

REMOTE FORMATIVE ASSESSMENT WITH MULTIPLE-CHOICE QUESTIONS AND LEVELS OF CERTAINTY: THE IMPACT OF FEEDBACK ON LEARNING

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Abstract

This study is part of the European Erasmus-CORETEV project (CO-construction Nord-Sud d'un Réseau d'Expertises pour l'utilisation des nouvelles Technologies en Évaluation), which aims to modernize education systems using information and communication technologies (ICT) while adopting a quality approach to learning assessment. To this end, the present work proposes an approach to provide remote formative assessment in the context of student self-learning. The assessment uses multiple-choice questions (MCQs), designed according to appropriate writing rules, while ensuring rigorous pedagogical alignment in order to guarantee the reliability and validity of assessments and promote continuous learning improvement.

The MCQs administered are enriched by the inclusion of degrees of certainty (DC), enabling more precise and detailed assessment and distinction of student responses according to their level of certainty. This also gathers valuable information about their knowledge and understanding of the subject, and encourages them to think critically and reflectively, assessing the validity of propositions before making their choice.

Indeed, the objective is to identify weak points and offer appropriate feedback, guiding students towards effective knowledge acquisition and continuous improvement of their performance. To achieve this, specific indicators are used from the tests to provide students with constructive, personalized feedback covering both cognitive and metacognitive aspects, based on their degree of certainty. This feedback stimulates in-depth reflection on the skills acquired, thus fostering autonomous progress.

Following the implementation of this system, an in-depth analysis of the results was carried out using a mixed methodology combining qualitative and quantitative methods. Quantitative data were collected from the answers provided by students during the tests. These data were used to measure the improvement in students' learning performance. To this end, statistical analyses were carried out to examine trends, correlations and significant differences in responses. Qualitative data were collected from participants' responses to a satisfaction questionnaire administered at the end of the course. Content analysis was used to extract relevant information on students' perceptions of the effectiveness of the device, the relevance of the feedback provided and its impact upon their learning.

The results of the distance formative assessment approach, using rigorous MCQs and degrees of certainty, provided an in-depth understanding of its effectiveness and impact on student learning. These findings demonstrated significant improvements in student learning performance and high satisfaction with the approach and feedback received. They reinforce the relevance of the approach adopted in the design and implementation of the system, offering promising prospects for improving the assessment of distance learning. Furthermore, this approach is part of a quality-oriented pedagogical framework, actively supporting student learning and fostering critical and metacognitive reflection. It opens up new opportunities for improving learning assessment practices, promoting a deeper understanding of the learning process and enabling more effective support for student learning.

Keywords: Distance learning, multiple-choice questions, degrees of certainty, formative assessment, quality approach in assessment, feedback, metacognition

1. INTRODUCTION

Formative assessment is of crucial importance for optimizing learning processes, providing teachers with precise insight into students' individual needs, enabling them to adapt their teaching [1]. In this article, we present an innovative distance formative assessment approach for third-year Electronics and Industrial Computing option students for the 2022-2023 academic year, as part of the European Erasmus-CORETEV project. The focus is on the integration of information and communication technologies (ICT) to modernize educational systems and enhance learning assessment. The study is based on remote formative assessments and feedback, contributing to the evolution of pedagogical practices through the advantages of digital technologies for personalized learning and individualized follow-up.

The impact of digital technologies on assessment has raised questions about its reliability, validity, and fairness [2]. Our approach is grounded in meticulous assessment design, utilizing Gilles' CGQTS model [3,4] and aligning with Biggs' pedagogy [5] to ensure coherence among learning objectives, assessments, and resources. This guarantees that students have a clear understanding of expectations from the outset, enhancing the overall effectiveness of our approach.

Moreover, we endorse the use of multiple-choice questions (MCQs) in accordance with the quality standards outlined in [6], and incorporate degrees of certainty (DC). This method, established since the 1960s thanks to the pioneering work of De Finetti [7], and substantiated by studies such as those conducted by Leclercq [8,9] and Leclercq and Gilles [10], allows learners to express confidence in their answers, thereby encouraging critical and thoughtful evaluation. The information gleaned is then employed to craft personalized feedback and concise performance summaries, contributing to the development of students' cognitive and metacognitive skills, including decision-making, realism, critical reflection, self-regulation, and learning enhancement.

Finally, this article adheres to a systematic structure, first presenting the theoretical framework, followed by an in-depth examination of research questions, methodology, and the study's results, encompassing students' performance and the influence of feedback on their cognitive and metacognitive skills. In conclusion, we summarize the main findings and propose avenues for refining learning assessment practices.

2. LITERATURE REVIEW

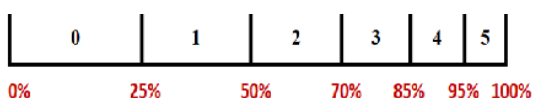
Formative assessment plays a central role in education, focusing on providing learners with constructive feedback and stimulating cognitive activation [11]. Following Perrenoud's principles [12], this approach actively contributes to students' learning and development, thereby regulating learning processes in accordance with educational objectives.

From various perspectives, this approach is considered an essential method for collecting data on student progress and delivering high-quality feedback. Its purpose is to identify learners' specific needs, encouraging them to reflect on their learning processes while adapting teaching methods accordingly [13]. Within the framework of "regulation" pedagogy, this evaluation is based on continuous adjustments during the teaching/learning process [14].

Feedback, also known as 'feedforward,' plays a crucial role in formative assessment, exerting a significant impact on learning in any educational context [1]. It encompasses all responses given after the fact, aiding learners in understanding their current level of learning or performance, thereby actively contributing to the regulation of their learning process [15, 16].

The incorporation of degrees of certainty naturally aligns with this perspective, enabling a more precise analysis of student performance compared to a simple standard test, which is solely concerned with the accuracy of answers. This technique provides teachers with the opportunity to offer more targeted feedback to students and to highlight potentially problematic situations. For students, it allows them to quantify their confidence in the chosen answer using the certainty scale (see Figure 1).

Scale of certainty according to Leclercq (1982, 1993, 1998)



Scale of scores according to (Leclercq, 1982; Leclercq and Gilles, 1994)

		DC					
		0	1	2	3	4	5
Response	Correct	+13	+16	+17	+18	+19	+20
	Incorrect	+4	+3	+2	0	-6	-20

Figure 1: DC certainty scale and associated scores.

The level of certainty distinguishes between certain and correct knowledge (assured knowledge), certain and incorrect knowledge (ignored ignorance), which can be potentially dangerous, and uncertain knowledge (correct or incorrect), which requires external verification before application. This metacognitive approach enables students to recognize that correct answers may correspond to potentially unusable or harmful knowledge.

Within this theoretical framework, it is evident that formative assessment, coupled with constructive, individualized feedback and the judicious use of degrees of certainty, constitutes an essential tool for supporting student learning. These approaches foster reflection, empower teachers to adapt, and transform errors into opportunities for enriching knowledge. When applied judiciously, these concepts offer significant potential for enhancing pedagogical practices and enriching the student learning experience.

3. RESEARCH QUESTIONS

This work focuses on research questions and hypotheses related to Determining the effects of quality distance formative assessment approach, based on rigorously written MCQs using degrees of certainty, on effective knowledge acquisition and continuous improvement of students' performance in terms of cognitive and metacognitive skills.

3.1 Research questions and associated hypotheses

Hypothesis 1 (H1): L'inclusion de QCM avec des degrés de certitude (DC) dans les évaluations formatives favorise la régulation des apprentissages chez les étudiants, ce qui conduit à une amélioration continue de leurs performances.

Related research question (RQ1): Do MCQs with DC in formative assessments promote learning regulation and improved student performance?

Hypothesis 2 (H2): Increased perception of certainty is positively correlated with improved student learning performance.

Related research question (RQ2): What is the relationship between perceived certainty and improved student learning performance?

Hypothesis 3 (H3): Incorporating the degree of certainty into students' formative assessments promotes the mobilization of the mental process of metacognition, thereby improving their ability to self-assess and regulate their learning accordingly.

Related research question (RQ3): How does incorporating the degree of certainty in formative assessments impact learners' metacognition and ability to self-assess, regulate their learning and analyze their calibration?

Hypothesis 4 (H4): Certainty-based feedback positively influences comprehension, information retention, learning progression, and the design of differentiated and personalized feedback supports student learning.

Related research question (RQ4): How does certainty-based feedback influence comprehension, information retention, learning progression, and the design of differentiated and personalized feedback?

Hypothesis 5 (H5): Learners tend to overestimate or underestimate their certainty when using a degree of certainty with MCQs. This tendency may influence their calibration and realism in interpreting the information provided by formative assessments.

Related research question (RQ5): What is the relationship between learners' estimation of certainty and the calibration of that certainty in relation to their answers, performance and realism in interpreting the information provided by formative assessments?

4. METHODOLOGY

The study was conducted on the Google Classroom platform, an online learning platform accessible via various mobile devices. This platform was chosen for the creation and delivery of the distance learning course, as well as for the sharing of essential resources facilitating students' progress, thus enriching their learning experience.

The course was structured into four chapters, introduced by the teacher via Google Classroom. Students were encouraged to read, discuss and engage in the associated exercises and assignments. Asynchronous learning enabled students to manage their schedules with greater flexibility.

A formative assessment was set up at the end of each chapter's self-study in the form of Multiple Choice Questionnaires (MCQs) with Degrees of Certainty (DCs). These assessments were based on the CGQTS Cycle methodology [3], guaranteeing alignment with the program.

The results of formative assessments were shared immediately, giving students instant feedback on their performance and reinforcing their involvement in the learning process. A variety of feedback techniques and resources were used to ensure the validity of the pedagogical approach, including summary sheets, practical order lists and explanatory video vignettes.

Key data was collected from student responses to these formative questionnaires and to a satisfaction questionnaire, administered via Google Forms. All learning resources were accessible exclusively via Google Classroom, with all communication also taking place on this platform or by e-mail. Responses were processed in binary (0 for incorrect and 1 for correct) and numerical values for DC.

The study involved 24 students enrolled in a Bachelor's degree 3 in Electronics and Industrial Computing option, taking into account their varied educational backgrounds in the design of the online course. The methodology enabled us to investigate the impact of formative assessments using MCQs with DC, highlighting the benefits of personalized feedback and exploring student reactions. The results will be presented in the next section.

5. RESULTS AND DISCUSSION

5.1 Presentation and discussion of quantitative results

After each assessment, student responses are recorded in an Excel file with binary values (0 for incorrect, 1 for correct) and numeric values (ranging from 0 to 5) to express their certainty. These data are analyzed using an in-house Python program developed as part of a project [4] to obtain various cognitive and metacognitive indicators. This includes realism, centration, ignored skills, and many others.

In our study, we examined data derived from our formative assessments to investigate the evolution of students' perception of their competencies over time. Here are our findings:

Firstly, we observed a noteworthy positive trend: as the assessments progressed, students seemed to gain a more accurate perception of their competencies. The average correct response rate of the class showed a slight increase, indicating a moderate acquisition of knowledge (see Fig. 2). Concurrently, their perception of reality also appeared to improve gradually, with the average rate transitioning from 74% to 92% (see Fig. 2). These distinct trends are promising and underscore the significance of the formative assessment process in aiding students to assess their competencies more accurately. This confirms our hypotheses H1, H2, and H3.

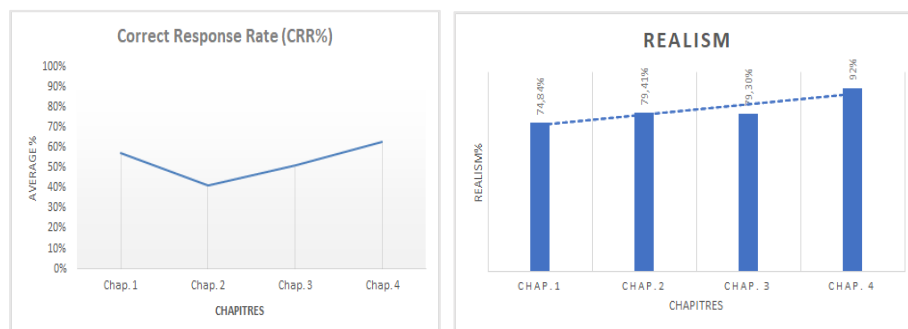


Figure 2: Correct Response Rate & Realism per chapter.

Realism measures their ability to assess their performance accurately in relation to their certainty. Relevant feedback is subsequently provided to students regarding their progress, self-assessment, and metacognition. This feedback takes the form of personalized reports containing a variety of crucial information concerning their metacognitive skills. The reports detail aspects such as ignored ignorance, doubted ignorance, recognized ignorance, recognized knowledge, doubted knowledge, and ignored knowledge specific to each student (see Fig. 3).

These personalized reports provide detailed explanations of these metacognitive indicators, allowing students to gain a deep understanding of their own thought processes and confidence levels. Moreover, this feedback includes targeted remediations to help students correct their erroneous assessments and enhance their metacognitive skills. This approach significantly enriches the learning experience by providing students with concrete tools to develop their understanding of their own cognition and skills, helping them become more effective learners.

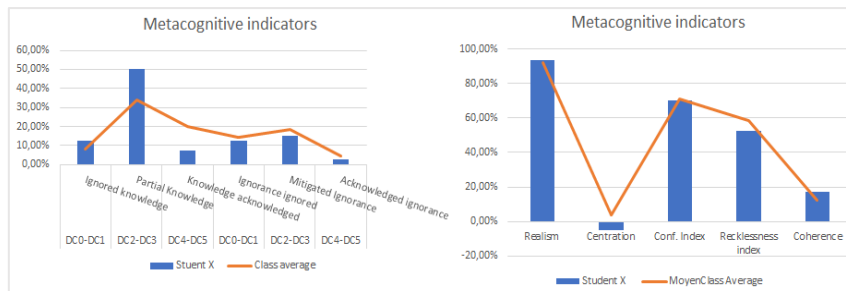


Figure 3: Metacognitive indicators (example of collected measurements).

Measuring the degree of certainty of acquired knowledge in the learning process is crucial. This dimension provides students with the opportunity to build learning based on independent reflection. They become aware not only of the knowledge acquired but also of their confidence levels in that knowledge [7]. Student centration, which compares the average of their certainty levels to their accuracy rate, reveals a tendency towards overestimation in cases of positive centration and underestimation in cases of negative centration [17].

By incorporating elements such as overestimation and underestimation, we added another metacognitive dimension. We observed a significant decrease in the overestimation rate and, simultaneously, an increase in realism, thus corroborating our hypothesis 5. At the beginning of the assessment, students tended to overestimate their competencies, possibly due to a lack of initial references for self-assessment. Although this initial overestimation may initially boost their confidence, it is crucial to manage these overestimations effectively through constructive feedback. In parallel, a slight tendency towards underestimation of skills was also noted, though less frequently. Some students seemed less confident in their abilities, perhaps due to strict assessment standards or personal doubts. This slight underestimation deserves our attention as it could potentially limit students' motivation.

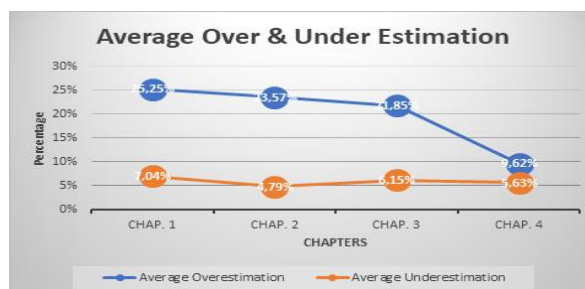


Figure 4: Average overestimation & underestimation.

This analysis of formative assessment data provides valuable insights into how students perceive their competencies over time. The results highlight the importance of guiding students towards a realistic perception while nurturing their self-confidence. For the future, there is much more to explore, including the underlying reasons for the observed trends and their long-term impact on student motivation and academic performance.

5.2 Presentation and discussion of qualitative results

In this section, we delve into the qualitative dimensions of our study, aiming to provide a comprehensive grasp of the nuanced insights derived from the amassed data. Through meticulous qualitative analysis, our objective is to unearth underlying layers of meaning and cultivate a more holistic view of the students' experiences and perceptions.

To solicit feedback from students regarding our self-study course, we employed an automated questionnaire distributed via email. This questionnaire assessed the efficacy of formative assessments in their learning journey. To maintain objectivity, responses were anonymized. The questionnaire comprised two sections: 18 closed-ended questions, rated on a Likert scale ranging from 5 to 1, and 6 open-ended questions designed to elicit detailed comments.

We systematically categorized the closed-ended questions thematically to scrutinize our hypotheses. This approach enabled us to glean invaluable insights into the influence of formative assessments on students' learning, all while considering their unique perspectives.

Table 1: Closed questions by theme.

<i>Theme</i>	<i>Questions</i>
Efficiency of Multiple-Choice Questions (MCQs)	Q1: Did the MCQs foster a deeper understanding, rather than solely assessing memorization? Q2: Did the MCQs assist in identifying and addressing knowledge gaps?
Alignment of Question and Answer Format	Q3: Were the MCQs suitable for assessing comprehension? Q4: Were the responses to the MCQs nuanced or easily guessable?
Use of Degrees of Certainty	Q5: Did the degrees of certainty encourage thorough consideration before responding? Q6: To what extent did they assist in accurately gauging the level of certainty? Q7: How effectively were you able to assess your level of certainty and analyze the coherence between responses and performance? Q8: How would you overall evaluate the use of MCQs with DC?
Effectiveness of Feedback and Summary Sheets	Q9: Did the performance indicator sheets help in evaluating your understanding? Q10: Did they contribute to reflection on your skills and learning improvement? Q11: Were they useful in assessing your own learning? Q12: To what extent did they assist in identifying your strengths and weaknesses? Q13: Did they facilitate reflection on the learning process and improvement strategies? Q14: What is the frequency of using the sheets, pedagogical support, and learning assistance? Q15: How do you evaluate the clarity and relevance of the explanations in the sheets and pedagogical support?
Self-assessment and Realism	Q16: Have you noticed a tendency to overestimate or underestimate your responses when using degrees of certainty? Q17: To what extent do you think this has influenced your learning and results? Q18: How do you believe assessments, including MCQs with degrees of certainty, have enhanced your self-assessment and perception of realism in learning?

The open-ended questions allowed students to share their opinions and provide suggestions. The table below presents these questions, covering various aspects of the assessment methodology in the self-study system. They addressed their experience with MCQs, Degrees of Certainty, summary sheets, feedback, tendencies to overestimate or underestimate responses, and provided relevant comments. Some of these responses will be used in our discussion to support our arguments.

Table 2: Open-ended Questions Asked.

N°	Question
Q1	Are there aspects of this evaluation method throughout self-study that could be changed or improved to enhance your motivation to participate actively?
Q2	How could we improve the MCQs to more accurately assess your learning and proficiency in the subject studied?
Q3	Do you have any suggestions for enhancing the evaluation method using MCQs with degrees of certainty?
Q4	Do you have any suggestions to improve the content or presentation of the sheets containing information about your understanding and reflection on the subject studied?
Q5	How do you think being aware of your tendency to overestimate or underestimate your responses can help you improve your learning in the future?
Q6	Would you like to add any additional comments or suggestions regarding this experience?

5.2.1 Analysis and Discussion of Qualitative Findings

In this section, we will examine the feedback from students who participated in this experience. The conclusions drawn from the analysis of student responses, presented in the figure below, prompt us to reconsider our initial hypotheses and provide answers to our research question: To what extent can the use of formative assessments involving Multiple Choice Questionnaires (MCQs) accompanied by degrees of certainty contribute to the improvement of their learning as well as their cognitive and metacognitive skills?

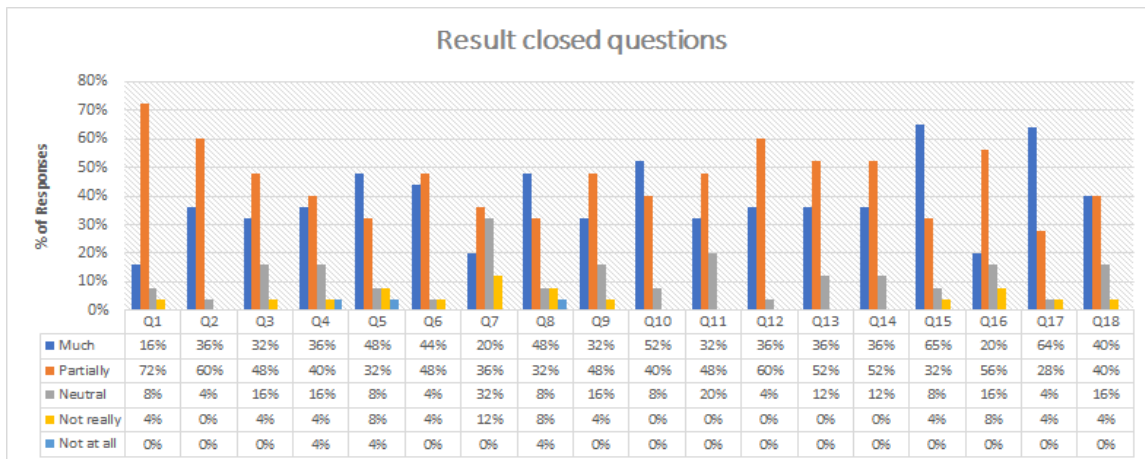


Figure 5: Analysis results for Closed Questions.

The analysis of the results shows that the vast majority of students (88%) believe that MCQs assessed their in-depth understanding of the subject studied (Q1). This finding suggests that MCQs go beyond mere memorization [3], allowing students to demonstrate depth of understanding and critical thinking [18]. This observation is encouraging, as it indicates that MCQs have succeeded in measuring the depth of understanding, which is essential for supporting learners' learning improvement.

Formative assessments were crucial in helping students identify and address their gaps (Q2), with a strong consensus in this regard (96%). This finding underscores the importance of these assessments in promoting autonomous learning and awareness of individual student needs, in line with [19].

80% of students believe that MCQs were an appropriate format to assess their understanding and knowledge (Q3). This correspondence with the common use of MCQs as an assessment tool in various educational contexts highlights the validity of this format, especially in self-directed learning where understanding underlying concepts is crucial as also emphasized by [20,3].

Regarding the response to Q4, students highlighted the nuance of the choice options, which required deep reflection [3]. However, some found certain answers more obvious than others, indicating room for improvement. Overall, the format of MCQs stimulated reflection while avoiding overly obvious answers.

The integration of degrees of certainty into MCQs (Q5 to Q8) had a positive impact, with the majority of students (92%) reporting better decision-making and deeper reflection. These MCQs aiming to assess critical thinking [21] and analysis allowed students to develop reflective learning and become aware of their knowledge and confidence in it [7]. The vast majority of learners (92%) found this approach useful in identifying their gaps. These results support the importance of formative assessments in promoting autonomous learning and awareness in the knowledge acquisition process [22]. In summary, these results confirm our hypotheses (H1, H2 & H3) that the use of MCQs accompanied by degrees of certainty would promote learning regulation and help students identify their gaps for continuous improvement of their performance.

Feedback based on remediation, summary sheets, and performance indicators (Q9 to Q15) were well-received by students, with 96% of them noting an improvement in their performance due to this feedback. These results align with the work of [1] on the effectiveness of feedback in improving student learning. The widespread use of this feedback, pedagogical support, and performance indicators (88%) testifies to their appreciation by learners, thereby reinforcing their autonomy and motivation. The clarity and relevance of the comments are also well-perceived (88%), although it is essential to maintain the consistency of these observations and encourage active student engagement in receiving feedback [23, 24]. Furthermore, performance indicators have a positive impact on reflection and learning improvement (92%), playing a crucial role in identifying learners' strengths and weaknesses according to 96% of students. These results thus confirm the relevance of our hypothesis H4.

An intriguing trend emerges among students, where 56% tend to underestimate their responses when using degrees of certainty (Q16), perhaps in order to encourage deep reflection and avoid excessive overestimation. This result confirms hypothesis H5. It is interesting to note that this trend is related to students' level of realism, where high realism is associated with more accurate assessment. However, despite this underestimation, 80% of students believe that the continued use of formative assessments via MCQs with degrees of certainty has improved their ability to self-assess and their realistic perception of learning (Q17 and Q18). This creates an apparent divergence to be explored in more detail with the quantitative results of the formative assessments.

The analysis of responses to open-ended questions showed that students were overall satisfied with our approach to learning improvement, which aligns with the results of previous studies [25, 26]. They particularly appreciated differentiated, continuous, and detailed feedback, which is in line with the work of [1, 27, 28], who demonstrated the positive impact of feedback on motivation, active engagement in learning, and learner autonomy, as also emphasized by [29].

Students' suggestions highlighted the importance of interactive feedback, timely receipt of feedback, thorough revision, external rewards for motivation, and clarification of learning objectives. These recommendations align with previous research on extrinsic motivation [30] and the importance of clarity of objectives [31].

Furthermore, students suggested the inclusion of MCQs based on real-life scenarios and authentic situations to assess the application of knowledge in practical contexts, which corresponds to the idea of authentic assessment supported by another research [3, 4, 33].

This initial analysis of student feedback testifies to their overall satisfaction with our approach to learning improvement, while highlighting areas of potential improvement to make the self-directed learning experience more engaging and accurate. Future studies with larger samples will be necessary to validate these conclusions.

6. CONCLUSION AND OUTLOOK

Our research highlights the remarkable effectiveness of formative assessments involving Multiple Choice Questionnaires (MCQs) accompanied by confidence levels in significantly enhancing student learning and cognitive skills. The results demonstrate a positive progression in self-assessment of skills over time, emphasizing the significant impact of this approach on students' perception of their own abilities. Importantly, this method also encourages a deeper understanding of the subject matter, prompting students to move beyond mere memorization and engage in critical thinking.

Furthermore, the introduction of confidence levels prompts student engagement in metacognition, a crucial aspect of contemporary education. The exercise of realism becomes, in essence, a metacognitive process that encourages students to target areas of the course where their understanding

is less solid. This enables them to gauge their learning against the course expectations while thoroughly analyzing their strengths and weaknesses.

It would be particularly enriching to deepen our understanding of the underlying factors behind the observed trends, especially those influencing initial overestimation and underestimation in certain students. This endeavor would allow for a better grasp of the cognitive and psychological mechanisms at play.

In this regard, a more in-depth study with larger sample sizes could prove pivotal. It would corroborate established findings while offering additional perspectives on the effectiveness of this innovative approach in the realm of formative assessment.

Another intriguing question arises regarding confidence levels: is it plausible that students with no prior knowledge in the subject are more inclined to underestimate themselves compared to those with some basic understanding, and vice versa? This nuance warrants thorough investigation.

Finally, to further enhance evaluation methods, it would be relevant to explore real-life scenarios and authentic situations to assess the practical application of knowledge. This approach, aligned with the concept of authentic assessment, offers an innovative perspective for evaluating students' skills in real-world contexts.

In conclusion, our research unequivocally underscores the substantial impact of formative assessments integrating MCQs and confidence levels. It paves the way for a thorough examination of students' metacognitive processes, while encouraging further in-depth studies to refine and broaden our conclusions.

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