Metacognition and self-assessment in informatics classes: exploring the impact of assessment criteria, motivation, and task complexity

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Abstract: *Metacognition and self-assessment are important in learning and cognitive development. Metacognition, the awareness and understanding of one's cognitive processes, plays a crucial factor in enhancing learning and performance by enabling students to understand how they think, plan, and monitor their thinking strategies. Self-assessment allows students to become more effective, independent, and adaptable learners.*

This research focuses on exploring the role of metacognition in the context of informatics classes, particularly aiming at self-assessment techniques. The study investigates the correlation between metacognitive awareness and self-assessment, as well as the influence of motivation, task complexity, and assessment criteria on metacognitive processes. Data was collected through a survey of 72 high school students in Chisinau, the Republic of Moldova. The results demonstrate a significant improvement in metacognitive strategies and self-assessment practices, emphasizing the importance of fostering metacognitive skills in informatics education. The study proposes evidence-based recommendations for teachers to enhance metacognition and self-assessment practices, leading to improved learning outcomes and academic achievements in informatics.

Keywords: Metacognition, Self-assessment, Metacognitive Strategies, Assessment Criteria, Motivation.

1. Introduction

Metacognition is a key concept in cognitive psychology and education, referring to the awareness and understanding of one's cognitive processes. It involves reflecting on one's thinking, knowledge of how the mind operates, and the capacity to monitor, control, and regulate cognitive activities. The concept of metacognition gained attention as a distinct research focus in the early 1970s, although educators and psychologists had observed the underlying knowledge and skills for many years. The theoretical contributions of James, Piaget, and Vygotsky established the foundation for this concept. Flavell and Wellman (1975), American psychologists, provided an initial definition of metacognition as "cognition about a

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type of human activity" (p. 5), which is associated with social cognition. He categorizes metacognitive knowledge into three types: knowledge of personal variables, task variables, and strategy variables. Further, research on metacognition has expanded, encompassing increasingly broader areas. Researchers commonly employ various working definitions of metacognition and its specific components. These components include reflection on one's thinking (Azevedo, 2020; Rodgers, 2002; Topping, 2018), self-regulated learning (Chytry & Medova, 2022; Drigas & Mitsea, 2021; Rican, Yong & Sokumaran, 2023), critical thinking (Ku & Ho, 2010; Rivas, Saiz & Ossa, 2022; Angelelli et al., 2023), problem-solving (Gick, 1986; Fyfe, Borriello & Merrick, 2023; Renkl & Atkinson, 2003), mindfulness (Daniel et al., 2023; Hirshberg et al., 2020), goal setting (Chang et al., 2018; Vieira & Grantham, 2011), self-assessment (Gutu, 2022a; Wong & Taras 2022; Wride, 2017), and more others. Overall, metacognition encompasses a wide range of con-cepts within educational research, with a focus on practical implications and applications across various aspects of the learning process. By promoting academic achievement and personal growth, metacognition plays a significant role in education.

Metacognition and self-assessment are closely interconnected in the realm of learning and cognitive processes. Metacognition refers to the higher-order cognitive process of thinking about thinking. It involves being aware of one's own thoughts, knowledge, and learning strategies. It encompasses various activities such as planning, monitoring, and evaluating one's learning experiences. Essentially, metacognition allows students to become active and reflective learners, enabling them to make informed decisions about how to approach different learning tasks and adapt their strategies based on their understanding of the material.

Self-assessment, the factors that affect data processing (Drigas & Mitsea, 2021), within the context of metacognition, is the act of evaluating one's knowledge, skills, and performance. It involves critically reflecting on one's learning progress and outcomes. By engaging in self-assessment, students utilize their metacognitive abilities to assess their level of understanding, identify areas of strength and weakness, and set meaningful learning goals. Through self-assessment, students gain insights into their learning processes and can adjust their strategies to improve their learning outcomes. Thus, self-assessment can serve as a formative assessment tool, allowing teachers to determine students' performance and estimate their learning progress (Gutu, 2023).

The connection between self-assessment and metacognition is evident in how they reinforce and support each other. Engaging in self-assessment requires metacognitive awareness, as students need to be able to accurately monitor and evaluate their performance. On the other hand, self-assessment enhances metacognitive skills by encouraging students to think critically about their learning approaches and adapt their strategies accordingly.

Moreover, self-assessment helps students become more independent learners, as they learn to take control of their learning and make informed decisions

about their studies (Gutu, 2022a). It fosters a deeper understanding of one's strengths and weaknesses, allowing students to focus on areas that need improvement. Additionally, self-assessment promotes a growth mindset, where students see challenges as opportunities for growth and continuous improvement.

Furthermore, self-assessment is an essential element of the metacognitive process. According to Gutu (2022), self-assessment empowers students to become more effective, independent, and adaptable learners, ultimately leading to enhanced academic achievement and lifelong learning success.

Therefore, this research aims to delve into the profound impact of metacognition in informatics classes and its influence on learning outcomes and performance, with a particular emphasis on the utilization of self-assessment techniques. The purpose is to explore how students' awareness and regulation of their cognitive processes shape their learning experiences in the context of informatics. By investigating this intricate relationship, the study endeavours to identify and uncover effective strategies and tools that can effectively enhance metacognitive skills among informatics students. This includes examining the diverse metacognitive processes, such as self-reflection, self-monitoring, and self-assessment, and their specific role in improving learning outcomes and performance in the Informatics. Through a comprehensive analysis, the study aims to contribute valuable insights to optimize metacognitive skills among informatics students. Consequently, it aims to enhance academic achievements in the informatics discipline and promote a varied understanding of the importance of Informatics in everyday life.

2. Methodology

In the realm of education, understanding the factors that contribute to effective learning outcomes has always been a focal point of research. In the context of informatics classes, where students are exposed to complex and dynamic challenges, the role of metacognitive awareness (Jaleel & P., 2016) and self-assessment (Gutu, 2022a) becomes increasingly significant. The study seeks to explore and uncover the correlation between metacognition, self-assessment, and various factors that influence the learning experience in informatics education. It was conducted during one academic semester (January - May 2023) in the Informatics classes at Lyceum "Vasile Vasilache" in Chisinau, the Republic of Moldova. The Informatics subjects are structured into both mandatory modules and optional modules for each academic year (Gutu, 2022a).

The first objective of this study is to delve into the relationship between metacognitive awareness and self-assessment in informatics classes. It entails an investigation into how students' awareness of their cognitive processes influences their ability to assess accurately their learning progress and performance.

The second objective is to identify the impact of students' engagement,

motivation, and self-regulated learning on metacognitive processes within the context of the informatics discipline.

The third objective aims to explore how students adapt their metacognitive approaches when faced with tasks of varying levels of difficulty or complexity in informatics classes. Understanding how students tackle challenges of different complexities will enable us to make informed recommendations on tailoring instructional methods to enhance metacognition for specific tasks.

The fourth objective focuses on evaluating the effectiveness of assessment criteria in fostering metacognition and self-assessment in informatics classes. Efforts have been made to understand how students' comprehension of assessment standards influences their ability to critically evaluate their performance and identify areas for improvement. This insight will be instrumental in refining assessment practices to better support metacognitive development.

Finally, the fifth objective of this study is to propose evidence-based recommendations for teachers and educational institutions to enhance metacognition and self-assessment practices in informatics classes. By drawing on the findings from the preceding objectives, we aspire to provide actionable insights for teachers to foster a more effective and self-directed learning experience for students. These recommendations will contribute to the continuous improvement of informatics education and empower students to become proficient and confident learners.

Building upon the study objectives, several hypotheses have been developed to investigate rigorously the relationships between various variables in informatics education as follows:

Hypothesis 1: There is a significant positive relationship between metacognitive awareness and self-assessment among students in informatics classes.

Hypothesis 2: Motivation significantly affects students' metacognitive processes and self-assessment practices in informatics classes, with higher levels of motivation leading to more effective metacognition and self-assessment.

Hypothesis 3: Learning task complexity significantly affects students' metacognitive strategies and self-assessment accuracy in informatics classes, with higher complexity tasks leading to more adaptive metacognitive approaches.

Hypothesis 4: The assessment criteria significantly affect students' metacognitive awareness and accuracy in self-assessment in informatics classes, with well-defined assessment criteria leading to improved metacognition and self-assessment practices.

Metacognition encompasses a range of cognitive processes that facilitate self-awareness, self-regulation, and self-directed learning. Consequently, the research is focused on the following three metacognitive processes such as self-reflection, self-monitoring and self-assessment. Self-reflection is a metacognitive

process (Azevedo, 2020) that involves introspection and critical examination of one's cognitive processes, knowledge, and experiences. It requires students to engage in a thoughtful analysis of their thoughts, engagements, and learning outcomes. Through self-reflection, students can gain a deeper understanding of their strengths and weaknesses, identify areas for improvement, and recognize patterns or preferences in their thinking. This introspective process encourages students to evaluate their learning strategies, set meaningful goals, and make knowledgeable decisions about future learning accomplishments.

Self-monitoring is another essential metacognitive process (Yong & Sokumaran, 2023) that entails the continuous observation and evaluation of one's cognitive processes during a learning task. It involves being actively aware of own attention, comprehension, and progress about the task. By engaging in self-monitoring, students can identify potential gaps in their understanding, detect errors or misconceptions, and regulate their learning strategies accordingly (Wirth & Leutner, 2008). This ongoing monitoring allows students to adapt their approaches, redirect their attention, and seek clarification or additional resources when necessary.

Self-assessment is a metacognitive process that involves evaluating and judging one's learning outcomes and performance (Wride, 2017). It enables students to critically analyze the quality, accuracy and effectiveness of their work. Through self-assessment, students can assess the extent to which their learning objectives have been achieved, assess the appropriateness of their strategies, and recognize areas where further improvement is needed (Gutu, 2022a). By engaging in this reflection process, students obtain valuable feedback, provided by the teacher or the student alone, by reflecting on the task completed by him/her in accordance with the assessment criteria, which can inform future learning efforts and help them to improve metacognitive strategies. Moreover, analyzing grading against the assessment criteria and specific student work also establishes a meaningful dialogue between students and teachers (Wong & Taras, 2022).

These metacognitive processes are interdependent and mutually reinforcing, as each process informs and influences the others. Self-reflection initiates the metacognitive cycle by encouraging students to engage in introspection and analysis, leading to a heightened awareness of their cognitive processes. This awareness then facilitates self-monitoring, enabling students to actively observe and regulate their thinking during a learning task. Finally, self-assessment completes the cycle by allowing students to assess the outcomes of their efforts and make decisions about future learning goals.

The teacher can facilitate the development of these metacognitive skills by providing opportunities for reflection, promoting self-monitoring practices, and fostering a culture of constructive self-assessment within educational settings. Certainly, the essential role of guiding the students in the learning process belongs to the teacher. Therefore, the application of metacognitive processes requires the

involvement of well-established criteria provided by teachers or students for each task. In addition, a diverse range of tutorials, encompassing text-based, video-based, presentation-based, and podcast-based formats, should be available for each topic, created or selected by the teacher and delivered to students. These tutorials have to provide diverse levels of difficulty and complexity, adapting to students' learning styles. Additionally, a comprehensive set of learning strategies should be designed to align with each student's identified learning styles.

Moreover, an essential feature in triggering metacognitive processes in students is their awareness and understanding of their learning style. Understanding own learning style is an essential aspect of metacognition because it allows students to recognize how they best absorb and process information. By recognizing their learning style, students can tailor their study techniques to align with their strengths. This self-awareness empowers students to choose learning methods that resonate with them, making the learning process more enjoyable and effective. Furthermore, students can become more effective and autonomous learners, empowering them to achieve better academic results and fostering a lifelong love for learning.

Significantly, the application of learning style questionnaires in schools for students is highly beneficial in understanding individual learning preferences and tailoring instruction accordingly (Gutu, 2022b). Therefore, in the case of this research, it was selected three widely recognized learning style questionnaires that can be used in schools: the Index of Learning Styles Questionnaire, the Honey and Mumford Learning Styles Questionnaire, and the Learning Style Inventory Questionnaire. The application of these learning style questionnaires in schools enables teachers to gain insights into students' preferred learning styles. By incorporating this knowledge into their teaching practices, teachers can create a more inclusive and engaging learning environment, ensuring that instruction aligns with students' individual preferences and maximizing their learning outcomes.

Another essential factor in fostering metacognitive processes involves offering students a compilation of metacognitive methods and strategies. In the context of this experiment, the following metacognitive strategies were provided as follows: Self-Assessment, Goal Setting, Think-Aloud Technique, Learning Journals, Concept Mapping, Breakdown of Complex Problems, Peer Discussions and Feedback, Error Analysis, Time Management, Regular Reviews, Scaffolding, Conceptual Questions, Visualization and Analogies, Learning Reflections, Self-Explanation, Mindful Learning, Use of Study Tools, Collaborative Learning, Celebrate Progress, Revision Strategies, Growth Mindset, and more. To make these strategies visible, they were integrated with the proposed tasks, whether in the classroom or outside of it. The selection of strategies was based on the specific activity to be taught, the student's learning style, the level of information acquisition, prior knowledge, engagement, monitoring, and motivation. Additionally, it was implemented flipped classroom strategy and transmedia learning activities (Gutu, 2019) for fostering self-reflection, self-monitoring, and self-assessment.

3. Results

In order to contextualize the findings, in this study, the survey method was employed to investigate how assessment criteria, student motivation, and task complexity influence metacognitive processes. The survey method was employed to collect data from 72 high school students (33 students from the humanistic profile and 39 students from the science profile), utilizing a questionnaire consisting of 32 questions categorized into four sections. The sections include "Metacognitive Awareness and Self-Assessment in Informatics Classes", "Motivation and Metacognitive Processes in Informatics Classes", "Learning Task Complexity and Metacognitive Strategies in Informatics Classes", and "Assessment Criteria and Metacognitive Awareness in Self-Assessment". Each section comprises eight questions (See Table 1 for details). The questionnaire items were formulated using a combination of Likert Scale and Rating Scale. Pre-test and post-test data were collected. A five-point scale was utilized for responding to the questions, with one denoting strong disagreement, two indicating disagreement, three representing weak agreement, four signifying agreement, and five representing strong agreement. The questionnaire was designed to gather anonymous and voluntary feedback from the students.

Table 1. Questionnaire Items and Categories

No	**The questionnaire Items and Sections**
Section 1. Metacognitive Awareness and Self-Assessment in Informatics Classes	
1.	I am aware of the strategies I use to solve problems in informatics.
2.	I reflect on my informatics learning experiences to improve my future performance.
3.	I struggle to evaluate objectively the quality of my informatics assignments.
4.	I am confident in my ability to assess my understanding of informatics concepts accurately.
5.	My self-assessment of my informatics skills aligns with external feedback (e.g., grades, teacher feedback, and classmate's feedback).
6.	I regularly review my self-assessment and adjust my learning strategies.
7.	I am aware of my learning and actively participate in self-assessment activities.
8.	I actively monitor my understanding of informatics concepts during learning activities.
Section 2. Motivation and Metacognitive Processes in Informatics Classes	
1.	I am motivated to excel in my informatics studies.
2.	I am interested in pursuing a career related to informatics.
3.	I am fearless in seeking help when I encounter difficulties with informatics topics.
4.	I actively seek to understand complex informatics concepts.
5.	I believe that my efforts and persistence will lead to better learning outcomes.

6.	I set specific goals to enhance my understanding of informatics topics.
7.	I am engaged in informatics self-assessment activities because they are personally meaningful to me.
8.	I am willing to put in extra effort to improve my informatics learning.
Section 3. Learning Task Complexity and Metacognitive Strategies in Informatics Classes	
1.	I use different metacognitive strategies when facing complex informatics tasks.
2.	I find it challenging to self-assess my performance in highly complex informatics tasks.
3.	I can assess accurately my performance on highly complex learning tasks.
4.	I am confident in my ability to identify effective metacognitive strategies for different levels of task complexity.
5.	I believe that metacognitive strategies are crucial for succeeding in Informatics tasks of varying complexities.
6.	It takes me more time than usual to reflect on my understanding when dealing with complex informatics concepts.
7.	I adjust my learning approaches based on the complexity of informatics assignments.
8.	I think the accuracy of my self-assessment on complex learning tasks improves with experience and practice.
Section 4. Assessment Criteria and Metacognitive Awareness in Self-Assessment	
1.	The assessment criteria provided by teachers influence my metacognitive awareness while working on learning tasks.
2.	Well-defined assessment criteria help me understand what is expected in my informatics assignments/evaluations.
3.	Clear and specific assessment criteria help me evaluate my achievements more easily, leading to more accurate self-assessments over time.
4.	I actively consider the assessment criteria while assessing my performance in the informatics tasks.
5.	Clear assessment criteria help me identify areas of improvement and areas where I excel in my learning tasks.
6.	I adjust my self-assessment process based on the provided assessment criteria.
7.	I am confident in applying metacognitive strategies effectively when the assessment criteria are ambiguous or undefined.
8.	Transparent and well-communicated assessment criteria contribute to a fair and reliable self-assessment process.

The first section (Hypothesis 1) of the questionnaire (Table 1) focused on exploring the level of metacognitive awareness among students and its influence on self-assessment in the Informatics classes. Based on the provided data for Hypothesis 1 (science profile) and using a paired two-sample t-test for means, the analysis reveals that the p-value (0.000183968) is significantly less than 0.05. Therefore, these results indicate a significant difference between the means of the

pre-test and post-test scores for Hypothesis 1 (science profile). The post-test mean is higher than the pre-test mean (see Table 2), which affirms a definite improvement in the variable being measured. Moreover, the analysis of the data for Hypothesis 1 (humanistic profile), similarly shows a significant difference between the means of the pre-test and post-test scores (see Table 3) and the p-value (0.000019527) is significantly less than 0.05.

Table 2. Paired Two Sample t-Test Results - Science Profile

	Hypothesis 1	**Hypothesis 2**	**Hypothesis 3**	**Hypothesis 4**
Pre-test Mean	2.804487179	2.910256410	2.858974358	3.663461538
Post-test Mean	3.041666667	3.150641025	3.019230769	3.923076923
p-value	0.000183968	0.000019527	0.001371241	0.000209954

Table 3. Paired Two Sample t-Test Results - Humanistic Profile

	Hypothesis 1	**Hypothesis 2**	**Hypothesis 3**	**Hypothesis 4**
Pre-test Mean	2.541666667	2.674242424	2.518939393	3.530303030
Post-test Mean	2.825757576	2.931818181	2.704545454	3.803030303
p-value	0.000019527	0.000007920	0.000131879	0.000025771

The second section of the questionnaire (Table 1) delved into the interaction between student motivation and metacognitive processes within the context of informatics classes. Based on the provided data for Hypothesis 2, science profile (Table 2), and humanistic profile (Table 3), the analysis reveals that the post-test mean is higher than the pre-test mean for both profiles, suggesting an improvement in the variable being measured. Furthermore, both p-values are significantly less than 0.05, indicating an improvement in metacognitive processes and self-assessment practices. This provides evidence in favour of Hypothesis 2, suggesting that higher motivation levels are associated with more effective metacognition and self-assessment.

The third section of the questionnaire (Table 1) aimed to investigate the effect of learning task complexity on students' metacognitive strategies. The analysis of the data for Hypothesis 3, in both the science profile (Table 2) and humanistic profile (Table 3), indicates that the post-test mean surpasses the pre-test mean, indicating an improvement in the measured variable. Moreover, both p-values are considerably less than 0.05, further supporting these findings. The data demonstrates that the post-test mean is higher than the pre-test mean, which suggests an improvement in metacognitive strategies and self-assessment accuracy. This supports Hypothesis 3, indicating that learning task complexity influences metacognitive approaches.

The fourth and final section of the questionnaire (Table 1) examined the correlation between assessment criteria and metacognitive awareness in the context of self-assessment. The examination of the data for Hypothesis 4, in both the science profile (Table 2) and humanistic profile (Table 3), reveals that the post-test mean exceeds the pre-test mean, indicating a noticeable improvement in the

measured variable. Additionally, both p-values are markedly less than 0.05, suggesting improvement in metacognitive awareness and self-assessment accuracy. The data unmistakably illustrates that the post-test mean is higher than the pre-test mean, thereby confirming hypothesis 4.

Completely, both analyses indicate a significant difference between the means of the pre-test and post-test scores for Hypothesis 1 in both the humanistic and science profiles. In both cases, the post-test means are higher than the pre-test means, suggesting an improvement in the variables being measured for both groups. The strong positive correlations between the pre-test and post-test scores further support this finding.

In the overall analysis of the average increased points per hypothesis for both the Science Profile and Humanistic Profile, as depicted in Figure 1, it is evident that both profiles exhibit an overall positive trend in the average increased points for each hypothesis. The results suggest noteworthy improvements in students' metacognitive strategies and self-assessment practices across the hypotheses in both profiles. These findings highlight the effectiveness of the interventions and the importance of fostering metacognitive skills and self-assessment practices in informatics classes, regardless of the profile. These improvements are likely to contribute to better learning outcomes and academic success for students in these classes.

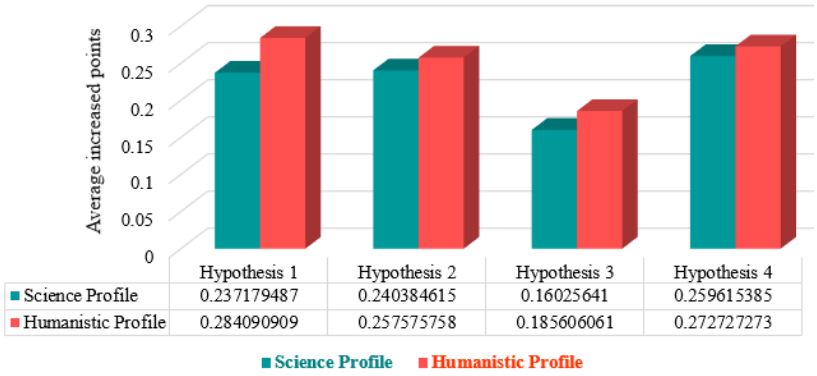

Figure 1. Average Increased Points per Hypothesis

Additionally, a comprehensive questionnaire was distributed to gather students' perspectives, aiming to acquire detailed information, insights, and opinions on various aspects of metacognitive processes, self-assessment, assessment criteria, motivation, and handling complex learning tasks within informatics classes. The primary goal was to design and refine the future teaching-learning approach to cater to the specific needs of the students.

The questionnaire comprised 17 questions and was voluntarily completed by students who actively participated in the effort to improve the teaching-learning approach. It gathered well-motivated and coherent responses, which offered

valuable insights into various aspects related to academic performance and the learning experience in Informatics classes. Nonetheless, it is important to note that some answers were vague, biased, or lacked clarity and meaning.

Conducting a qualitative analysis of the distributed questionnaire and the collected answers has provided us with a profound understanding of the influence of metacognition strategies and self-assessment on students' outcomes. These valuable insights will be significant in improving teaching practices, learning activities, and curriculum development in the Informatics classes. Consequently, the analysis of the collected answers is presented on a per-question basis, as outlined below:

1. Have you noticed any changes in your academic performance in the Informatics discipline since becoming more aware of metacognitive strategies? If yes, please write about it.

Students generally agreed that metacognitive strategies positively influenced their academic performance in the Informatics. They expressed that being more aware of these strategies led to improvements in their learning approach and understanding of the subject matter.

2. Which metacognitive strategies do you find most effective in improving your learning and problem-solving? You can choose multiple options. Journaling; Setting clear goals and objectives; Monitoring your understanding and progress; Using specific learning techniques (e.g., summarization, self-questioning); Seeking help or guidance when faced with difficulties; Taking breaks and allowing time for reflection; Using metacognitive apps or tools; Seeking feedback from others (e.g., friends, parents, teachers); Other (please specify).

The most commonly mentioned effective metacognitive strategies were journaling, seeking help/guidance when faced with difficulties, and goal setting. Students appreciated the benefits of journaling, which helped them reflect on their progress and solidify their understanding. Setting clear goals was seen as essential for staying focused and motivated throughout their studies. Seeking help or guidance when faced with difficulties helps them to overcome difficulties and reach their full potential. Additionally, students mentioned other metacognitive strategies, including time management, revising and reviewing, peer teaching, self-assessment, and scaffolding learning.

3. When faced with challenging tasks in your informatics classes, how do you apply metacognitive strategies to regulate your learning process and make informed decisions? Please describe the steps you take and any particular metacognitive techniques you find most helpful.

When facing challenging tasks in Informatics, students relied on metacognitive strategies to overcome obstacles. Breaking down complex problems into smaller parts and seeking help from teachers, peers, or online communities were common approaches mentioned by students.

4. Are you comfortable with self-assessment in your informatics classes? Not at all comfortable; Slightly comfortable; Moderately comfortable; Very comfortable; Extremely comfortable.

The students varied in their comfort level with self-assessment. While most felt moderately or highly comfortable with it, a few students were at the extremes, either not comfortable at all or exceptionally comfortable with the self-assessment process.

5. Have you noticed any significant changes in your self-assessment accuracy over time? If yes, what factors do you attribute these changes to?

Students reported improvements in their self-assessment accuracy. Regular practice and feedback from teachers were cited as contributing factors to this growth.

6. Can you identify any specific instances where self-assessment has played a significant role in improving your understanding of the subject matter and academic performance?

Self-assessment was identified as a key factor in improving academic performance. Students shared how evaluating their work against assessment criteria helped them identify strengths and weaknesses, leading to targeted improvements.

7. When you receive feedback on your academic work, how do you use metacognitive strategies to reflect on the assessment criteria and understand where you met or missed the expected standards?

Students used metacognitive strategies to analyze feedback on their academic work. They emphasized the importance of aligning feedback with assessment criteria to gain insights into their performance and identify areas for improvement.

8. Can you provide examples of how metacognitive awareness has influenced the way you interpret feedback, make adjustments in your subsequent work, and continuously improve your performance in alignment with the assessment criteria?

Metacognitive awareness significantly influenced students' interpretation of feedback. They expressed how aligning feedback with assessment criteria allowed them to make meaningful adjustments in subsequent work, leading to continuous improvement. Most of the examples provided were taken from programming modules, thus suggesting that the topics covered in these modules are the ones causing the most concern among students.

9. When faced with project-based learning or complex tasks, how do you engage in setting your assessment criteria to guide your self-assessment process?

Some students considered their learning process by establishing their assessment criteria, based on a clear understanding of the project requirements. They highlighted the importance of breaking down complex tasks into smaller

components and creating distinct assessment criteria for each one. Whereas other students acknowledged seeking support from their peers, teachers, or online communities to accomplish the task.

10. How has the practice of setting personal assessment criteria influenced your learning outcomes and overall academic performance?

Students emphasized that establishing personalized assessment criteria had a positive impact on their learning outcomes. This motivation prompted them to assume responsibility for their learning process and actively pursue a comprehensive understanding of the subject matter. While some students found it challenging to establish personal assessment criteria, they recognized that doing so made accomplishing tasks easier and facilitated a deeper understanding of the topic compared to using the criteria provided by teachers.

11. What factors contribute most to your motivation? You can choose multiple options. Intrinsic factors (e.g., personal interest, enjoyment); Extrinsic factors (e.g., rewards, recognition); Support from others (e.g., family, friends, teachers, classmates); Clear and achievable goals; Previous success experiences; Assessment criteria given by the teacher; Other (please specify).

On this particular question, we couldn't get clarity since nearly all students selected all the bullet points from the provided list. This entails that the teachers have to consider all these factors during the teaching-learning process.

12. How does your motivation change after engaging in self-assessment and identifying areas for improvement? Becomes more focused and determined; Remains the same; Decreases slightly; Decreases significantly; Not applicable (I haven't noticed any change).

Engaging in self-assessment consistently motivated participants to improve. Most of the students confirmed that they became more focused and determined in their work.

13. Can you share examples of how being motivated has influenced your ability to plan, monitor, and regulate your learning strategies effectively?

Students highlighted that motivation significantly influenced their learning strategies, e.g. planning their study, seeking additional resources, and dedicating sufficient time and effort to achieve their academic goals. They also noted that when motivated, they were able to work for extended periods and felt satisfaction with the outcomes they attained. The majority of the provided examples were related to project-based learning, case studies, problem-solving, or complex tasks.

14. Reflecting on your informatics learning experiences, can you identify any specific factors that have consistently motivated you to engage in metacognitive processes and self-regulated learning?

Students expressed a consistent motivation to engage in metacognitive

processes and self-regulated learning due to their desire to excel academically and thrive in the field of informatics. The most frequently mentioned factor was the involvement of technology in all areas of daily life, and the students regarded this discipline as highly significant. However, there were also some contradictions in the responses; a few students mentioned that they do not find the relevance of studying informatics because they consider what they learn in the informatics classes is not significant.

15. How often do you encounter learning tasks that you find challenging or complex? (Very Often; Often; Sometimes; Rarely; Never.)

The analysis of the responses to the question revealed a broad spectrum of answers. Most participants selected options ranging from "often" to "rarely," indicating that they encountered challenging or complex learning tasks with varying frequency. Specifically, five students chose "very often," while two students opted for "never." The majority of responses fell within the categories of "often," "sometimes," and "rarely".

16. In your opinion, do the complexity levels of learning tasks align well with the assessment criteria used to evaluate your performance? Yes, perfectly; Yes, to some extent; I am not sure; No, not really; No, not at all.

The analysis of responses to the question indicates that the majority of students expressed satisfaction with the alignment between the complexity levels of learning tasks and the assessment criteria. Specifically, most students chose the option "Yes, perfectly," indicating a strong agreement with the suitability of the assessment criteria. Only a few students selected the option "Yes, to some extent," suggesting a moderate level of alignment for this group. Notably, none of the students were uncertain about the alignment ("I'm not sure"), and no students chose the options "No, not really" or "No, not at all".

17. Do you have any additional comments or suggestions regarding the complexity of learning tasks and the assessment criteria?

Students perceived challenging tasks as opportunities for personal growth. These tasks encouraged critical thinking, the development of problem-solving skills, and the expansion of their knowledge in informatics. Some students mentioned that providing more explicit assessment criteria for learning tasks could enhance their understanding. Additionally, others recommended that teachers offer more guidance on the complexity of tasks and the underlying rationale behind the assessment criteria.

In conclusion, the qualitative analysis of the distributed questionnaire revealed that metacognitive strategies, self-assessment, and motivation played crucial roles in shaping students' academic performance in the Informatics. The insights provided by the students highlighted the significance of incorporating metacognitive strategies and fostering a supportive learning environment in Informatics education.

4. Recommendations

Metacognition is a fundamental concept in cognitive psychology and education, influencing learning outcomes and academic achievements. This research has demonstrated the significant impact of metacognition on informatics education, particularly in terms of self-assessment practices. By examining the relationship between metacognitive awareness and self-assessment, as well as the role of motivation, task complexity, and assessment criteria, the study offers valuable insights for teachers.

The results indicate that fostering metacognitive skills through self-assessment positively influences students' learning experiences in informatics classes. The findings support the notion that metacognitive processes enhance students' abilities to understand, monitor, and regulate their cognitive activities, leading to improved learning outcomes and performance.

Based on the confirming hypotheses that demonstrate a strong correlation between metacognitive processes, self-assessment, assessment criteria, motivation, and complex learning tasks in informatics classes, along with the findings from the additional questionnaire, we present evidence-based recommendations for teachers and educational institutions to enhance metacognition and self-assessment practices:

1. Promote Metacognitive Strategies in the Curriculum: Educational institutions should integrate metacognitive strategies, such as self-assessment, into the curriculum. Providing students with tools and guidance to develop metacognitive skills will empower them to take a more active role in their learning process and improve their understanding of complex concepts.
2. Offer Metacognitive Training for Students: Conduct workshops or training sessions on metacognitive strategies for students. These sessions can help students understand the benefits of metacognition and how to apply these strategies effectively in their studies.
3. Provide Feedback on Metacognitive Practices: Teachers should provide feedback on students' metacognitive practices, encouraging them to refine their approach. Constructive feedback can further enhance students' metacognitive skills and foster continuous improvement.
4. Cultivate a Culture of Self-Assessment: Encourage students to engage in self-assessment regularly. Schools and teachers can guide students on how to critically evaluate their work and provide opportunities for self-assessment as part of the learning process.
5. Offer Training on Objective Self-Assessment: Provide training to students on objective self-assessment techniques. Teaching them how to overcome biases and accurately evaluate their work will lead to more meaningful self-assessment outcomes.

6. Strengthen the Feedback Process: Teachers should provide timely and constructive feedback on students' academic work. Clear and specific feedback, aligned with assessment criteria, will help students understand their strengths and areas for improvement.
7. Enhance Student Motivation: Schools should recognize and celebrate students' achievements in Informatics, fostering intrinsic motivation. Additionally, teachers and parents can provide continuous support and encouragement to maintain students' motivation to excel.
8. Personalized Learning: Encourage students to set their assessment criteria for project-based learning and complex tasks. This personalized approach will empower students to take control of their learning and pursue a comprehensive understanding of the subject.
9. Offer Challenging Learning Opportunities: Provide students with challenging learning tasks that require critical thinking and problem-solving skills. These tasks can serve as opportunities for intellectual growth and deeper comprehension of the subject.
10. Foster Open Communication: Create an environment where students feel comfortable discussing their academic challenges and seeking help when needed. Encouraging open communication between students and teachers can enhance the learning experience and support system.
11. Align Learning Tasks with Assessment Criteria: Ensure that learning tasks align clearly with assessment criteria. Providing explicit explanations of the alignment will enhance students' understanding of the evaluation process and promote a fair assessment.
12. Continuous Professional Development for Teachers: Offer continuous professional development opportunities for teachers to enhance their understanding of metacognitive strategies, self-assessment techniques, and motivational techniques. Well-trained teachers are more capable of providing better support to students in their academic endeavours.
13. Advantage Technology for Self-Assessment: Explore the use of technology tools and platforms that facilitate self-assessment and peer assessment. Digital platforms can provide students with immediate feedback and aid in self-reflection.
14. Create Learning Communities: Foster learning communities where students can collaborate and support each other. Peer-to-peer interactions can enhance metacognitive skills and motivation through knowledge sharing and encouragement.

By implementing these evidence-based recommendations, teachers and educational institutions can foster a culture of metacognition and self-assessment in classes, leading to improved learning outcomes and student success.

5. Conclusion

The study highlights the importance of metacognition in education and its potential to enhance students' academic achievements and personal growth. By integrating metacognitive training, tailoring instructional methods to individual learning styles and providing a variety of metacognitive strategies, teachers can create a more effective and self-directed learning environment for students. Thurthermore, by nurturing metacognitive skills in informatics classes, teachers can empower students to become proficient and confident learners, preparing them for success in their academic and professional pursuits. However, further research and investigations are warranted to delve deeper into the underlying factors and potential variations across different educational contexts.

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