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UNDERSTANDING THE IMPLEMENTATION OF A COMPETENCY-BASED APPROACH IN AN ENGINEERING TRAINING PROGRAMME

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ABSTRACT
Engineering and design courses are often rooted in strong professional practices. Recent graduates often express a gap between the educational content of their degree courses and professional practices. The competency-based approach enables educational professionals to fill this gap. Thus, the question we are asking in this paper is the following: if the competency-based approach is introduced into an engineering school in a structured way, how do the various stakeholders react to and take ownership of this new teaching method? To answer this question, we will use two types of data collected as part of the creation of a 'Bachelor of Science and Technology - Sustainable Design' programme. The first set of data comes from a questionnaire distributed among the stakeholders of an engineering school. The aim of this questionnaire is to assess their understanding of the competency-based approach and the means they are using to implement it. The second set of data was obtained from a recording of a competency-based approach training course for the same stakeholders. This second set of data enables us to understand the reaction of stakeholders to the technical issues involved in implementing the competency-based approach within a training course and an institution. This paper shows how the competency-based approach enables stakeholders of a training programme to improve their pedagogical activities.

Keywords: Competency-based approach, competency, engineering programme

1 INTRODUCTION
Engineering and design courses are often rooted in strong professional practices. Recent graduates often express a gap between the educational content of their degree courses and professional practices. This gap can reduce the ability of future engineers and designers to be operational or at least to feel at ease in the professional environment. In recent years, the competency-based approach has been launched in France, and engineering schools are linking their training programmes to job descriptions to bridge the gap between education and working life. However, this competency-based approach is encountering several obstacles to its implementation, notably a fear of change on the part of teachers and Engineering school stakeholders [1]. The aim of this article is to gain a better understanding of how the clear structuring of a methodology for the implementation of the competency-based approach enables the players involved to take ownership of it and become ambassadors for it.
The term competency (in the competency-based approach or CBA) is understood as "complex know-how based on the effective mobilisation and combination of a variety of internal and external resources within a family of situations" [2]. Until now, most approaches have focused on objectives, assessed by marks. The competency-based approach assesses competencies, no longer in the form of marks, but by level of acquisition of a competency. The aim is to come back to the same competency several times, with each teaching unit complementing the other as part of a learning path [3]. The question we are asking is the following: **if the competency-based approach is introduced into an engineering school in a structured way, how do the various stakeholders react to and take ownership of this new teaching method?**
To answer this question, we will use two types of data collected as part of the creation of a 'Bachelor of Science and Technology - Sustainable Design' programme. The first set of data comes from a questionnaire distributed among stakeholders of an engineering school who agreed to train themselves to the CBA, through a dedicated training programme. The aim of this questionnaire is to assess their

understanding of the CBA and the means they are using to implement it. The second set of data was obtained from a recording of a CBA training course for the same stakeholders. This second set of data enables us to understand the reaction of stakeholders to the technical issues involved in implementing the CBA during the training course. The results show that non-teaching staff help to speed up the implementation of this teaching method because they pass it on to staff from outside the engineering school (e.g. temporary staff) and to students. The results for the teaching staff are more complex to analyse, as various diversionary strategies are used to avoid having to modify existing practices. On the other hand, when it comes to the creation of new courses, the competency-based approach is encountering fewer obstacles by those involved. It is important to mention that our article is a descriptive study. It has to be reinforced by further research and offers avenues to explore.

2 METHOD

The final goal of the study is to improve the implementation of the CBA in educational setting, here engineering higher education ecosystems. Thus, our approach is close to action research, as we intervened in the system we are analysing. We followed a mixed-methods approach, as we collected both quantitative (questionnaire) and qualitative (questionnaire and notes from training sessions) data, in a concurrent way [4].

2.1 Questionnaire

The questionnaire on the CBA was sent to all individuals involved in setting up the Bachelor's degree using the competency-based approach (9 people). Additionally, since this Bachelor's programme was being developed at a small engineering school site, staff members from this site who were not directly involved in its implementation were also surveyed. Given that the three-stage training on the CBA was offered on site (both for those involved in setting up the Bachelor's programme and other staff members), we decided to include them in the study to assess whether the introduction of the CBA in the programme had enhanced local stakeholders' understanding of the approach. It was also important for us to include non-teaching staff members in order to observe their role in the CBA adherence. Those staff members do not teach but there are in interaction between all stakeholders of the curricula (students, permanent teachers, temporary staff) and have unformal discussions during which they can explain and defend the CBA approach (to temporary staff especially).

The answers of the questionnaire were anonymised for the analysis. First, we asked each respondent to assess their level of expertise regarding the CBA. For those who had already implemented a CBA, we inquired about their understanding of the approach, including aspects they found clear and those they did not. We also asked whether certain activities had been helpful in improving their comprehension of the CBA. Respondents were then asked to rate statements on a Likert scale, such as: *"The CBA gave me a better understanding of the teaching methods I was going to use in my lessons."* Finally, open-ended questions were included, such as: *"What actions do you plan to take to implement the CBA in practice?"* We collected 18 responses: 9 from participants in the Bachelor's programme and 9 from staff members who were aware of the programme's development but did not take part in it.

Among the respondents to the questionnaire, we had teachers, teacher-researchers, the institute director, an instructional designer, two administrative assistants (who interact with students and adjunct faculty), engineers specialised in life cycle assessment (LCA) who do little teaching but are active in the institute's ecosystem, and a person in charge of continuing education.

2.2 Feedback from the training sessions

Three training sessions were organised by a pedagogical engineer. The first session was titled *"Defining a Competency Framework,"* the second *"Defining the Expected Level of Competency,"* and the third *"Designing Learning Situations Aligned with the Expected Level."* Each workshop was based on heuristic, demonstrative, and applied teaching methods. The training followed a structured approach: first, building on participants' prior knowledge, then introducing new concepts through demonstration, and finally applying them in practice.

For the exercises, real documents that the Bachelor's programme's pedagogical team needed to complete were used as case studies. Each activity followed a three-step process: first, providing a definition (heuristic and demonstrative approach), then explaining how this definition is applied in the CBA (heuristic and demonstrative approach), and finally illustrating it with an example (demonstrative and

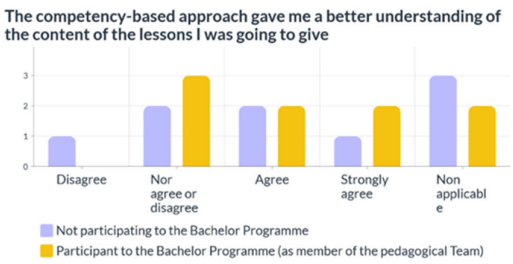
applied approach). The pedagogical engineer observed the participants and took written notes on their reactions.

3 RESULTS

3.1 Results from the questionnaire

Figure 1a shows that 6 respondents never heard about the CBA before the training sessions, 9 already heard about it vaguely, and only 3 knew the approach.

Figure 1a (left). Self-positioning of respondents regarding their knowledge on the CBA. Figure 1b (right). Self-positioning regarding the sentence "The CBA gave me a better understanding of my role in the training programme"



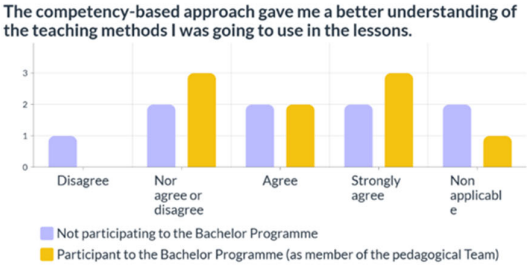
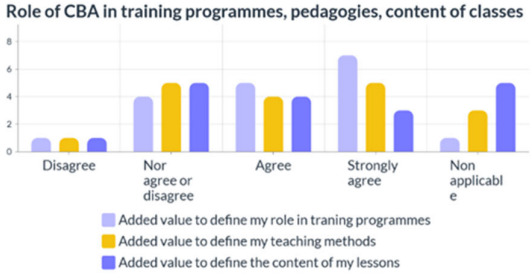


Figure 2a (left). Self-positioning regarding the sentence "The CBA gave me a better understanding of the content of the lessons I was going to give"

Figure 2b (right). Self-positioning regarding the sentence "The CBA gave me a better understanding of my role in the training programme"



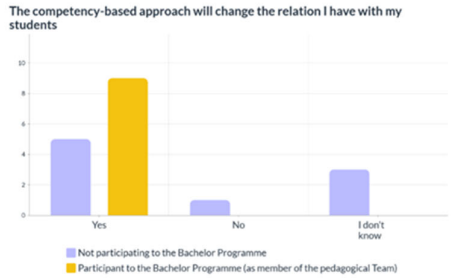


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Figure 3a (left). Gathering of the results of all respondents for the 3 questions (Figure 1b, 2a, 2b)

Figure 3b (right). Opinion of the respondents (with a distinguishing between participants and non-participants to the Bachelor programme) on the impact of the CBA on their relationship with their students

Figures 1b, 2a and 2b enable us to observe the difference of answers between the respondent who participated to the Bachelor programme and the rest of the respondents. The respondents were asked to position themselves on each of the sentences above the charts. On the question "The CBA gave me a better understanding of my role in the training programme", we can observe a strong difference between the two groups of respondents on the "agree" answer: 4 agreed for the participants to the Bachelor,

whereas only 1 agreed on the non-participants side. Otherwise, the answers of both groups are quite similar. The results of the three questions are aggregated in Figure 3a. Figure 3b shows the difference of opinion of the impact of the CBA on the relation with students. A clear gap exists between the two groups of respondents

Also, some qualitative data has been gathered through this questionnaire, enabling the design of Table 1. Some quotes appear twice because they correspond to two sub-sections.

Table 1. Qualitative data gathered from the questionnaire and structured by sections and subsections

Section	Sub-section	Quote from the questionnaire
Positive aspects mentioned about the CBA		
Improvement for students	Giving meaning to students (7 verbatims)	"The student understands what is expected, the objective of the course, and can see how he or she is progressing, with a clearer understanding of the action to be taken if certain objectives are not met." "Identify the contribution of a course in terms of competencies provided to the student" "Transpose the knowledge seen in class into competences to be acquired. Use knowledge to develop competencies" "It allows resources (subjects) to be linked to the competences targeted, while making it easier to draw up syllabuses." "Appropriation by students, global vision of knowledge, know-how and interpersonal competencies and their applications, etc."
Quality of the education	Pedagogical alignment (between activities and evaluation) (4 verbatims)	"Building a course around these competencies to ensure that expectations are matched by the elements being taught" "Raising the learner's level and assessing the competencies progressively acquired are also important points in this method." "Appropriation by students" "Appropriation by students, global vision of knowledge, know-how and interpersonal competencies and their applications, etc."
	Giving meaning to the pedagogical team (2 verbatims)	"It allows resources (academic subjects) to be linked to the competences targeted, while making it easier to draw up syllabuses." "Interdisciplinarity, so teachers work together to create projects"
	Alignment with the needs of the industry (1 verbatim)	"Alignment between industrial and academic needs"
	Structure training programmes (4 verbatims)	"Allows you to structure a new training programme with a fresh approach." "It's a different way of learning from what we're used to."
Negative aspects mentioned about the CBA		
The CBA in practice	How to put in practice the concepts (7 verbatims)	"Putting it into practice is complicated for me because it's new." "It takes time to set up" "Sometimes too many cross-cutting resources between different competencies: difficult to apply in practice"

		"Concepts of CBA don't have the same scope of other institutional frameworks close to CBA"
	The links between CBA and already existing training programmes (regarding the structure of the evaluation and the grades) (3 verbatims)	"How can it be easily implemented for existing training courses, and how can the link be made between [competency] assessment grids and grades?"
The theory around CBA (2 verbatims)	Sematic of CBA (difficult to understand and remember for non-experts)	"The perimeter of certain concepts" "Initially difficulty in finding the right definitions - several of the same words for different concepts"

3.2 Feedback from training programme

The pedagogical engineer took notes about the training sessions. We asked her to recap the training sessions (the content) and to track the reactions of the participants. Here are some quotes about her feedback, after the first training session:

"*To measure participants' reactions, I asked them to give me a word before the workshop that reflected their perception of this approach, without any judgment or commentary. The words given at the beginning of the session indicated that the approach was seen as tedious, unfamiliar, or even unnecessary and complicated. At the end of the two-hour session, I asked the participants to provide a word again (allowing them to keep the same word if their perception remained unchanged). The shift in their perception was unanimous, as all negatively connotated keywords were changed to neutral or positively connotated keywords. The discussions with participants underlined that this shift was mainly due to a better understanding of the usefulness and relevance of [the competency-based approach] despite its challenging implementation."*

Here is the remark of the pedagogical engineer after the third training session: "*What I also observed from the participants' reactions was their growing interest in this approach, which at first did not seem relevant to them. [...] For example, staff members working in academic administration later asked me whether it would be possible to open the workshops to external contributors to the institute so that they too could be introduced to this approach."*

4 INTERPRETATIONS

One of the key takeaways from the pedagogical engineering feedback was that the CBA can foster stakeholder collaboration within a training programme. This is particularly essential for designing engineering training programmes, as it facilitates interdisciplinarity and the development of cross-cutting projects. This is in line with the outputs from the study of [5] or [6] who have shown that administrative support to the CBA helps teachers to integrate this approach in educational programmes.

One of the first surprising results we obtained is shown in Figure 1. Although the CBA has been promoted in the higher education system since the early 21st century (approximately 25 years), it appears that none of the 20 persons surveyed apply this approach. Indeed, none of the respondents to the questionnaire had prior practical experience with the CBA. This could be interpreted as a failure of a top-down strategy to push CBA (which has also been observed in certain contexts such as in [7]). Conversely, in just six months, through training workshops and the practical implementation of the competency-based approach in designing a new Bachelor's programme, around twenty staff members from an engineering school have acquired the fundamentals of the CBA. More importantly, they have developed the motivation to put it into practice, as it was expressed in the feedback of the pedagogical engineer. At the first training session, one participant asked « I don't understand why we need to apply this approach? », whereas at the end of the training session he asked « so, how can we apply this approach [in our training programmes]? ». Training programmes have played a role in demystifying the CBA.

According to [1], one of the consequences of the competency-based approach is the diversification of pedagogical activities. It means that instead of classic lectures, teachers propose role-playing exercises, or case studies. This is in-line with the results obtained in Figure 2b where none of the respondents disagree with the statement “CBA gave me a better understanding of the teaching methods I was going to use in the lessons”.

Our method has some limits, as we are working on a small group of professionals. Thus, statistical analysis is not possible due to the little number of persons interviewed and the specificities of our case study. In addition, the specific wording of some questions may have been leading, when asked to agree or disagree to a positive affirmation for example. This limit will be addressed in subsequent work. Moreover, we are questioning the stakeholders on their understanding and feelings about the CBA. This perspective and methods position us in a constructivist perspective, obliging us to limit the validity of our study.

A particular testimony seems important for our study. Indeed, a participant who attended part of the training and only teaches a few hours per programme (around 3 hours) expressed their lack of understanding regarding the relevance of applying the CBA to their specific case. What is particularly interesting is that this course is highly practical and appears to have a direct link with the concept of competency as *"know-how."* However, the participant described it instead as a *"presentation of available resources," "use of a software tool,"* and ultimately concluded with, *"I don’t see how to modify my course within this framework".* Thus, a more individualised support seems to be needed, and is in-line with some remarks of other colleagues, listed in Table 1, column “The CBA in practice”.

5 CONCLUSIONS

The competence-based approach, developed over more than 30 years, seems to be both a source of intense tension between the players in the academic world and a source of inspiration for the renewal of teaching practices. These two aspects were observed over the course of the 6 months, with some members expressing mediation with regard to the CBA, while others saw the CBA as a means of finding the right teaching method for their classes.

In response to our research question, we found that through a bottom-up approach, the competency-based approach was largely embraced by our participants. It fostered collaboration among pedagogical team members, creating synergies that were widely recognised as valuable for enhancing the quality of teaching programmes. We hope this descriptive article will serve as a source of inspiration for design engineering pedagogical teams trying to transform or create their training programmes.

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