

## **PHYSICS AND/OR COMPETENCY ACQUISITION?**

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In Flanders the technological educations were not so long ago sharply focused on knowledge and technical skills. ‘Softer’ competences such as life long learning, the ability to reflect critically, to obtain information and to process this information, to communicate with laymen and experts, teamwork and learning to perform research, etc. are barely or only implicitly included in these educations, although they become more important in the professional field. Consequently, it becomes more and more a necessity to stimulate the development of these ‘soft’ competences for our students during their regular education.

In a two years pilot project we have attempted to stimulate and to evaluate these competences.

Keywords: competences, life long learning, reflecting critically, communicating, teamwork, the jigsaw method, interference, diffraction.

### **1 Preface**

Currently, the higher education policy emphasises more specifically on our students’ creation and development of competences. In Flanders, the profile of the bachelor and master education is determined in terms of competences<sup>1</sup>. This tendency can be situated in the quickly changing technological developments and consequently the changing professional field. Because knowledge fades very fast, the skills of the employee play more and more a significant role in the working field as before. Other aims implicate also a different approach. To stimulate the development of competences with students, we have to create a similar learning environment: a lecturer as an expert and as a coach; the implementation of active learning methods, the assessment of competences, etc.

The goal of our two year pilot project was to teach a number of competences and to evaluate these in the first three semesters of a technological education [1] [2].

Students bachelor in elektromechanics worked on a project during several weeks. In small groups they study 4 terms which are related to the physical working of a CD player. These are “interference”, “the laser”, “electromagnetic waves” and “optica in the CD player”. They have to look up information about these subjects independently. Secondly, in each team experts have to go deeply into one of the subjects. During the experts’ meeting the experts of the different teams exchange their information. These experts have to evaluate each other in terms of knowledge about that specific subject. Afterwards the experts return to their original team where they exchange their information about the four concepts. The following step is creating

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<sup>1</sup> The general competences (not only the specific qualifications) which perform a central role in the different technological educations are: thinking and reasoning, obtaining and processing information, reflecting in a critical manner, handling a problem as a project in a methodological way, life long learning, leadership, structured problem solving, sense for social responsibility, teamwork, research.

a poster and searching an experiment about the physical working of a CD player. Both become the subject of a poster exhibition for an external audience.

First year students master of industrial engineering sciences study during three laboratory sessions in small groups the physical working of a CD player. As a preparation to these lab sessions the students have to look up information independently and have to present it to their colleagues. About the subject itself, the students have to perform a number of experiments.

Both projects are guided by the digital learning platform.

The subject was determined by: “the physics behind a CD player”. The working methods which were used, can be transferred to other field contents. Bachelors and masters are both working on the same subject. The same working methods are partly used in both educations. On the one hand, the bachelor education emphasized on the conceptual physics; on the other hand, the first year of the master education also emphasized on measurements and processing measurements.

In this article we want first to demonstrate how the development of the different competences is stimulated through these working methods. Furthermore we explore the different evaluation methods.

## **2 Competences: working forms and evaluation.**

The used working forms are a combination of activating working forms such as: the jigsaw method, a presentation, a poster, teamwork, a research assignment,...

The evaluation is determined by on the one hand a lecturer-assessment and on the other hand a self-assessment and peer-assessment. In the lecturer-assessment an evaluation of product and process is required in a formative and summative way. The peer- and self-assessment is particularly formative but has a minor influence on this project's end-result.

### *2.1 Teamwork and life long learning*

During the course of this project, the students are required to work in groups. They are obliged to organize meetings and to work together on the divers assignments. At the start of the project they are informed about the fact that how they function in the group, can influence their individual end quotation. The behavior-indicators<sup>2</sup> (table 1 and 2) on which they will be evaluated, are announced in advance. This will be evaluated by two peer- and self-assessments. The first peer- and self-assessment takes place several weeks after the project had started. During this assessment each student is obliged to complete an evaluation-form about himself and his fellow students. This form stipulates how the student has given proof of the behavior which is formulated in the different behavior indicators. The main issue here is that the student is obliged to judge himself and his fellow students independently, to think about the assignment and not to follow the opinions of the other students. Furthermore each member of the team will be evaluated by mutual agreement. A point of improvement is noted for each member of the team. During the whole process of this project every student should emphasize on his/her point of improvement. At the end of the project a second peer- and self-assessment is organized and the student's evolution with regards to this point of improvement, will be evaluated.

Through observing their own possibilities, the competence of *life long learning* is shaped.

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<sup>2</sup> The behavior-indicators determine behaviors which indicate whether or not the student masters a competence.

Furthermore, this peer-assessment is a lecturer's tool to create his opinion about the teamwork. In this way the scores can be differentiated within the group.

Table 1:

Indicators of behavior: teamwork:
<ul style="list-style-type: none"> <li>• The student participates actively in team.</li> <li>• The student follows the agreements and finishes his assignments on time.</li> <li>• The student lets other team members finish when they are talking.</li> <li>• The student reacts actively and constructively about other team members' proposals and ideas.</li> <li>• The student shares all information, necessary to obtain a group result, with his fellow team members.</li> <li>• The student changes his own ideas and proposals when input of fellow members is appropriate and well-considered.</li> <li>• The student accepts the team's conclusions and sticks to the made agreements.</li> </ul>

Table 2:

Indicators of behavior: life long learning:
<ul style="list-style-type: none"> <li>• The student describes a weak point which was stipulated in the 1<sup>st</sup> semester's peer-assessment.</li> <li>• The student invents and formulates activities to improve this weak point during the lab sessions.</li> <li>• The student performs the determined activities with regard to improvement of this weak point.</li> <li>• During the lab sessions, the student reflects on a regular basis about the way he is improving this weak point.</li> </ul>

## 2.2 Reflecting critically

The competence *reflecting critically* is part of the jigsaw-method: this is a particular form of teamwork. The students are taking part in different teams and have to share their own expertise and the expertise of their first group (the basis team) in a second group (team of experts). In a session with the basis team each student has a handwritten sheet with all the information he/she has gathered about his/her specialized topic. We determine this as an expert sheet. During the second meeting (the meeting of experts) the students have to evaluate critically the work of their fellow experts. This peer-assessment takes place according to a form that stipulates the behavior indicators which characterize the implicated competence in this working form. The student is able to indicate how the work of his/her colleagues sums up to the behavior indicators (Table 3). This takes place according to a specific process. The experts' meeting consists of 6 members, originally from 6 different basis teams. Each one of these 6 members has to evaluate independently the work of the 5 others. In a second step a team conclusion is created for each individual student. A positive point as well as a point of improvement is formulated each time.

The lecturer will evaluate the competence *reflecting critically* in a formative way during a group session: the students obtain feedback about their evaluation skills. If necessary the content of the expert sheet can be changed.

Table 3:

Indicators of behavior: reflecting critically
<ul style="list-style-type: none"> <li>• The student understands the text and figures on the expert sheet of his colleague-expert.</li> <li>• The student points out if there is false information on the expert sheet of his colleague-expert.</li> <li>• The student points out if and what information is missing on the expert sheet of his colleague-expert.</li> <li>• The student points out if his colleague-expert used enough information sources for his expert sheet.</li> <li>• The student points out if the used information sources for the expert sheet of his colleague-expert, are appropriate and truthful..</li> <li>• The student adds suggestions to improve the expert sheet of his colleague-expert.</li> </ul>

### 2.3 Gathering information and processing

Another competence that occurs in these projects is *gathering information and processing*. To practice this competence, students have to perform a research assignment. The students have to look up and to synthesize information on the expert sheet, a poster or a presentation. This competence is being exercised but not evaluated.

### 2.4 Communicating with laymen and specialists.

A last competence we want to mention, is *communicating with laymen and specialists*.

During a three hour session, the students have to develop a poster with an overview of their study about the topic. This takes place at the campus to be sure that everybody participates actively and to stimulate negotiations. Colleague-lecturers and students are invited to this exhibition. Furthermore, lecturers of other educational institutes (experts on the topic) are invited. In advance the audience is asked to visit the different teams and to ask questions concerning the poster's content.

The students have to answer the questions of the audience as good as they can. The lecturer visits each group and formulates an opinion about each member's knowledge of the studied topic.

### 2.5 Competences versus knowledge?

We want to point out that we are aware about the fact that by means of this teaching method the transfer of pure knowledge will be smaller than by means of hearing colleges ending with a traditional exam. We are convinced that for a great part only the short term memory is stimulated by a hearing college. Consequently, we were willing to sacrifice a part of pure knowledge to this working form. We are convinced that in our fast changing society it is as important to know how to gather information, to process and to communicate it, than only having the knowledge. Of course it is impossible for our students to have all the knowledge when they start their professional career. Therefore we want to train them in searching, processing and communicating the information they need, in order to be prepared to solve no matter what problem. Also the other competences (life long learning, reflecting critically,...) are of great interest for the professional field, more than pure knowledge.

### 3. Perception of the students

The students were questioned about these working and evaluation forms. In the following you can find a sample of the questionnaire's results. About 80 students had to give their opinion according to a scale: not agree, more likely not agree, more likely agree, agree. Furthermore they had the opportunity to clarify their opinion in open questions.

Proposition:

"Thanks to this way of working, I am more involved and remember more about the topic."

More likely agree to agree: 80%

Proposition:

"Thanks to working in team for this project, I have learned working together with fellow students."

More likely agree to agree: 62%

*Student: "You learn working together because the assignments have to be divided. Each one gets his part and you can ask each other for help or teaching each other new things, new ways to do something in an easier way."*

Proposition:

"By gaining information myself, I remember more about the topic."

More likely agree to agree: 84%

Proposition:

"Exchanging information during the experts' meeting with colleague students who did research about the same subject, was very interesting."

More likely agree to agree: 68%

Proposition:

"I found it easy to correct the expert sheet of other students."

More likely agree to agree: 40%

*Student: "To correct objectively is hard."*

Proposition:

"I was able to answer the audience's questions."

More likely agree to agree: 93%

*Student: "I am very sensitive to stress, but I am convinced that the more possibilities and opportunities I can get to talk before an audience, the better I will be prepared and the less nervous I will be in the future."*

Proposition:

"During the postsession I learned more about the working of a CD player."

More likely agree to agree: 84%

Proposition:

"I think it is good to evaluate one another."

More likely agree to agree: 61%

*Student: "You learn dealing with criticism."*

*Student: "You have to express your opinion within a group."*

Proposition:

“The lecturer’s moment of feedback about the expert sheet and the way to reflect critically was interesting.”

More likely agree to agree: 71%

*Student: “It is important to know what you did well or badly. A lot of lecturers just give you a score and that’s it. Communicating with the lecturer about a specific topic is surely a good idea.”*

Proposition:

“Life long learning: I find it very interesting to work about a point of improvement from the former peer-assessment during this lab session.”

More likely agree to agree: 64%

*Student:” You don’t always know your inferior characteristics, so other students’ feedback is a helpful tool to change yourself (if possible).*

#### **4 Perception of the lecturer**

Although the fact that the student takes his own learning process in hand, this still demands from the lecturer a lot of enthusiasm and effort. This teaching method is nearly tailor made because every student is being followed in his/her total development. Consequently, this way of working is very demanding. The lecturer has to be prepared to embrace these new methods and to be a coach, as well as an expert. Sometimes this needs education. Students’ reactions and questionnaires’ results encourage us to hang on to this working method and to develop it further.

#### **5 Conclusion**

With these working and evaluation forms we want to work towards the needs in our current society which expects in education not only achieving knowledge but also developing competences. The period in which this pilot project took place, was not long enough to conclude about long term learning effects regarding competences.

Enhance, students’ questionnaires learn us that they appreciate these working methods and that the methods which demand an active participation, motivate the student. Reflection and feedback on their learning process is for most students a positive element.

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