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TLIC PAPER

Certainty-Based Self-Assessment in Higher Education: A Strategy for All?

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ABSTRACT

This study explores students' behavior in response to a study-learning system during one semester at university, based on the certainty-based marking strategy. The learning support system pursues to encourage diagnostic formative self-assessment. In total, 258 students complete the full study program and respond to an additional sociodemographic questionnaire. An exploratory study was performed. Two individual variables were considered for basic statistical analysis: gender and prior academic experience. Results show progression of students' confident responses, especially by the third trial. No differences were found with respect to gender. In contrast, strong differences were found related to prior academic experience. These latter results must be taken carefully, in expectance of further research to look for connections with other individual variables.

KEYWORDS

self-assessment, formative assessment, metacognition, degrees of certitude, certainty-based marking, higher education

1 INTRODUCTION

Developing a competence for life-long learning has become one of the most important challenges in higher education. This competence is central to any discipline. Closely related to it is gaining self-awareness of one's own knowledge and abilities, hand-by-hand with the ability of identifying doubt, searching for trustworthy sources and others' help to take responsible professional decisions. *Certainty-based marking (CBM)* [1], [2] also known as *Assessment of Degrees of Certitude (ADC)* [3], [4], [5] offers an assessment tool to this goal. This study presents results from a very first experience at a multi-level exploration of the impact of using certainty-based assessment at higher education. In this paper we share some ideas and empirical results that should challenge higher education instructors consider new forms of assessment for the sake of improving students' engagement and metacognitive activation towards a life-long learning professional competence.

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1.1 Background

Previous research on CBM or ADC comes from a variety of disciplines, for example: Chiropractic Education [6], Medical Education [7], [8], [9], [10], Aviation Education [11], Foreign Language Education [12], Business Administration and Management [13], Engineering [14], and Law Education [15]. However, the proposal originates in back the decade of 1980. Leclercq proposed an innovative psychometric algorithm to be used with multiple-choice learning quizzes (MCQ), that should contribute to a more valid and reliable assessment of knowledge [3]. His original motivation was to address the challenges of teaching and assessing big groups of students. Later on, he refers to *degrees of certitude* [4], [5]. Gardner-Medwin [1], [2] picked this idea and denominated it *Certainty-based Marking* or CBM. This strategy promotes meta-cognitive reflection on the answers one is providing and the possibility of becoming aware of our knowledge, and thus increase engagement in the learning process [16].

This exercise of self-consciousness appears to be extremely important in the context of higher education and also vocational education, as a life-long learning competence becomes crucial. In the professional or real-life context, there is little interest in knowing something with a great amount of doubt or uncertainty [5]. Such knowledge is rather *useless* for professional decision taking, as the authors state. On the other hand, a great certitude of mistaken answers neither is desirable. Such knowledge would be *pernicious* or *nocuous*, since wrong and misfortunate decisions could be inspired by such mislead certitude. Eventually, it is desirable and expectable that professionals construct correct knowledge and develop a positive certitude of it, along with a basic awareness of moments of doubt, and a sensible and honest attitude to confront and solve it. These would be precisely important qualities of a competent professional, regardless the particular discipline.

1.2 State of the art, missing answers and open questions

As novel as research about CBM in different disciplinary areas is [6]–[16], a crucial lack of the current state of the art refers to the study of students' reactions and perceptions at different educational levels, that is, educational experience, or *study expertise*. In our literature search we found only two references located in secondary education [17], [18], reporting a general positive acceptance. Indeed, a comparative approach is missing to understand if there might be different approaches to the instrument.

Also, most of previous studies do not provide any inquiry into gender differences related to the implementation of this assessment strategy. Only one study we found addressing it, with report of barely any difference [14]. Taking into account gender-related differences in reactions to stressing situations [19], and particularly academic test anxiety [20], more research is needed in order to better understand how men and women could be profiting from it in different manners.

So far, we could identify only one study [9] addressing the issue of time-of-response, in the sense of likely time increase while the subjects deliberate about their certitude. However, in that study students were asked for their evaluation of their perception of invested time. No direct measure was considered.

1.3 How CBM/ADG works

The CBM/ADG system offers a procedure or an instrument to confront students with their own doubts. CBM or ADG consists of applying an alternative algorithm to the

grading of students' performance in learning tests with multiple choice questions. Along with choosing the answer option which the students think is correct at each single item, they have to reflect on and declare a particular degree of certainty about the correctness of the chosen option (out of three options: low, middle, high certainty). Depending on the answer being correct or false, the student gets marks following the original [3] formula:

- +3 points (right answer, high certainty);
- +2 points (right answer, middle certainty);
- +1 point (right answer, low certainty);
- 0 points (wrong answer, low certainty);
- –2 points (wrong answer, middle certainty);
- –6 points (wrong answer, high certainty).

1.4 Goal and research questions

In this study our goal is to explore potential benefits and risks of the progressive certainty-based evaluation system with a formative purpose. To reach this goal, research questions are formulated revolving two principal variables: gender and prior education:

- RQ-1. Are there differences in response-time, score range, and declared certainty in students' response to the CBM-system related to *gender* (female-male)?
- RQ-2. Are there differences in response-time, score range, and declared certainty in students' response to the CBM-system related to *prior education* (pre-grad, graduate, postgraduate)?

2 METHOD

This is an exploratory study. We mean to describe and understand students' behavior in approaching this pedagogical system for study support. A same instructional plan for supporting self-assessment with diagnostic purposes was implemented in six different university courses. Students were invited to participate on a voluntary basis. Informed consents were collected as required by the ethical standards of the institution. The students were presented a 10-item knowledge test thrice during one trimester, always in advance of the topics to be addressed during the following weeks in their respective course. The multiple-choice questions referred in each course to specific prior knowledge, as it was considered necessary to better tackle the course program. In that sense, it was an instrument for diagnostic self-assessment. The results of these CBM tests had no effect on students' course grades, so they could feel safe about committing errors. Students were offered a student-guide were the CBM/ADC was presented and explained to them.

To help the students make sense of the results, a qualitative scale of results was proposed: range 0 (negative results up to 0 points), range 1 (1–10 points), range 2 (11–20 points), and range 3 (21–30 points). This scale is drawn considering hypothetical cases of all answers at one same level of certitude. For example: an individual with low certitude but correct answers at all ten questions would receive 10 points; another student with mid-level certitude in ten correct answers, would receive 20 points; finally, a student with ten correct answers at high certitude, would get 30 points. These three levels of quality should help students interpret their own results. In all of the previous studies, students were offered a sort of bonus-mark

for participation. In this study, however, students are invited to answer only with a strict formative and diagnostic purpose, with no effect on final grades in the course.

2.1 Participants

Table 1 presents the composition of the final sample of participants regarding both variables considered in this study: gender and highest educational level prior to this experience. Some exclusion criteria of attempts were applied for curation of the final data sample: response attempts had to (a) take more than 10% of the allotted time (quicker attempts were excluded), (b) offer each time 10 complete answers (blank items were excluded as missing data); and (c) be first response attempts (repeated attempts by the same student were excluded). A wider sample of students were initially enrolled in the course and responded to the first knowledge test. To carry this particular analysis, we considered only the sub-sample of those who completed participation with three responses during the semester and a sociodemographic questionnaire, which correspond to an 18% of the students.

Table 1. Participant subsamples

Group of Participants	n	(%)	Age M(SD)
TOTAL (out of 1.407 initiating participation)	258	100	24.3(5.74)
Women	172	66.67	24.3(6.1)
Men	86	33.33	24.3(4.94)
Pre-graduates (college or vocational education)	65	25.20	19.4(2.43)
Graduates (First bachelor finished)	137	53.10	25(4.97)
Post-graduates (Second bachelor/Master/PhD)	56	21.70	28.4(6.27)

2.2 Data collection and analysis

The students responded the tests either during the lecture or at home (depending on the instructor's planning) through the institutional virtual campus (LMS Moodle). Each test presented the same 10 multiple choice course-related questions for all students in the same course, presented hazardously; response time was limited to 10 minutes. Approximately one month of classes passed between responses. Students received automatic numerical feedback from the system, according to the CBM grading algorithm. The virtual campus automatically registered students' answers concerning (a) hit/error (b) degrees of certitude, and (c) response time. Students additionally responded to a sociodemographic questionnaire from which gender and prior education level were gathered.

Basic statistical analysis was performed on the data (t-Student test or Chi-square test depending on the type of data). Effect size was calculated when significant results were obtained.

3 RESULTS

Prior to reporting the results relative to each research question, Tables 2, 3, and 4 and Figures 1 and 2 present the general, plain results. Response time was calculated

as proportional to the given time limit (10 minutes). Scores were considered both as direct result (average and deviation) and percentage of qualitative score ranges.

Table 2. General results of the first self-assessment occasion

First CBM-Self Assessment Experience	Response Time % M(SD)	CBM Direct Score M(SD)	Range of Response, Qualitative Scale			
			Range 0 (%)	Range 1 (%)	Range 2 (%)	Range 3 (%)
Women	0.56 (0.20)	5.27 (9.29)	23	51	24	2
Men	0.60 (0.22)	5.92 (9.41)	27	43	24	6
Pre-graduates (college or vocational education)	0.58 (0.23)	7.11 (8.99)	23	43	28	6
Graduates (First bachelor finished)	0.57 (0.19)	4.20 (9.60)	25	53	22	1
Post-graduates (Second bachelor/Master/PhD)	0.58 (0.19)	6.75 (8.63)	23	43	27	7

Table 3. General results of the second self-assessment occasion

Second CBM-Self Assessment Experience	Response Time % M(SD)	CBM Direct Score M(SD)	Range of Response, Qualitative Scale			
			Range 0 (%)	Range 1 (%)	Range 2 (%)	Range 3 (%)
Women	0.55 (0.19)	5.37 (8.15)	27	49	22	3
Men	0.60 (0.21)	5.24 (9.87)	28	45	20	7
Pre-graduates (college or vocational education)	0.52 (0.21)	6.97 (10.77)	28	32	28	12
Graduates (First bachelor finished)	0.58 (0.18)	4.66 (8.06)	31	52	17	1
Post-graduates (Second bachelor/Master/PhD)	0.59 (0.22)	7.5 (6.80)	18	55	23	4

Table 4. General results of the third self-assessment occasion

Third CBM-Self Assessment Experience	Response Time % M(SD)	CBM Direct Score M(SD)	Range of Response, Qualitative Scale			
			Range 0 (%)	Range 1 (%)	Range 2 (%)	Range 3 (%)
Women	0.51 (0.22)	9.66 (7.81)	13	43	38	6
Men	0.57 (0.23)	9.84 (8.82)	14	34	42	10
Pre-graduates (college or vocational education)	0.44 (0.24)	6.20 (7.74)	22	54	18	6
Graduates (First bachelor finished)	0.56 (0.21)	10.50 (7.74)	10	37	46	7
Post-graduates (Second bachelor/Master/PhD)	0.57 (0.21)	11.89 (8.44)	11	30	46	13

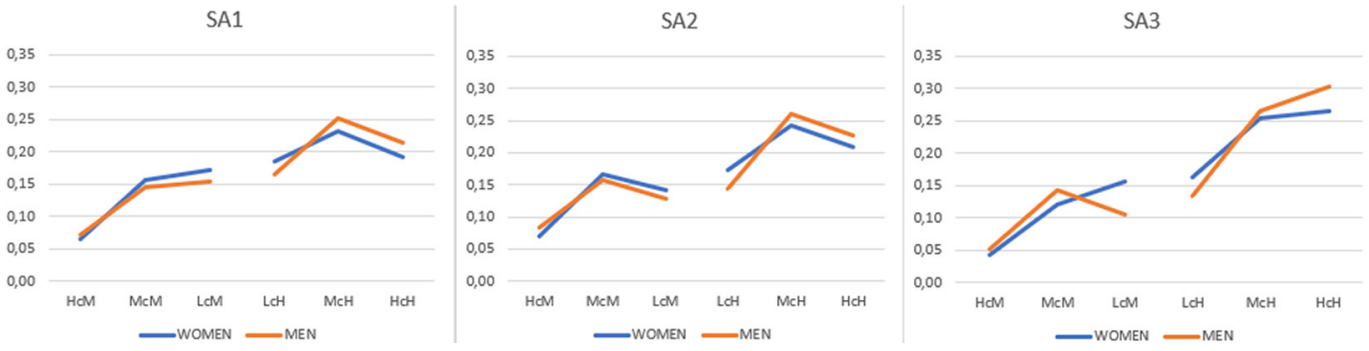

Fig. 1. Progression of certitude and correctness of answers, by gender

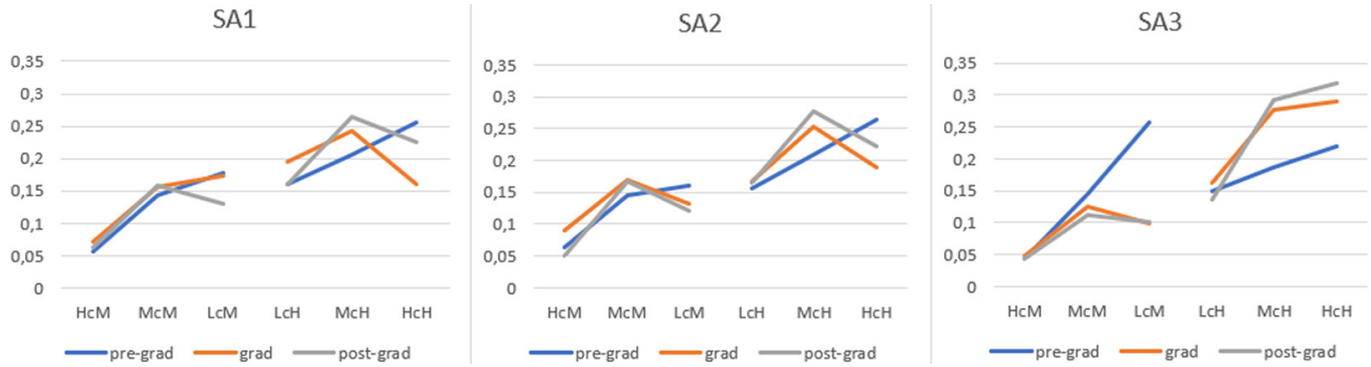

Fig. 2. Progression of certitude and correctness of answers, by prior education

3.1 Results concerning research question #1: differences by gender

The analysis of data concerning the variable gender offers the following results.

Response time. With regard to response time, we found no significant difference between genders, although men systematically need a bit longer than women to answer the presented learning tests (see Tables 1–3).

Learning results. Regarding learning advances (see Tables 1–3), we found no significant results in an intergender comparison; however, an improvement with moderate effect size for both genders (intra-gender longitudinal comparison), can be noticed between the second (SA2) and the third self-assessment (SA3) occasion, when considering direct CBM scores: Women, SA2 ($M = 5.37$, $SD = 8.15$), and SA3 ($M = 9.66$, $SD = 7.81$), $t(342) = 5.685$, $p < .00001$, Cohen's $d = 0.556$; Men, SA2 ($M = 5.24$, $SD = 9.87$), and SA3 ($M = 9.84$, $SD = 8.82$), $t(170) = 3.466$, $p = .00041$, Cohen's $d = 0.482$. According to these improvements, for both genders we could identify a displacement towards range-2 and range-3 of qualitative range results, although no significant differences could be established, either intra- or inter-gender.

Certitude. With respect to the progression of certitude along the course (Figure 1), both women and men experienced a similar improvement from SA1 to SA2, and further to SA3, that is, an increase of certain and correct answers. Significant improvements can be located only between SA2 and SA3 (Women, $\chi^2(10, n = 172) = 56.29$, $p = 0$; Men, $\chi^2(10, n = 86) = 35.28$, $p = .00011$), although with minor effect sizes (Women, Phi = 0.10; Men, Phi = 0.11).

3.2 Results concerning research question #2: differences by prior education

The analysis of data concerning prior education considered three categories: students in first or second year, with no previous higher education degree (pre-graduates), students with one previous Bachelor degree (graduates), and finally students with more than one finished degree or post-graduate courses, master's level or PhD (post-graduates).

Response time. We found no differences in response time for graduate and postgraduate students (see Tables 1–3). However, among pre-graduates, we identified a significant decrease of response time with moderate effect size by the time of SA3 (pre-grads, SA2, $M = 0.52$, $SD = 0.21$, and S3, $M = 0.44$, $SD = 0.24$, $t(128) = -4.115$, $p = .00003$, Cohen's $d = 0.354$).

Learning results. Regarding learning advancement, we found indeed differences in students' performance when carrying out both intra-group and inter-group comparisons (see Tables 1–3). There were no significant results for pre-graduate students along time, either with respect to direct scores nor to qualitative ranges. However, graduate and post-graduate students present noticeable changes when performing an intra-group analysis.

Graduate students have the weakest results in CBM-direct scores at first attempt, and even a decrease in SA2. But for the third attempt they show the highest increase with a very strong effect size (grad, SA2 $M = 4.66$, $SD = 8.06$, SA3 $M = 10.5$, $SD = 7.74$, $t(272) = 7.783$, $p = 0$, Cohen's $d = 0.865$). When regarding qualitative results ranges, we found a significant movement-although with a moderate effect size-between range-1 and range-2 from SA2 to SA3 (graduates, $\chi^2(10, n = 137) = 53.45$, $p = 0$, Phi = 0.36).

Post-graduate students, on their side, show a progressive improvement along the semester, with a significant increase also between second and third attempts with a moderate effect size (post-grad, SA2 $M = 7.5$, $SD = 8.8$, SA3 $M = 11.89$, $SD = 8.44$, $t(110) = 3.467$, $p = .0005$, Cohen's $d = 0.57$). Concerning qualitative results ranges, we found also a light significant difference in the increase of range-2 at SA3 (graduates, $\chi^2(10, n = 56) = 15$, $p = .02$, Phi = 0.30).

Certitude. With respect to certitude evolution, the analysis allowed us to identify significant differences within and among all groups, pointing to a diversity of study-behavior affected by the academic experience, although it is noticeable that all cases present a small effect size (Figure 2).

Pre-graduate students show a significant regression of certitude at SA3 (pre-graduates, $\chi^2(10, n = 65) = 23.45$, $p = .009$, Phi = 0.11), so that low certitude or confidence predominate.

Graduate students, on their side, reveal a significant increase of confidence/certitude by the third attempt of CBM (graduates, $\chi^2(10, n = 137) = 122.2$, $p = 0$, Phi = 0.17).

Postgraduate students, finally, also show an increase of certitude towards the end of the course, despite a lesser difference (postgraduates, $\chi^2(10, n = 56) = 26.45$, $p = .003$, Phi = 0.12).

4 DISCUSSION OF RESULTS

In this project we meant to explore students' differential behavior towards a CBM system proposed for encouraging diagnostic self-assessment. We specifically looked at differences between genders and between students with three levels of 'study-expertise'. A first general result to be noticed is that changes were indeed identified along the three knowledge tests during the semester. Students' results generally improved after the second occasion of using CBM

Concerning gender differences, the most important result from our study is that both men and women did gain equal benefit from participating in the study in terms of increase of certitude or confidence in their own knowledge. While previous research indicates certain disadvantages for women with regard to coping with anxiety, especially in test situations [19], [20], in our study those results are not supported. Our results resonate with those of [14] in noticing this lack of gender differences, however, that previous study did only take a dichotomic option for certitude (*certain, not certain*).

Regarding response time, men appeared systematically taking more time than women to respond. These differences could be related with a slower reading velocity

among men, or also a hastier response (less hesitating) by women. However, these are only speculations since results do not throw significant differences.

The results concerning prior academic experience, however, cannot be contrasted with previous results, since no similar research has been published so far, to our knowledge. The most salient result of our study is the identification of certainly a strongly different behavior depending in the student-expertise. By the third occasion of self-assessing with CBM, students without much experience at higher education (pre-graduates) appear to step backwards into low certitude. One could think that they are losing their personal security and thus the system is potentially affecting their learning process in a negative manner. In contrast, students with a longer (and deeper) academic history showed a great increase in personal confidence. However, we would advise against any simplistic interpretation of these results. To what extent other personal variables are intervening here, we do not know at the moment. For example: are pre-graduate students more prone to *declare* low certitude because they simply pursue to prevent getting negative results? If so, the system would be failing as a pedagogical tool, because dishonesty prevails over sincerity subject to the goal of preventing frustration, hence, results would be invalidated as actual *learning* results. Or perhaps are pre-graduate students declaring low certitude in order to get results in the range between 1–10 points, so they can easily make sense of them as they return to the traditional grading scheme (in their institutional context). In that case, a metacognitive strategic behavior would be flourishing, likely influenced by students' conceptions of assessment. Last but not least, in our sample, average age of pre-graduates and post-graduates expands over almost ten years (19–28y), precisely in a phase of still important personal advances and life changes. Hence, the variable of study-expertise, or academic experience, should perhaps be considered complementary to the individuals' age. In other words, to what extent are the developmental and the educational criteria interacting with each other?

5 CONCLUSION AND FURTHER RESEARCH PERSPECTIVES

Our study contributes to the advancement of knowledge with regards to the potential benefits of the CBM assessment strategy by better understanding its effects on students' behavior. Differences between men and women were not confirmed, that is, both genders do equally benefit from the strategy. On the other hand, important differences were found related to the academic experience of the participants. A practical conclusion of our study is the suggestion of implementing the CBM system a minimum of three times in a course, to offer students the chance of getting familiar with the system.

Many open questions remain for further study with regards to the deeper reasons behind students' differential behavior. Also, more research is needed to understand the connections between CBM-related behavior and other individual variables, such as emotional reactions, motivation, learning strategies, conceptions of assessment, and also epistemological conceptions.

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