

INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Organizing and Managing
Project Based Learning



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Identification and assessment of behavioural competences in multidisciplinary teams within design projects

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Abstract

In the technological area, there is a tendency of higher complexity of products. It is essential to the industry to have professionals capable of creating innovative concepts and ideas. The demand for employees with different disciplinary and cultural backgrounds able to collaborate efficiently in multidisciplinary and multicultural contexts is increasingly higher. Universities and companies aware of this have created programmes to prepare students for this demanding setting. The Danish audio designer and manufacturer Bang & Olufsen created the Conceptual Design and Development of Innovative Products programme where students from seven European universities work in an industrial setting for three **weeks on the company's headquarters in Struer, Denmark. The programme is characterized by an intensive schedule, team-oriented activities, problem-based learning with a multidisciplinary and multicultural approach.** It aims to provide students with a better understanding across different technical backgrounds while, at the same time, develop new products and concepts for the company. Currently, the programme does not provide means to evaluate the **students' competences growth and evolution** and, with this specific purpose a methodology was created and applied in the 2011 edition of the programme. This paper seeks to present the results and conclusions obtained with the evaluation process.

Keywords: competence; multicultural; multidisciplinary; new product development.

1 Introduction

In a globalised world, companies have a great need to improve their products and services to answer the market needs fully and successfully. Creative approaches to problems, out-of-the-box thinking and innovative ideas to satisfy clients are an ever increasing need. Within this global context there is, more than ever, a need for people who are not only hard/technically competent but also equipped with competences and skills that allow them to work with others outside of their technical fields. In the engineering field, research suggests **that there is a 'competency gap' between what the industry requires and the outcome of the students' learning** regarding the ability to work within multicultural and environments and other non-technical competences (Nair, Patil, & Mertova, 2009).

Most education institutions focus their courses structure in fragmented disciplines and, as a consequence, students lack multidisciplinary competences indispensable in faster and more demanding multicultural and multidisciplinary contexts. Engineering graduates lack collaboration competences to work with professionals **from different backgrounds because they don't have an understanding of significant design constraints of other disciplines besides their own** (Larsen, et al., 2009).

This kind of education is obtained not by theoretical learning but by hands-on experimentation with projects and problems to be solved. This kind of learning is called Project-Based Learning or Problem-Based Learning (PBL) which is characterized by a small scale project/problem to be dealt with in a matter of a week of a few weeks in which a report and a prototype are to be delivered at the end of it (Powell, 2004). This approach to education focused on hands-on learning is very important in a global context in great need of engineers who **can successfully "synthesize solutions and not simply (...) analyse problems. It needs the engineers' ability to take a systems view at a range of scales, from devices and products through to the large-scale delivery of infrastructure services"** (UNESCO, 2010).

Awareness to the problematic of the growing need for professionals able to work in multidisciplinary and multicultural environments has risen in the last decade. **The Australian study 'Engineering graduates' perception of how they were prepared for work in industry'** (Martin, Maytham, Case, & Fraser, 2005), the Portuguese report on competences used by computer engineers from Instituto Superior Técnico (Martins, Carvalho, Fernandes, Spinola, Próspero, & Carrilho, 2006) or the Portuguese study on soft skills of higher education graduates through the graduates and employers perspective (Cabral-Cardoso, Estevão, & Silva, 2006) confirm and state that students percept they have not developed their non-technical competences during their formal education with employers, in general, corroborating this notion (Cabral-Cardoso, Estevão,

& Silva, 2006). As a result, many international companies have already taken measures to improve their **employees' competences and skills through programmes and activities either inside the companies or through collaborations with other institutions and/or companies.**

The Danish company Bang & Olufsen (B&O) is a brand that strives to have products with cutting edge design and technology and where creativity and innovation competences are highly demanded within the company. The company is constantly looking for new ideas and concepts created within the company and from outside parties. This need lead the company to invest in activities in local Danish schools, where they raise awareness to the field of engineering, and universities, where they conduct internship programmes and an international summer school in collaboration with several European university-level institutions, the Conceptual Design and Development of Innovative Products (CDDIP) programme. The CDDIP programme is an example of multidisciplinary projects that are increasingly being developed and deployed by numerous institutions. These projects can be of academic nature, industrial nature or even a combination of these two, which is the case for B&O Summer School.

The CDDIP programme has a multicultural and multidisciplinary nature and aims to give an opportunity to students to develop competences while developing new ideas and concepts for products. Within this PBL context, a referential for competences applied and developed is needed. Since the students use project management competences and the presence of project managers has a great impact on the outcome of product development projects (Muller & Turner, 2007), the referential used will be that of project management.

The product development aim of the programme corresponds to a project-based learning environment that forcibly develops the needed competences for these frameworks. However, the CDDIP is not currently assessing the acquisition of these competences by any means which means that there is not any information of the degree of development and attainment of these competences by the students. It is the purpose of this study to analyze and evaluate the process from the point of view of **the students' competences' development** in the context of the CDDIP programme and to evaluate their perception on the impact the programme had on their non-technical competences.

2 Competence

The demand of today's societies on the individuals is such that they need a wide range of competences. To correctly identify these competences, it is required to find first a correct definition for competence or competency. There is a slight difference between these two words. 'Competence' usually refers to functional areas whereas 'competency' refers normally to behavioural areas (Hoffman, 1999) but used infrequently as shown by several authors cited by Deist & Winterton on their paper (2005). Due to this infrequent usage, and **in the sake of a coherent form of presenting the concept, from now on 'competence' will be the term used.**

The concept of competence has several meanings and purposes over the time, reflecting different points of view according to the area it was applied. According to Hoffman (1999), who approached the subject through an industrial point of view, competence had several meanings for psychologists, management theorists, human resource managers, educationists and politicians. Nevertheless, Hoffman describes two models that encompass these different views. Competence is either an observable set of performances previously defined and described in written standards or a descriptive model where competence **is defined by the "underlying attributes of a person" which, in turn, can be defined as the "standard or quality of the outcome of the person's performance"** (Hoffman, 1999). This dichotomy was due to the approaches other authors had when studying the subject, some using an American approach and others a British approach, all in an industrial context.

In the education field, in an international context, the main organization dedicated to the assessment of competences is the Organization for Economic Co-operation and Development's (OECD) **Programme for International Student Assessment (PISA)**. This programme aims to assess the acquirement of knowledge and competences of students near the end of their compulsory education (OECD). Competences, they describe, that are essential for full participation in society both in the domain of **an individual's formal and life educations necessary for being a functional member of the society** (OECD, 2005).

For this purpose, PISA created the Definition and Selection of Key Competencies (DeSeCo) Project which describes competence has involving the ability to draw and mobilise psychosocial resources (behavioural and **technical abilities included) in particular contexts. It resembles Hoffman's definitions where the observable performances defined the competences the individual had.**

In 2005, Deist & Winterton go further than Hoofman went in 1999. They analyze several sources of **competences literature from human resources literature to management strategy literature from the 90's**. They do not attempt to create a definition of competence but reach the same conclusions as Hoffman where he says various definitions are to be found on several literatures depending always on the context and country analysed.

They confirm Hoffman's ideas of observable, defined set of competences and also confirm the three dimensional model that PISA describes: the cognitive (PISA's act autonomously category), functional (PISA's interactive use of tools category) and social (PISA's interact in heterogeneous groups category) competences. They even go a little further by suggesting a holistic model by adding a 'meta-competence' that facilitates the acquisition of the remaining three competences increasing them to four.

All these authors reinstate the concept that competences can be determined, identified and somehow measured but these authors did not define any set of competences. However there is much literature that provides lists of competences always depending on the context of the subject such as the study by Cabral-Cardoso et al. (2006) and project management literature. Since, in the context of the programme, the project management framework is the one used for the evaluation, the International Project Management Association (IPMA) Competence Baseline (ICB) and the Project Manager Competency Development (PMCD) Framework stand out as being critical sources of information. Both are international standards that define and evaluate **"competence required for a project management certificate"** (IPMA, 2006) and ensure a **"rigorous methodology for the development, assessment and recognition of competence in individual project managers"** (Project Management Institute, 2002).

Despite the different contexts in which the ICB and the PMCD and PISA are used, is possible to find a common **framework for the definition of competence. The ICB describes a competence as "a collection of knowledge, personal attitudes, skills and relevant experience needed to be successful in a certain function"** (IPMA, 2006), **a similar definition to the PISA's and PMCD's ones in the fact is that both state that competence is the drawing of resources to face a certain situation.**

As it is possible to ascertain, there is not a definitive, exact and consensual definition for the concept of competence and respective ranges of competences. With that in mind, in the present work, the context is the major influence on how competence can be defined. Since the work was made on a multicultural context, with students from six European countries (Czech Republic, Denmark, The Netherlands, Poland, Portugal and United Kingdom) and having a multicultural aspect that stimulates multidisciplinary work team with every group having members from different technical backgrounds, a new definition of competency has to be made to take into account these factors.

In this context and taking into consideration all of these constraints, competence can be defined as: the ability to draw and mobilise a collection of personal resources (attitudes, skills, experience and knowledge of various kind) and apply them to meet **certain contexts and demands necessary in one's personal and professional life.**

3 Study context

The **'Conceptual Design and Development of Innovative Products' (CDDIP) programme is the main activity of this kind that B&O undertakes joining students from various areas and several European countries.** The CDDIP programme is held since 2008 in an effort to develop professionals with skills to work in multicultural and multidisciplinary contexts through a three week programme. The collaboration was made between seven European institutions, the local high school, Struer Gymnstation, and B&O. The company provides space within its headquarters, materials and guidance from several employees, and the educational institutions provide teachers and a group of students each. On Table 1, the number of students and respective field of expertise are presented.

Each European university was responsible to select five students from their respective **student's body within certain criteria. These were the student's English language skills, technical skills, motivation to participate in a multidisciplinary project and the subject of their degree.** Most of them were on their last year of studies or had one year left to finish from a broad area of expertise in a combination of B.Sc. and M.Sc. students. Besides these various expertises, there were also five students from the final year of the local secondary school, **Struer's Statsgymnasium, with ages between seventeen and eighteen.**

Table 1 - Data on the 2011's edition students

Country	University	Students' Course	Number of students	Nationality
Portugal	University of Minho	Production Engineering	2	Portuguese (5)
		Computer Science	2	
		Electronics Engineering	1	
Czech Republic	VSB – Technical University of Ostrava	Electronics Engineering	3	Czech (5)
		Computer Science	2	
Denmark	Engineering College of Aarhus - IHA	Electronics Engineering	1	Danish (4) Spanish (1)
		Computer Science	2	
		Mechanical Engineering	2	
The Netherlands	Hanze University Groningen	Human Technology	5	Dutch (5)
Czech Republic	Tomás Bata University	Product and Industrial Design	5	Czech (5)
Poland	Cracow University of Technology	Mechanical Engineering	3	Polish (5)
		Production Engineering	2	
United Kingdom	Newcastle University	Computer science	5	British (4) Romanian (1)
Denmark	Struer Statsgymnasium	Science class	5	Danish (5)
Age average		22.59 years old (total)		
		23.43 years old (without high school students)		
Gender		10 female		
		31 male		

Throughout the duration of this programme, teams of students from different origins and technical backgrounds face a challenge, to develop new products for the company inside a framework that mixes academic and industrial contexts. This allows the students to develop their competences and grow their awareness to the need of competences in innovation, creativity and, above all, expertise working in multicultural and multidisciplinary environments (Hansen, 2012).

4 Methodology

According to Martin et al., (2005) **inquiries aren't the best method to evaluate the students' own perception on their competences. This conclusion came out of Martin et al.'s study due to their approach to the subject.** Instead of using the usual method of data treatment of questionnaires, Martin et al. used semi-structured interviews that gave them the opportunity to look into and explore the answers the volunteers gave, an **opportunity that inquiries don't give.**

In the context of the programme, since it's not feasible to interview all 41 students, a compromise had to be made and a combination of both methods, inquiries and interviews, was made. The questionnaires were the **main tool to evaluate the students' development and their own perception of development. They were made** on the first and last day of the programme during which semi-structured interviews were made to some students selected through their results from the first questionnaire.

Regarding the competences subject of evaluation, and since the **competences' framework** to be used is the project manager one, the ICB model of competences was the one used for this purpose. This choice was made taking into account the more detailed nature of the competences identification in compared to the PMCD Framework.

The ICB has 3 ranges of competences (behavioural competences, technical competences and contextual competences), each with several competences of their own in a total of 46. The choice of range of **competences for this study was made according to the project's aim in which was to evaluate** the development of non-technical competences necessary for working in multicultural and multidisciplinary environments which falls under the behavioural competences: leadership; engagement & motivation; self-control; assertiveness; relaxation; openness; creativity; results orientation; efficiency; consultation; negotiation; conflict & crisis; reliability; values appreciation; ethics.

It was considered that all these 15 competences couldn't be used due to several constrains. For each competence, there are 3 questions to be made which leads to each questionnaire having dozens of questions. Since the programme is of intensive nature, this limit the time students have for this study. People assign different meanings to the same competence if they are given just its name. In an effort to avoid **misunderstandings, the questions made to the students use the competences' definition** and not their names but some of these definitions are very similar between themselves. The competence ethics was discarded due

to being a complex subject to study on its own. Several of the others were combined regarding affinity of meaning. For the sake of a clear results presentation and analysis, the competences names are used to identify them on this study.

The final list of competences presented to the students on the questionnaires was the following:

- *Leadership*: -to provide direction and motivate others in their roles/tasks;
- *Engagement & motivation and Results orientation*: -make others believe in the project, follow and focus on key objectives;
- *Self-control*: -to deal with pressure and stress within the team;
- *Assertiveness*: -to ability to communicate points of view clearly, efficiently and persuasively;
- *Relaxation*: -to take adequate actions whenever tension arise in the team;
- *Creativity*: -to generate/manage innovative ideas and different ways of thinking and acting;
- *Efficiency and Reliability*: -to deliver results as they were agreed with minimum use of time and other resources;
- *Openness, Consultation and Values appreciation*: -to listen, respect, understand and make others comfortable enough for them to express their ideas, points of view and opinions;
- *Negotiation and Conflict & crisis*: -to deal with conflicts, to settle disagreements and to mediate different interests within the team.

For each competence, 3 questions were made. The students were asked to evaluate their own competences, **the importance in having these competences, i.e. the importance students' give in having these competences**, and also the importance they think employers give to these competences. This allows for a better comparison between what they think are the employers expectations and the importance they give comparing to how they evaluate themselves.

The Likert scale was used in the questionnaires with a range between 1 and 6 where, on the questions about the importance given to competences 1 was Extremely Unimportant and 6 Extremely important and on the self-evaluation questions, 1 was Very poor and 6 Very good.

The choice for an even number of choices was made to avoid a neutral choice that many students could choose from and, therefore, not reaching satisfactory conclusions.

Of all 41 students who took part on the programme, 36 answered the first questionnaire on the first day of the programme and only 25 answered the final questionnaire over a period of several weeks after the **programme's end**.

5 Findings and Discussion

The result analysis was made by comparing the questionnaires results from the first and last days of the programme, drawing conclusions from these results and confirming their interpretation with the interviews made to some of the students.

During the data analysis, there was a problem with the data collection that stood out. In the following charts where the data collected is presented, the *Efficiency and Reliability* competence is lacking the results from the **final questionnaire The questions for this competence weren't present at the final questionnaire which derailed the data collection**. This lack of data will be dealt with in a later stage.

In Figure 1 **the students' self-evaluation** is presented. Generally, the self-evaluation showed that students' evaluated themselves relatively low by comparison with the questions regarding the importance for them in having these competences and the importance they think employers give to these competences.

All competences decreased in the final questionnaire with the exception of *Creativity* which maintained its score through both questionnaires. These results could be explained **by the programmes' intensive and demanding nature** which the students never experienced before. This environment brought out their difficulties and made them realize they need to improve in all competences in general.

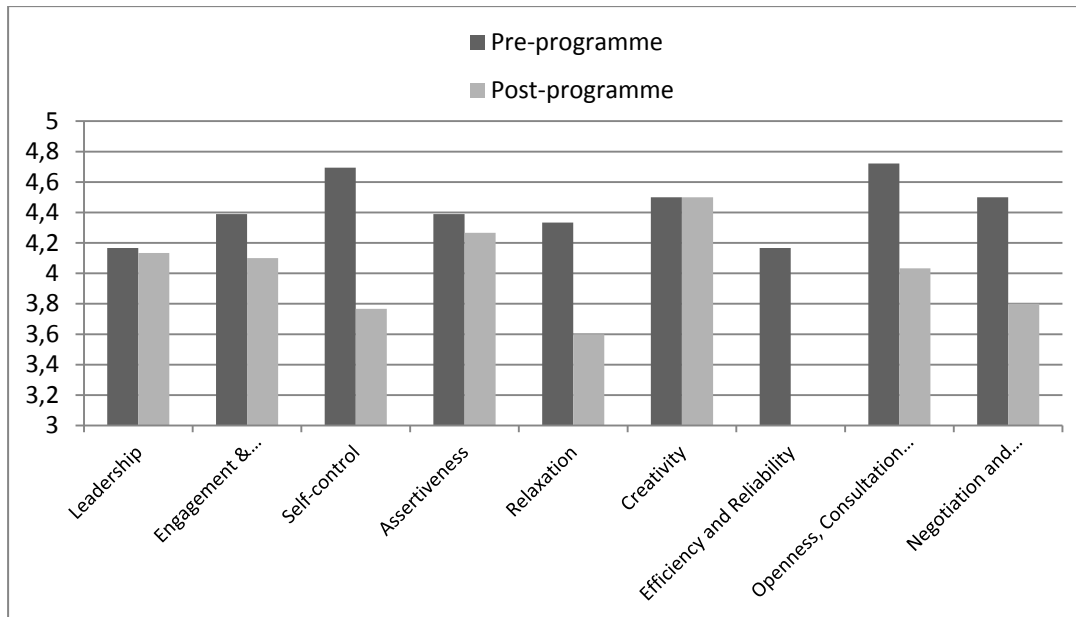


Figure 1 - Students' self-evaluation

This trend doesn't apply to *Creativity* which the students rated with the same score pre and post-programme. It may be the only competence where they haven't changed their opinion and, hence, their first perception is the correct one corroborated by the final questionnaire's results.

These results clash with the ones presented in Figure 2 presented below.

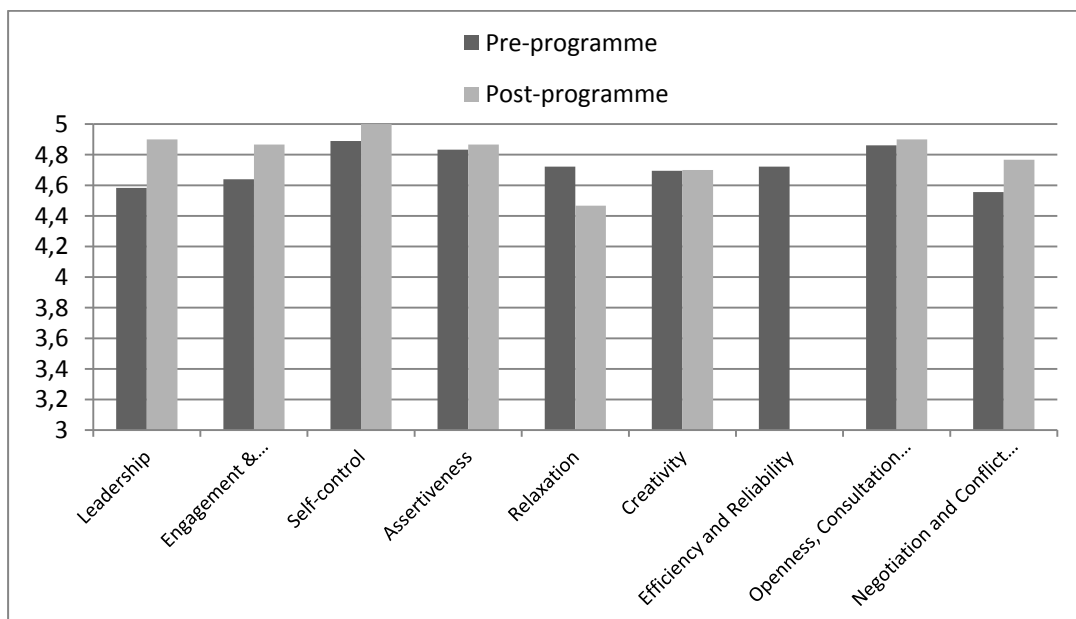


Figure 2 - Students' perception about the importance for students in having these competences

The questions made on their perception about the importance for students in having these competences shows that they think rate themselves low comparing to what they think students should have. This means that, despite their positive perception on their own competences and that having these competences is **important, they think they don't have these competences as developed as they should.**

This conclusion is further enforced after analysing the results of the final questionnaire which shows a rise in the importance students give to these competences. *Relaxation* is the only competence that decreased but still maintains a higher score than the results from the self-evaluation which reinforces this finding.

Nevertheless, *Creativity* continues to not have changes between the first and last questionnaire which, once again, means that their self-evaluation may be a correct one.

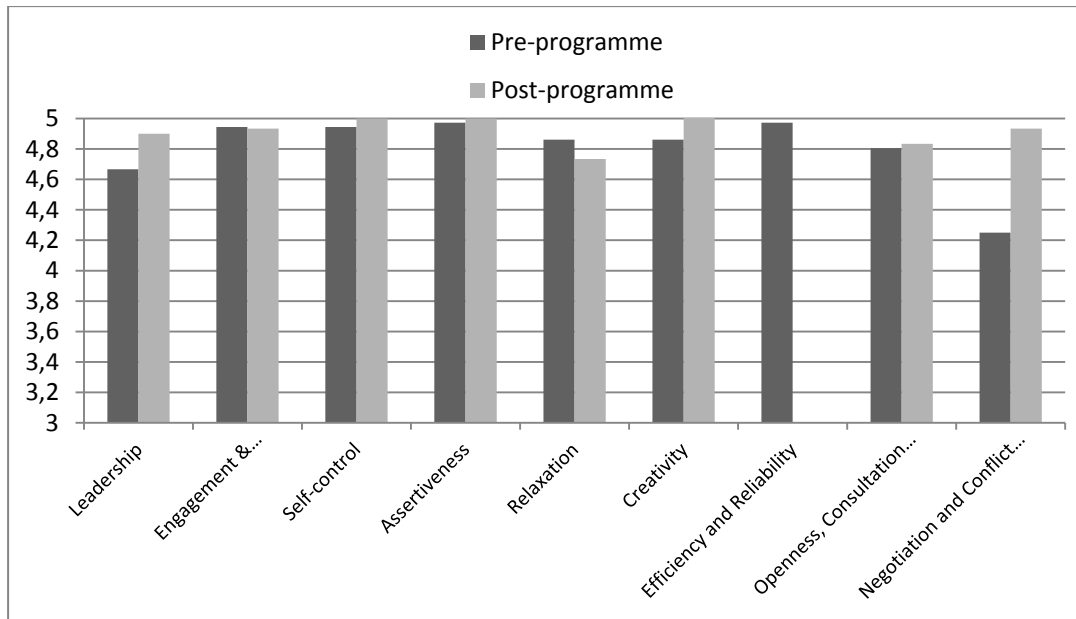


Figure 3 - Students' perception about the importance employers give to competences

In Figure 3, the results are presented for the questions on how the students rate the importance they think employers give to these competences. In general, the results are the highest of the 3 different questions made about the competences with the *Negotiation and Conflict & Crisis* competence being the only case where the importance given is actually lower than their self-evaluation. This means that, on their first questionnaire, the students thought they had this particular competence more developed than what they thought was the employers demand. This was not the case on the final questionnaire where they inverted their answers stating that they were worse prepared than they first thought.

In general, the high results from this question show one trend which is that, despite the importance they give for students in having these competences and despite their positive self-evaluation, they think they are not ready to meet the employers expectations. This conclusion is acknowledged by one of the students, interviewee no. 6, who says that this high score students gave can be explained by the high expectations that they think employers have when hiring.

These findings also contradict interviewee no.1 who has a point of view opposed from the others and, despite valorising the acquisition of **competences, thinks that employers don't give much importance to them.**

In general, all competences maintain their slight rise trend with *Leadership* and *Negotiation and Conflict & Crisis* having the highest rise on the final questionnaire with the exception of the *Relaxation* competence. These changes show that, for the students, employers give more importance to competences related to dealing with others than their employees inner attitudes such as the ones revealed by the *Relaxation* and *Openness, Consultation and Values appreciation* competences.

Comparing these high results with the other questions made, it is obvious the students rated themselves lower than what they think employers expect from them. This may have several explanations which regard the need for different instruments of competence assessment or even a need for future chance on the programme.

6 Conclusion

The conclusions drawn from the results presented on the figures show several obstacles the programme has to face in the future. The results demonstrate that students rate themselves lower than what they think others may expect from them. This may mean that: the programme may be failing to develop the needed **competences for its particular context; the students may think they aren't developing the** needed competences and/or the students may be creating a better and more accurate perception of their **competences development and realising the difficulties they have. If it's the case of the former, the** programme may actually be doing what proposes which is the development of the students competences. By dealing with **the programme's high demands, the students grow aware of the high expectations they face and** realise what they need to improve in the future.

The study presented is of a subjective nature. It **shows the students' self-perception**, with little to no intervention from another party to assess and confirm their perceptions and, because of that, it reinforces the idea that is necessary another point-of-view besides the one of the students. Future work is needed to clarify this matter in the form of evaluation instruments to assess the development of competences within contexts similar to this one.

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