Reinventing Evaluations with Competency Based Assessments: a Practical Experiment with Future Computer Science Engineers

Sébastien Combéfis
ECAM Brussels Engineering School (ECAM)
Woluwé-Saint-Lambert, Belgium
sebastien@combefis.be

Guillaume de Moffarts
Computer Science and IT in Education (CSITEd)
Louvain-la-Neuve, Belgium
guillaume.demoffarts@csited.be

***Abstract*—This innovative practice work-in-progress paper presents a pedagogical device, supported by a tool, moving evaluations at the heart of the learning process. The device gives back to students the control over their own learning and provides them with real-time feedback about their progress. Instructors can also monitor the progress of their classrooms.**

Designing a proper evaluation is not an easy task for instructors. It must make sense to students and should be adapted to the way they learn. Students are often quite afraid, stressed and not motivated by evaluations whose main perceived role is to achieve a decent grade to succeed the course. The method presented in this paper follows a competency based assessment approach. Each course's objectives are described with a list of competencies to get. Students have to prove they master them by passing evaluations ranging from simple quizzes to projects, including missions, codings and oral interviews. Students can choose the assessments to work on, that best suit their own way of learning. They can present them at their own pace.

The proposed pedagogical device and associated developed tool are being tested for the first time during this 2019–2020 academic year. It has been proposed to second-year bachelor to master computer science engineering students, on classrooms with between 17 and 34 people. First feedback collected from students is globally positive and engaging, and the system will undergo a more formal and thorough evaluation.

***Index Terms*—Competency based assessment, Evaluation.**

I. Introduction

Evaluating students is important and designing assessments is not easy for instructors [1]. Students' perception of the learning environment has an impact on how they learn. If they see assessments as "inappropriate" ones, they may be encouraged to follow surface learning approaches [2]. The perceived role of assessments also impacts students' motivation and the quality of their learning. They frequently regard evaluations as a reporting tool, not part of the learning process [3]. Teaching, learning and assessment should be seen as a whole [4].

This paper proposes a pedagogical device for higher education, based on competency based assessments. Its main goal is to give back to students the control over their learning. It is also meant to change the culture of assessments by making them part of the learning process. It is supported by the *"stars system"*, a tool for instructors to encode evaluations and for students to track their own progress.

A. Related Work

The *competency assessment tool* (CAT) is a blog based platform where instructors record assessments [5]. They can check whether students achieved competencies and provide feedback to them, a very demanded feature [6], [7]. Both instructors and students can keep track of students' progress, in terms of acquired competencies. The *"stars system"* follows a similar approach with a more detailed progress tracking.

The *MyCompetencies* mobile application tracks competencies [8]. It helps instructors to adapt their course while they are delivering them during the semester. Unlike their approach where competencies are attached to weeks, the *"stars system"* allows students to work at their own pace.

Finally, existing learning management systems (LMS) can also be used for competency based education [9]. The *"stars system"* proposed in this paper, is a prototype tool developed from scratch for this work. It may nevertheless be integrated into an LMS in the future, with some additional work.

B. Motivations

The main motivation of this work is to propose to students better evaluations, which are better aligned with the course objectives. Students should also get better feedback about their own performances. Assessments should involve them more with their learning, while being integrated with the learning process [10], [11]. The proposed approach aims at changing the culture of assessments. It also equips instructors with a tool collecting real-time data about students' performance, so that they can adapt their teaching. The proposed system helps to individualise and personalise students' learning experience. Finally, it should be possible for students to have their extracurricular/personal projects taken into account in some evaluations for courses they follow.

The remainder of the paper is as follows. Section II explains how competency based assessment is used in this work. Section III presents the *"stars system"* tool. Section IV discusses the first results of an experiment with computer science engineering students. Finally, Section V concludes the paper with future developments.

II. Competency Based Assessment

Competency based education (CBE) is regaining popularity, especially for health professions [12], [13]. Assessments based on competencies are typically used to test whether someone meets the standards of performance required for a given job [14]. They are also used for transversal skills such as ICT ones, for example [15]. CBE is quite common in the primary and secondary education and only reached higher education recently [9], [16]–[18]. Competency management systems are heavily used in large organisations, but are less common in educational settings [8], [19].

The goal of CBE is to determine whether a person can perform a task and evaluate how well it has been done [14], [17], [20]. Competency is defined by NPEC as *"a combination of skills, abilities and knowledge needed to perform a certain task."* [21] They are more general than learning outcomes which are very specific statement describing what learners will be able to do after completing a course [22]. According to the conceptual learning model defined by the ED, skills, abilities and knowledge of students are interacting to form learning bundles related to tasks they are working on [20].

With CBE, assessments can be seen as an opportunity for students to demonstrate their skills. The focus is changed from instructors collecting data to give students a grade to students willing to demonstrate what they learned. Assessments are, in this way, completely integrated in the learning process.

There are many benefits to CBE, including that:

- it provides feedback to students about their performances and gives them a clearer understanding of their own progress and skills gained over time,
- it is an opportunity for instructors to personalise the learning to better fit students' traits and characteristics,
- it makes it possible to develop a different culture of assessments as they become part of the learning process, making students less afraid of taking evaluations,
- and finally, it allows instructors and students to have a better understanding of students' learning profile.

The remainder of this section explains how CBE has been implemented in the pedagogical device proposed in this work.

A. Competency

Course objectives are described with a list of *basic and advanced competencies*. TABLE I shows the seven competencies of a course introducing the Go programming language. Students must master the basic competencies to succeed the course, as they are specific to it. Advanced ones are those for which there is an opportunity to make some progress on. They typically are basic competencies of another course coming later in the program. They can also be transversal to several courses, and be trained in any of them.

TABLE I
The objectives of the "Introduction to the Go Programming Language" micro-course are described with a list of four basic and three advanced competencies.

Code	The student is able to...
Basic	
GP001	*correctly use the syntax of Go programming.*
GP101	*write, compile and execute a single source file Go program with the command line.*
GP002	*use basic built-in data structure: array, slice and map.*
GP401	*understand basic Go compiler errors and warnings and fix the code accordingly.*
Advanced	
GP003	*manipulate structures and define methods manipulating them.*
GP301	*handle rigorously the errors when calling function.*
GP004	*use functions from the Go standard library given their specification.*

B. Assessment

For each course, a list of *assessments* that can be taken to prove mastery of competencies is provided. Students choosing to work on an assessment have to pass an evaluation, possibly after a preparation of a work. Several types of assessments are available, including MCQ, quiz, mission, coding, project and interview. An assessment covers a subset of the course competencies. There are also more assessments than needed to succeed the course. This diversification of learning activities allows students to choose the ones that better fit their own way of learning. Assessment competencies are also split into mandatory and optional ones. These latter correspond to advanced tasks students may work on. Typically, they correspond to advanced competencies. They have been put for students willing to go further and extend their works.

Students can also come with their own assessment proposition that they will define with the instructor, with the list of competencies that can be assessed. It is then made available for all the other students. The proposed approach uses a direct assessment model [18]. Students demonstrate competencies at their own pace, having the opportunity to make progress when they are ready to do so.

C. Evaluation

For each competency, students must obtain five stars to validate them as shown on Fig. 1, the student's view for a course on the *"stars system"*. The reason is to force students to work several times on each competency before validating them. Students may earn from one to three stars for each assessed competency. The number of stars depends on the precision of the evaluation to measure the mastering of a competency. For example, students can only earn one star with an MCQ, since they can randomly guess the correct answer. With an oral interview, they can earn up to three stars, since instructors can check more precisely whether the assessed competency is well mastered or not.

Students cannot "fail" an evaluation anymore, as it is possible with classical exams, for example. They may just miss an opportunity to earn stars, which helps to reconcile them with the evaluation sessions spent with instructors. They are opportunities for students to demonstrate their skills and to take stock on what they learned, how they are going and what they will learn next. Students' mindset is meant to change to follow an active learning cycle going through self-assessment, assessment, learning, re-assessment, etc.

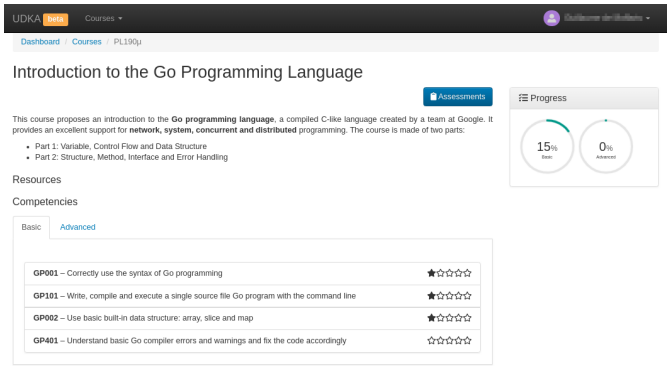


Fig. 1. Students can check their current progress, for each basic and advanced competencies, for each course they are registered to.

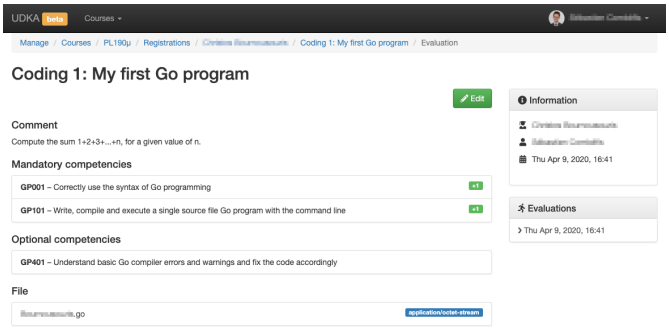


Fig. 2. Students and instructors can read detailed information about each evaluation that has been taken, consisting of a comment, the list of validated competencies and attached files.

D. Feedback

Evaluations provide instructors and students with real-time feedback about students' performance. Feedback making sense to students is not easy to produce, which make some of them misusing or neglecting them [7]. They also often have issues with the language of feedback, finding them inconsistent or vague. Also, too structured feedback instruments may have a harmful effect on the teaching and learning [6]. The proposed approach tackles by focusing on evaluations and putting feedback at the heart of the learning process, most of them being directly provided during the evaluation meeting.

III. The Stars System

The pedagogical device proposed in this paper is supported by the *"stars system"*, a prototype platform developed for this work. Its main goals are to allow students to keep track of their own progress and allow instructors to monitor their students and classrooms and to encode the feedback of evaluations.

A. Course and evaluation

Fig. 1 shows the course page for students where they can check their progress for each competency. The *"Assessments"* button shows the list of assessments with the competencies that can be assessed. All the taken evaluations are also available on the platform. Fig. 2 show the detailed view students and instructors have for evaluations. The platform also stores the optional feedback comment written by instructors, the list of validated competencies with the number of obtained stars and a list of attached files testifying the work done by the student.

B. Statistics

Instructors have, of course, access to a global overview of their classrooms, with the progress of each student. They can also get detailed information about students, namely their current progress and the list of evaluations they already took, with the associated details. Instructors can also get statistics about the taken evaluations, such as the percentage of the classroom which managed to get stars for each assessed competency, for example. This information can suggest to the instructor that some material has to been understood and should be reviewed with students.

TABLE II
THE *"stars system"* HAS BEEN TESTED DURING THE TWO SEMESTERS OF THE 2019–2020 ACADEMIC YEAR, WITH STUDENTS FROM SECOND-YEAR BACHELOR TO MASTER STUDENTS IN COMPUTER SCIENCE ENGINEERING.

Course	Year	# students
First semester		
C programming	third-year BSc	31
Software architecture	fourth-year MSc	22
NoSQL	fourth-year MSc	17
Algorithm design	fourth-year MSc	20
Computer security	fifth-year MSc	34
Second semester		
Numerical computing	second-year BSc	33
Data structure	third-year BSc	31
Operating system	fourth-year MSc	25
Artificial intelligence	fourth and fifth-year MSc	31

Another interesting tool useful for instructors is the progress of students with time, for each individual student and for the whole classroom. This information can help instructors to book time for evaluations and to better understand individual student's learning profile and progress.

IV. The Experiment

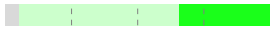
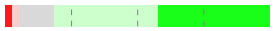
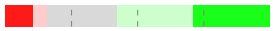
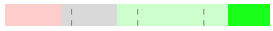
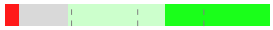
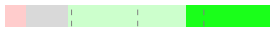
This section presents the experiment led this year with computer science engineering students and the results of a first short survey conducted at the end of the second semester.

A. Experiment

The pedagogical device presented in this paper is currently being tested for the first time, during this 2019–2020 academic year, with students in computer science engineering. During the first semester, the *"stars system"* has been tested on five courses from third-year bachelor to master students. During the second semester, an improved version has been tested with four courses starting from second-year bachelor to master students. TABLE II shows the nine courses with the corresponding number of attending students. The same instructor was responsible for all of them. As an example, all the material of the *"Introduction to the Go Programming Language"* micro-course is available on: https://sebastien.combefis.be/teaching/ucourses/golang/.

All the courses concerned by this experiment have been run in parallel with "traditional" courses and in the current

TABLE III
THE RESULTS OF EIGHT AFFIRMATIONS THAT STUDENTS HAD TO EVALUATE ON A 5-LEVEL LIKERT SCALE SHOWS THAT THEY ARE GLOBALLY SATISFIED WITH THE NEW PEDAGOGICAL DEVICE.

A1	I am generally happy with this device.	
A2	I have the feeling that I better assimilated/understood the material.	
A3	I have the feeling that the evaluations made with this device are more fair.	
A4	I have the feeling that I spent more time working (during the year, the revision break and the exam session).	
A5	I have the feeling that I have been better supported in my learning.	
A6	I regularly checked my progress on the platform to find out where I was.	
A7	I have the feeling that I have had better control over my learning.	
A8	I appreciated to be able to progress at my own pace.	

setting and regulations of the school. Some adaptations have therefore been made, to ensure students get a grade out of 20 at the end of the year, for each course. First, students do not have exams anymore for these courses, that have been declared as continuous evaluation courses. For students, it means that they have no more revision break nor exam sessions for these courses. The time they save is used for evaluations, which can also occur during the lab sessions and at other specific time during the semester. For their final grade, if they do not manage to master all the basic competencies, they will obtain a 0/20. Otherwise, they will obtain $10 + 2x/n$, where x is the total number of advanced stars obtained and n is the number of advanced competencies.

B. Survey

A short survey has been conducted at the end of the second semester before the exam session period. This survey targeted $n = 38$ second-year bachelor to master students who have presented at least four evaluations, with or without success. Other students have not been active enough during the year and were left out. These students were in fact anticipating courses which may explain why they were not involved. Students were subjected to eight affirmations to evaluate on a classical 5-level Likert scale. The results are presented on TABLE III. Students were also asked for more general open comments about the pedagogical device and to explain their perceived strengths and weaknesses of the system.

C. Discussion

Compared to other courses, students seemed to be happy with the proposed system (A1). They appreciated being able to progress at their own pace (A8) and they had the feeling to better understand the material of the course (A2). They also found the evaluations more fair (A3) as it was indeed a goal of the proposed approach. Students have to prove they master the required competencies during a one-to-one meeting with the instructor, even for group works. The system does not guarantee that students worked alone, but they have to individually understand what they present during the evaluations. They also felt to have a better control over their own learning (A7) and regularly checked their progress on the online platform (A6), which is confirmed by the connection logs. Finally, some students had the feeling to have spent more time working on the courses with the proposed system (A4) and to have been less supported in their learning (A5). These two last perceptions are maybe caused by the Covid-19 crisis which disrupted education from mid-March in Belgium.

Answers to the open questions revealed other interesting elements. Students appreciated being able to choose the assessments to work on or to propose their own ideas. About 15% of them came with personal projects they were working on or with projects they had to do for other courses not using the proposed approach, to validate some competencies. This is, of course, easy with computer science since any project covers several needs (programming, database, security, algorithm, etc.) spread on several courses. Several students also pointed out that they learned how to be autonomous and better organise their time. The proposed system also stimulated them to learn without the pressure of having only one chance to present and succeed an exam. Students also would like to have group works that they can present by pairs during the evaluation.

The main concerns and weaknesses of the platform are, so far, related to the logistical organisation for the allocation of evaluations slots with instructors and for the provision of enough assessments to at least cover the basic competencies. Also, some students reported that it was not always easy to ask questions about the assessments during the year, outside the scheduled lab sessions.

V. CONCLUSION AND FUTURE WORK

Even if the setting up of the proposed system, the definition of the competencies and the creation of all the assessments took a lot of time, it was worth it. The pedagogical device presented in this paper is a pragmatic and concrete way to bring competency based assessment in higher education. It was an opportunity for instructors to better define the learning outcomes of each course and to check for coherence between courses. For students, it offers them a more transparent, individualised and personalised evaluations approach. Data collected by the *"stars system"* also help instructors to better adapt their teaching to their classrooms and students.

Future work includes several technical improvements to the *"stars system"*. More detailed surveys will also be organised after the end of the year, to get the feedback of students about this experiment. Data collected by the platform will also undergo more detailed analyses, along with correlations with students' perceptions. Finally, following the Covid-19 crisis and the successful use of several tools, such as Discord, Zoom and Calendly, the platform will be improved to tackle the logistical issues reported by students.

REFERENCES

[1] S. Bloxham and P. Boyd, *Developing Effective Assessment In Higher Education: A Practical Guide*. UK: McGraw-Hill Education, 2007.

[2] K. Struyven, F. Dochy, and S. Janssens, "Students' perceptions about evaluation and assessment in higher education: A review," *Assessment & Evaluation in Higher Education*, vol. 4, no. 30, pp. 325–341, 2005.

[3] R. B. Fletcher, L. H. Meyer, H. Anderson, P. Johnston, and M. Rees, "Faculty and students conceptions of assessment in higher education," *Higher education*, vol. 1, no. 64, pp. 119–133, 2012.

[4] D. Boud and N. Falchikov, "Redesigning assessment for learning beyond higher education," *Research and development in higher education*, vol. 28 (special issue), pp. 34–41, 2005.

[5] G. Ion, E. Cano, and N. Cabrera, "Competency assessment tool (CAT). the evaluation of an innovative competency-based assessment experience in higher education," *Technology, Pedagogy and Education*, vol. 25, no. 5, pp. 631–648, 2016.

[6] R. Bailey, "Undergraduate students' perceptions the role and utility of written assessment feedback," *Journal of Learning Development in Higher Education*, vol. 1, 2009.

[7] R. Bailey and M. Garner, "Is the feedback in higher education assessment worth the paper it is written on? Teachers' reflections on their practices," *Teaching in Higher Education*, vol. 15, no. 2, pp. 187–198, 2010.

[8] S. Gottipati and V. Shankararaman, "MyCompetencies: Competency tracking mobile application for IS students," in *2016 IEEE Global Engineering Education Conference (EDUCON)*. IEEE, 2016, pp. 254–260.

[9] J. P. Monat and T. F. Gannon, "Two professors' experience with competency-based education," *The Journal of Competency?Based Education*, vol. 3, no. 2, 2018.

[10] D. Boud and Associates, "Assessment 2020: Seven propositions for assessment reform in higher education," Australian Learning and Teaching Council, Sydney, 2010.

[11] R. Klein-Collins, "Sharpening our focus on learning: The rise of competency-based approaches to degree completion," *Occasional Paper*, vol. 20, 2013.

[12] C. Carracio, S. D. Wolfsthal, R. Englander, K. Ferentz, and C. Martin, "Shifting paradigms: from Flexner to competencies," *Academic medicine*, vol. 77, no. 5, pp. 361–367, 2002.

[13] L. D. Gruppen, R. S. Mangrulkar, and J. C. Kolars, "The promise of competency-based education in the health professions for improving global health," *Human Resources for Health*, vol. 10, no. 1, 2012.

[14] R. P. V. der Merwe and T. E. Potgieter, "Assessment in the workplace: a competency-based approach," *SA journal of industrial psychology*, vol. 28, no. 1, pp. 60–66, 2002.

[15] T. J. van Weert, "ICT-rich and competency based learning in higher education," *The New Educational Benefits of ICT in Higher Education*, pp. 112–118, 2004.

[16] T. R. Nodine, "How did we get here? A brief history of competency-based higher education in the united states," *The Journal of Competency-Based Education*, vol. 1, no. 1, pp. 5–11, 2016.

[17] J. Gervais, "The operational definition of competency-based education," *The Journal of Competency-Based Education*, vol. 1, no. 2, pp. 98–106, 2016.

[18] P. A. Book, "All hands on deck: Ten lessons from early adopters of competency-based education," Western Interstate Commission for Higher Education, 2014.

[19] B. Simon, "A discussion on competency management systems from a design theory perspective," *Business & Information Systems Engineering*, vol. 2, no. 6, pp. 337–346, 2010.

[20] R. A. Voorhees, "Competency-based learning models: A necessary future," *New directions for institutional research*, vol. 2001, no. 110, pp. 5–13, 2011.

[21] E. A. Jones and R. A. Voorhees, "Defining and assessing learning: Exploring competency-based initiatives. Report of the national postsecondary education cooperative working group on competency-based initiatives in postsecondary education," National Postsecondary Education Cooperative, Tech. Rep. NCES-2002-175; NCES-2002-159, Sep. 2002.

[22] R. Hartel and E. Foegeding, "Learning: Objectives, competencies, or outcomes?" *Journal of Food Science Education*, vol. 3, no. 4, pp. 69–70, 2004.