Students participated: 91 Pass rate: 75%	Students participated: 59 Pass rate: 91%

The table above shows the teachers involved for each case and the pass rates. The pass rates are high but cannot be compared to the pass rates of the previous year because of the different setup with the old courses in the academic year 2017-18. It does show there is no significant change; the cases are logically composed according to students and the pass rate of KV130 of 75% shows the 3D CAD skills are causing a lower rate because this is the first case students learn how to work professionally with CAD software. With the KV110, 120 and KVA30 students expected more theoretical depth, but the case setup is based on theory composed and divided over different case assignments fine-tuned to the subject of the case. Students may not experience the depth in theory in each case but do know how to apply them accordingly. This is the major change compared to the previous year, where students acquired a lot of theory, but did not know how to apply them in different assignments.

5.3 Summary of teacher evaluation

At the end of February 2019, the 7 teachers most involved in the development of the cases and were asked 5 questions about the development of the whole course line and their own opinions. The following questions are summarised answers of these 7 teachers involved.
Are you better enabled to monitor the development of the students?
Different teachers make full time monitoring hard to do due to limited time spent with students during the week. Because one to one contact moments with students are scarce, it's hard to follow their development. The connection of different subject's ad relations within the cases are better and the teacher can better anticipate to specific learning questions form students.
Do you see students apply the knowledge and skills into projects?
The application of knowledge and skills cannot yet really be seen in projects because not all teachers are involved in these projects. Teachers that are involved have seen clear results of the knowledge and skills learned in the cases being applied into projects. It is important that teachers who are involved in the projects give intensive feedback to the student's applications of the acquired knowledge and skills.
Do students now learn more useful and usable information that in the old course line?
Teachers notice the cases all have integrated subjects, so students feel it is obviously more useful compared to the old situation, though the assignments themselves are new and more combined versions of the previous year.
Students learn how to better apply knowledge and skills in a meaningful context, but the knowledge and skills themselves are not necessarily more useful. So, students need to learn the missing

information themselves. Some of the depth of knowledge learned in the earlier situation now feels sort of pushed in too much while not necessarily useful for the case. Students forget knowledge if it cannot be not directly applied into an assignment.

Do the cases facilitate more depth in theory?

There is noticeably less depth in theory due to limited time, so students need to learn the missing information themselves. Also, not all teachers have all-round expertise because of different experiences and backgrounds. Also, not all teachers are available full time during the week. Students might get away now with lesser results.

The right learning environment and freedom of choice in assignments and expertise can lead to deeper learning. More depth in knowledge and skills might be useful in the future, as with the current situation it feels that there is much focus on getting the case done with just the right and sufficient information that is needed instead of focussing on the deeper theory behind the assignment.

Do the cases cause better student motivation and attendance?

There is a noticeable higher motivational behaviour in the courses but focus on variation in didactic forms is important to maintain connection with students. The stress in on the distribution of work load for students instead of learning for the deadline.

Second year students are likely to attend more classes, because they are more aware of their professional development compared to first year students. The connection with the real world is important, organising excursions to companies enhances motivation and attendance.

Further notice:

There is a noticeable positive effect on diversity and approach, methods and expertise in the broader range of different teachers, leading to a more dynamic, calibrated working and learning environment.

Though not all teachers can share the same personal knowledge and skills, interchanging teachers during the week is hard to organise. Good calibration and evaluation is therefore necessary. The cases as a whole are the right direction. But students expect deeper knowledge and theory and as a team we should take this into account for the next case development.

6 CONCLUSION

The structured case week with clear assignments, a variety of didactic and pedagogical forms like classes, workshops excursions and formative feedback meetings from different teachers enhances motivation and class attendance compared to the old situation. Because of the different teachers involved, it also creates communication challenges in both first and second-year cases, therefore good calibration and communication is crucial.

Through evaluation sessions with teachers and students it is mentioned that the amount of theory base classes is limited, though students learn more theory and integrated knowledge and skills by directly applying them. Students quickly learn by thinking and doing in a more contextualised assignment, so students will better understand the integration of the different subjects [4].

By intensively monitoring students, formative feedback and applying knowledge and skills in a practical and meaningful context as mentioned earlier by Merriënboer [3] and Dochy [2], a deeper and higher-level of conceptual knowledge can be achieved in this new setup. The application of knowledge and skills into real life projects are visible, but more development time and collaboration with teachers and students are needed to fine tune the case design structure.

7 RECOMMENDATIONS

The cases consist of diverse knowledge and skills subjects, but are sometimes too forced into a case, resulting in a lack of depth and students miss the learning goal of the subject.

The integration and amount of knowledge and skills and theoretical depth needs to be optimised in order to achieve the right balance and learning goals.

The teachers also spend a lot of time and effort in organising the new case setup with different teachers and ‘just in time’ lessons, which makes this setup less flexible at the same time. If students miss a few days, they are already behind schedule. Also, the availability of teachers during the week is limited, especially if a certain expertise is needed. By sharing more overall expertise teachers can participate more easily. Therefore, the next step is to focus on more flexibility and online (flipped) lessons for the academic year 2019-20.

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