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Metacognition in an educational game guided by the nursing process on electrolyte disorders

Metacognição em um jogo educativo orientado pelo processo de enfermagem sobre distúrbios eletrolíticos

Metacognición en un juego educativo guiado por procesos de enfermería sobre trastornos electrolíticos

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Abstract

Objectives: To describe the metacognitive events contained in nursing students' reports after participating in an educational game and identify the metacognitive operations present in nursing students' reports after their participation. **Method:** This was a qualitative study to understand the events and metacognitive processes of twenty-six students who were engaged in solving a case of electrolyte disturbances and guided by the nursing process. Data were collected by semi-structured interviews, and content analysis was performed with theoretical categories of metacognition for deductive and classificatory procedures. **Results:** Fifteen process and control characteristics were identified during the game, with metacognitive operations from metacognitive events present in the participants' speeches. The phases of anticipation, performance control, and reflective self-regulation were used to classify the fifteen emergent characteristics of the task. **Conclusion:** Participation in an educational game oriented towards learning the nursing process can evidence descriptions of metacognitive events, clarifying mental processes. **Implications for practice:** Knowing the characteristics of a more common metacognitive path can facilitate the teacher's role as a mediator and facilitator of learning in specific aspects.

Keywords: Problem-Based Learning; Games; Metacognition; Nursing Process; Clinical Decision Making.

Resumo

Objetivos: Descrever os eventos metacognitivos contidos nos relatos de alunos de enfermagem após participação em jogo educativo e identificar as operações metacognitivas presentes nos relatos de alunos de enfermagem após participação no jogo educativo. **Método:** Estudo qualitativo para a compreensão de eventos e processos metacognitivos de vinte e seis estudantes engajados na solução de um caso de distúrbios eletrolíticos, orientados pelo processo de enfermagem. Dados coletados por entrevista semiestruturada. Análise de conteúdo com categorias teóricas da metacognição para procedimentos dedutivos e classificatórios. **Resultados:** Foram identificadas quinze características do processo e do controle durante o jogo, com operações metacognitivas a partir de eventos metacognitivos presentes nas falas dos participantes do jogo. As fases de antecipação, de controle da performance e de autorregulação reflexiva foram utilizadas para classificar as quinze características emergentes da tarefa. **Conclusão:** A participação em um jogo educacional orientado à aprendizagem do processo de enfermagem pode evidenciar descrições de eventos metacognitivos, clarificando processos mentais. **Implicações para a prática:** Conhecer as características de um trajeto metacognitivo mais comum pode facilitar a atuação do professor como mediador e facilitador da aprendizagem em aspectos específicos.

Palavras-chave: Aprendizado Baseado em Problemas; Jogos; Metacognição; Processo de Enfermagem; Tomada de Decisão Clínica.

Resumen

Objetivos: Describir los eventos metacognitivos contenidos en los reportes de estudiantes de enfermería luego de participar en un juego educativo e identificar las operaciones metacognitivas presentes en los reportes de estudiantes de enfermería luego de participar en el juego educativo. **Método:** Estudio cualitativo para comprender los eventos y procesos metacognitivos de veintiséis estudiantes involucrados en la solución de un caso de trastornos electrolíticos guiados por el proceso de enfermería. Datos recopilados mediante entrevista semiestructurada. Análisis de contenido con categorías teóricas de metacognición para procedimientos deductivos y clasificatorios. **Resultados:** Se identificaron quince características del proceso y control durante el juego con operaciones metacognitivas a partir de eventos metacognitivos presentes en los discursos de los participantes del juego. Las fases de anticipación, control del desempeño y autorregulación reflexiva se utilizaron para clasificar las quince características emergentes de la tarea. **Conclusión:** La participación en un juego educativo orientado al aprendizaje del proceso de enfermería puede revelar descripciones de eventos metacognitivos, aclarando procesos mentales. **Implicaciones para la práctica:** Conocer las características de un camino metacognitivo más común puede facilitar el papel del docente como mediador y facilitador del aprendizaje en aspectos específicos.

Palabras clave: Aprendizaje Basado en Problemas; Juegos; Metacognición; Proceso de Enfermería; Toma de Decisiones Clínicas.

INTRODUCTION

The training of nurses requires adequate content in different competencies, encompassing patterns of knowledge and skills of a complex order that may reduce students' academic performance if not properly explored. Among the skills that attract attention from researchers in education and psychology, metacognitive skills can be highlighted as crucial and related to learning performance.[1] Pedagogical approaches and strategies have been investigated for their effect on metacognition, and among them, one can include problem-based teaching, the traditional method,[2,3] and simulation with problem-based learning.[4]

Metacognition, a term originally coined by John H. Flavell in 1979, refers to a person's knowledge of their cognitive processes (i.e., the knowledge, awareness, and control of their mental operations). It has also been related to the concept of self-regulated learning, with metacognitive monitoring being understood to imply the student's ability to evaluate their learning and identify needs for changes in the course of action.[5,6]

In the literature, metacognition is often treated at an aggregate level. Sometimes, it is cited as a single phenomenon and associated with various learning or work performance aspects.[7-9] Particularly useful for identifying these phenomena and their different effects on learning is the comprehensive definition of metacognition as a second-level discourse about cognition, characterized as a system of thought focused on human cognitive activity.[10] For the analysis of manifestations of metacognition in human speech and writing, the concept of metacognitive events has been used to indicate occurrences that, because of their characteristics, allow the analyst to infer some metacognitive activity of reflection, control, or monitoring of cognitive processes of the individual, which are contained in the verbal or written message.[9]

In the case of tests such as the Metacognitive Awareness Inventory (MAI), even with some division, metacognition is still seen as an ordinal variable of the "a lot" or "a little" metacognition type.[11] In other cases, it is treated even more abstractly, as is the case of Johnsen,[12] in which metacognition is expressed in the form of "thought processes" such as "making decisions" or "setting priorities."

In the specific conditions of self-regulation of learning, the concept of metacognitive operations has been used to indicate operations performed by the learner to monitor and control cognitive, motivational, metacognitive, and behavioral processes.[13,14] In short, they refer to a "set of actions, where the subject becomes aware of the different moments of their cognitive activity, enabling their development as an autonomous, critical, and intervening subject."[10]

For decades, nursing has recognized the value of metacognition in different fields, such as forming the creative process,[15] instruction in the field,[16] and diagnostic reasoning.[17] In a sense, nursing studies address a perspective of metacognition as a property or instrument that facilitates developing competencies and skills for professional performance. However, a complete understanding of metacognition in the field requires developing research that explores how pedagogical strategies influence metacognitive processes.

In this study, the pedagogical strategy of an educational game is applied as a learning tool for the nursing process, and events and operations of metacognition in students engaged in the task are investigated. Here, metacognition is seen as a dynamic phenomenon and, therefore, allows its description in the process of construction. To this end, the term "metacognitive path" is used further.

Game-based learning is a strategy with benefits that has been published in the nursing literature for years.[18] A recent integrative review[19] updated the topic, now directed to the digital medium, reporting that, although without quantitative data on knowledge retention, digital learning in the form of games, gamification, or scenario-based activities positively affects student motivation and participation.

Nonetheless, the question of how to motivate the expression of metacognition in game-based learning environments remains unclear.[20] The lack of knowledge on the metacognitive process during student participation in educational games may hinder initiatives to build an interactive experience with the task that stimulates self-regulated learning and forms a learner with an appropriate degree of autonomy. Hence, it is highly relevant to investigate the metacognitive events that occur during participation in an educational game to highlight the operations performed by the learner when executing the learning task.

Given the above, this study aimed to describe the metacognitive events[9] contained in nursing students' reports after participating in an educational game and identify the metacognitive operations present in nursing students' reports after their participation.

METHODS

This was a qualitative content analysis[21] study guided by the interpretivist paradigm[22] to understand events and metacognitive processes that are revealed in the experience provided by the educational game entitled "Save the Patient."[23]

"Save the Patient" comprises a board game with cards that simulates patient records at a reduced scale. Data evaluation/collection included a description of the patient's problem, evidence from the physical examination, and other signs and symptoms specific to the electrolyte disturbance, laboratory test results, elements for the nursing diagnosis, and selection of interventions for therapeutic decision making. The game can be played by one player, in pairs, or in triplets.

The participants chose one of five paths characterized by colors to play the game. The nursing process is described in each path, which is traversed by pawns that represent the student-player. A short chart illustrates clinical cases of some of the most common morbid entities for each path, emphasizing the characteristics that will lead to the electrolyte disturbance to be diagnosed.

After correctly answering the name of the disorder, the participant moves on to the nursing diagnosis space, where it is presented to the student. Here, the player chooses diagnoses

for which they will perform the care prescription. The winner is the player who correctly answers the prescriptions for the diagnosis and manages to reach the end of the game, thereby saving their patient.

This study was derived from data obtained while conducting an academic master's dissertation and developed at a nursing school in the city of Rio de Janeiro.[23] During the data collection period, the target audience of the research consisted of all students attending the 5th, 6th, 8th, and 9th terms, totaling 34 students. Seventh-term students were also sought but unavailable due to their practical courses at other partner institutions outside the university.

All 34 students were sought out and personally invited by one of the researchers, who was neither their professor nor had any hierarchical ascendancy over them. The nature, characteristics, and ethical aspects involved in the study were explained during the approach process. Eight students declined the invitation, leaving 26 students who made up the total number of participants; the Informed Consent Form was also presented and signed. It is also worth mentioning that this and subsequent steps were only initiated after approval both of the university and Research Ethics Committee of the Anna Nery School of Nursing (protocol 684.340 and CAAE: 31041014.6.0000.5238). Research subjects are represented by pseudonyms that respect their declared gender.

There were three inclusion criteria; besides agreeing to participate in the study, only those who had formal knowledge about the theme were included, as attested by their approval in the discipline entitled "Health of the Adolescent, Adults, the Elderly, and the World of Work." This discipline is taught in the fifth term and includes, among others, the topics "electrolyte disturbance" and "systematization of nursing care." They also needed to have participated in the educational game "Save the Patient". There were no excluded subjects. All 26 students who agreed to participate played the game actively and enjoyably and later willingly participated in the semi-structured interviews described below.

There were three main reasons for choosing the topic and the game. Firstly, the inclusion criteria, since metacognitive events would be studied in discourses of the game participants. Secondly, diagnosis and treatment were treated objectively in the context of the game. Therefore, the game context reduced the variability of events and intervening circumstances to favor the isolation of the variable under study (i.e., metacognition). Lastly, from the nursing perspective, electrolyte disturbances occur in various health problems across different age groups and, like all other nursing diagnoses and interventions, presuppose the competent use of systematized nursing care.

No saturation criterion was established for two reasons: the census nature of the study, as it had no intention of producing inferences of any kind, and the objectives of the study were to identify and classify metacognitive events in the participants' speeches. In this sense, according to previously established criteria, the mere occurrence of classifiable events allowed not only to satisfy the proposed objectives but also to subsidize to some degree the theorizing efforts, as we presented in the Discussion topic.

The data collection technique was the semi-structured interview,[24] for which a script was built (Chart 1). The interviews were conducted after the different sessions of the game, in which the subjects participated individually, in pairs, or in triplets, according to the specific circumstances of the moment. Each participant's interviews were recorded and transcribed by one researcher and later audited by another. The same procedure was performed during coding and data analysis when the steps were done by one and audited by another. In some cases where doubts arose, the audit was done jointly by the different authors,

Chart 1. Interview script

Guiding questions for the interview
1. Were you able to understand the task proposed by the game?
2. If yes, describe what was covered in the game.
3. What went through your mind the moment the clinical cases were read?
4. What were the main difficulties and facilities you felt in accomplishing the task proposed by the game?
5. How did you get around the difficulties?
6. Can you tell how your mind worked to solve the problems proposed in the game?
7. Do you know why you couldn't win the game?
8. What steps did you take to solve the problem proposed in the game?
9. Which parts did you need to think about the most?
10. What were the strategies you used to try to solve the proposed problem?
11. Which aspect of your performance was particularly important? Why was it important?
12. What is your opinion about the game?

Source: Prepared by the authors.

who organized themselves according to their expertise and/or possibilities. After the transcription, charts were built to allocate the questions and answers from the interview script. Finally, the data were transposed to the Atlas.ti™ Qualitative Analysis software.

For the purposes of this study, in addition to the definitions of metacognition, events, and metacognitive operations, the term "metacognitive path" was used to express, from a metacognitive perspective, the sequence of the student's thinking process. Lastly, the metacognitive categories were presented here as metacognitive knowledge, experience, and skill.[25] Metacognitive knowledge was defined as the declarative knowledge stored in memory regarding cognitive skills and strategies, tasks, and models of cognitive processes such as memory and language. Metacognitive experience was presented as the interface between the person and the task; it is what the person is conscious of, what they feel when facing a task and processing the information related to it. On the other hand, metacognitive skills are the competencies necessary for voluntary control over one's cognitive processes through procedural knowledge expressed through the deliberate use of strategies.

In the coding, the metacognitive activity was initially observed by identifying metacognitive events.[9,26] For instance, in Antonio's speech in the extract "we knew it was a disturbance in the sodium and potassium pump," the passage "we knew" expresses metacognitive activity, insofar as it constitutes an affirmation by the subject about their knowledge (i.e., a second-level discourse about cognition).

The theoretical categories were constructed twice under the metacognitive bias from the metacognitive variables defined by Flavell[5] and Efklides[26] first and then by selecting a representative model of metacognition-related types of thinking that support clinical reasoning in nursing[27] for deductive and classificatory procedures. For example, in Ken's speech, "Oh man, what do I do now? I go to the infirmary and the patient is like this. How will I act to solve the problem?" is an expression of metacognitive skill in the extent to which the student employs a necessary competence for voluntary control over their cognitive processes by means of procedural knowledge.[25] At the same time, it corresponds to a more comprehensive perception about the level of difficulty of the task according to models of self-regulation.[28,29]

For the analysis, the events were organized according to their order of appearance during the student's participation in the game. Then, the logical pertinence of relating one event to another was verified. Finally, by simultaneously considering these two criteria, a narrative describing the student's metacognitive path was constructed (Chart 2).

RESULTS

A total of 432 metacognitive events were identified in the students' speeches, which were approximately homogeneously distributed. Hence, 142 were classified as metacognitive knowledge and distributed among task, person, and strategy. Another 123 were categorized as a metacognitive experience and distributed as awareness about the characteristic of the task, processing result, and feelings of confidence and difficulty. Lastly, the remaining 167 events were classified as metacognitive skills and distributed among evaluation, attention control and regulation, planning, conflict resolution, inhibitory control, and error detection.

Chart 2. Example metacognitive path referring to the participant's thought sequence in the game.

Step 3 of the game: Answer what the electrolyte disturbance is. At the moment of decision-making, the pair must answer or not answer the question. The students move to the next square by answering correctly, while wrong answers mean game over. If they choose not to answer, they are directed to the "worsening" square.
Student's report
Antonio: We knew it was a sodium-potassium pump disorder [metacognitive skill (MS) of working memory regulation], but we couldn't (MS of error detection regulation). I don't know, my anxiety got the best of me, it happened too fast (MS of monitoring/emotional regulation) because I had high sodium, right? But we had hypernatremia, although it was the opposite (MS of evaluation). Catarina: We got the terminologies mixed up too (MS metacognitive assessment), the names, but I think I knew (MS learning judgment).
Metacognitive path
Here, the account refers to a complex evaluative process of the game flow. Antonio evaluated that he knew the diagnosis but did not do it due to this anxiety. Thus, not having correctly used the MS of monitoring/emotional regulation, he inhibited his MS of working memory regulation, which would allow bringing to previously known consciousness contents. Using her MS of evaluation, Catarina reported that she mixed up the terms. In the same sentence, she expressed her MS of evaluation of learning judgment. Both, at this moment and through the skills already mentioned, were able to use their MS of error detection regulation to perform a higher-level synthesis evaluation, encompassing the whole thought process and actions of the third stage of the game.

Source: Prepared by the authors.

Given that the interviews referred to events that occurred throughout each completed game, a narrative was constructed for each game stage, resulting in 72 narratives. For example, in Chart 2, the metacognitive path of two students who participated in a game session together is presented. This path describes their thought process during the third stage (answering the electrolyte disorder) from a metacognitive perspective. Although all 72 narratives were analyzed, presenting them in their entirety would be highly demanding. Nevertheless, for consultation, they are all available at Saraiva.[23]

The analysis of these narratives allowed the different metacognitive paths that described the process of control and monitoring of the participating team during the game to be identified. Despite these differences between the teams, it was possible to clearly perceive the coherence between the actions and thoughts projected by the game builder[23] and the corresponding actions and thoughts observed in the participants' reports. Therefore, according to the analysis of the participants' speeches, we identified five moments and their characteristics during the game. These characteristics and illustrations of the reports are listed in Chart 3.

The events, operations, and metacognitive paths were interpreted and aligned to a representative model for verifying adherence to the reflective self-regulation mode of thinking to make the metacognitive operations explicit (Chart 4).

DISCUSSION

The interpretation of the results points to the role played by the three categories of metacognition identified: experience, knowledge, and metacognitive skill. Furthermore, we observed that the presence of these categories was in line with the purposes of game making.

At the initial moment, the emphasis on the rules of the game and its structure seems to have been a mobilizing factor for experiences linked to affection and appreciation about metacognition about the task.

Metacognitive knowledge concerning the task allows the individual to understand which characteristics are typical of the activity; to guide the development of the cognitive process; and to enable discrimination of the level of difficulty in reaching a goal. This is explained since it includes knowledge about the requirements and objectives.[5]

It can easily be inferred that when first faced with the task, in this case, the game's characteristics, rules, and purposes, the participant seeks to recognize what tools and knowledge they have to deal with the situation. The reports revealed that the participants attempted to anchor the requirement of the new task in similar situations (previous real or simulated cases in teaching), and this depends on their ability to recognize the state of knowledge. From the triarchic theory of mind, it is known that, in the inner world of the individual, metacomponents, performance components, and knowledge acquisition components are necessary.[30] Metacognitive self-regulation skills are essential for clinical reasoning and require processes of self-monitoring, self-evaluation, and self-reinforcement.[27] This contributes to reducing diagnostic errors and improving diagnostic performance, and education strategies and training for these clinical reasoning skills are essential.[31] As verified in the different moments of participation in the educational game, the participants resort to evaluation and monitoring, especially of the state of their knowledge.

There are types of thinking related to metacognition in the nursing literature that support clinical reasoning; the types that are considered essential are reflective self-regulation, complexity thinking, systems thinking, creative thinking, and critical thinking.[27]

While not the only type of thinking of a metacognitive nature, reflective self-regulation seems to be the most useful in interpreting the metacognitive trajectories evidenced from the analysis of participation in the educational game. It involves procedural stages that can be applied to interpretation. Self-regulation involves self-monitoring that ultimately can lead to changes in the individual's strategies, cognitions, and affections. Its main stages would be anticipation, performance control, and self-regulation or, for some, self-reflection.[27,28]

Different models deal with self-regulation of learning, with more or less relation to metacognition.[28] Zimmerman is one of the pioneering researchers on the subject, with widely recognized models, being the most recent of which, published in 2009, represents a multilevel cyclical model.[28,29] In this model, the three phases are named anticipation, performance, and self-reflection; these models are useful for characterizing the metacognitive operations identified in the research.

In the anticipation phase (forethought), students analyze the task, set goals, and plan how to achieve them, and motivational beliefs influence the activation of learning strategies.[28] This phase precedes action and initiates the stage for clinical reasoning, in which the search for schemas and the identification of prototypes tend to occur.[27] The results demonstrate, especially in moments 1 and 2 of the game, the students' attempts to anchor the experienced situation with familiar cases, that is, the clinical schemas or prototypes stored in memory. The reports also showed that the students drew plans of how to act to solve the case, which is compatible with the tasks of the anticipation phase. From what the participants said, it is possible to infer that this anticipation generated metacognitive experiences, which triggered metacognitive operations linked to affective states, but especially allowed the anticipation of the activity's complexity. However, it was not clear from the results obtained what role motivational beliefs played in the game.

As they progress through the execution of a task, students engage in the performance control phase, monitoring progress and operating with self-control strategies to maintain engagement and motivation.[28] In the game, during the third stage, challenges were inserted that increased the requirements for solving the case and mandated a deeper detailing of the task by reading the case. Based on the self-regulation model, it was possible to expect the performance of self-control and self-observation actions, including metacognitive monitoring.[28]

Chart 3. Moments of the game, characteristics of the game process and control, and metacognitive events emerging from students' speech.

Characteristics of process and control elements applied during the game	Excerpts corresponding to the metacognitive events in the participants' reports
(1) Presentation of the rules and the game's structure	
1) Emergence of metacognitive experiences related to success and failure.	"At first, I had a little difficulty." (Hello Kitty) "Nervousness, despair." (Lalalopsi)
2) Checking for access to metacognitive knowledge regarding the task.	"I remembered the DHE* class, that's all that came to my mind." (Barbie) "I remembered the patient has a patient we got in the last term." (Furby) "This would be a Directed Study." (Opereta) "That I was on House [TV show]." (Merida) "I tried to grasp [the task] as much as possible, but I kind of need to systematize it." (Polly)
(2) Reading the clinical case	
1) Requirement to integrate metacognitive experience with metacognitive knowledge.	"I was desperate, I was trying to understand what had happened, but it actually seemed to be a bit of desperation of not knowing exactly [what happened] and immediately what was going on." (Ariel)
2) Emergence of the broader perception of the task's level of difficulty level.	"Oh man, what do I do now? I go to the infirmary and the patient is like this. How will I act to solve the problem?" (Ken)
3) Accessing memory content to search for available knowledge, applying metacognitive knowledge.	"It seemed to me not what the nursing diagnosis was, but the diseases that could be." (Rosinha) "Several different diagnoses went through my head because [for] every symptom I talked about, I imagined something different." (Bella)
(3) Insertion of challenges into the game	
1) Increasing the task complexity brings out the metacognitive experience of feeling difficulty, allowing one to assess processing fluency.	"Association (steps to resolution)." (Nina) "The difficulty is that we don't have the normal results in our heads yet; the evaluation of the results is that the patient's disease is not well known. I managed to get around it by analyzing the results, thinking since the patient's admittance until their release... After I made the notes, I tried to remember, I tried to get feedback of everything we learned so far and also with a little of the experience we have had so far in practice." (Alice)
2) Expanded use of metacognitive control and monitoring skills.	"The greatest difficulty was because we were in doubt between the two. In fact, before, we were thinking about which diagnosis that it wasn't because of the mental confusion, of the urea, and it wasn't, it was sodium." (Judi)
3) Planning regulation to direct attention to relevant information and diagnose the electrolyte disturbance.	"With what we were good at, I think we were bad at one and good at the other. So, I will associate one and the other, signs and symptoms and lab tests." (Marie)
4) Correction in the flow of actions to achieve goals by the metacognitive skill of conflict regulation.	"One balanced the other (signs and symptoms)." (Bella)
(4) Decision-making	
1) Metacognitive experiences are developed for monitoring and controlling thinking. 2) The student evaluates the effort required to achieve the proposed goals. 3) Self-evaluation as successful or unsuccessful in the task and search for ways to correct any perceived problems.	"It was when you gave me a hint with the joker [card], that I had an easier time, then I thought more and went deeper, then it hit me [that it was] potassium and sodium, but I answered potassium because I didn't know which was intra and which was extra." (Tinker Bell)
4) Dynamically integrates metacognitive knowledge, skills, and experiences.	"Basically, the correlation between the different problems, what they related to regarding cause and effect, what causes that problem, and what are the effects of their repercussions and so trying to form a chain to see what that patient's grievance is, its complexity, and how to act, how to solve it." (Dexter)
(5) Final performance evaluation	
1) Once the game is over, the student retrospectively evaluates their steps using metacognitive skills integrated with metacognitive knowledge.	"I think the game worked with a very complete level of case study... it manages to create a scenario and all that storyline as if you were there. And even that can be bad because it can bring fear, insecurity, and uncertainty to those who don't have that, but on the other hand, you bring the need for the person to actually think, to impose themselves; it's not because the clinic is saying it's that and it's interesting because you can experience a little of what it is, here in a safe environment, a controlled environment, [...] a game, in quotes, because it's not a game, we know it's a scientific work but a game in quotes that is pleasurable, entertains, and teaches, I think this is the future of education." (Dexter)
2) The student performs a self-assessment by appreciating their metacognitive experience.	"Ah, look, I manage, I already managed after much studying alone at home, reading this thing of the electrolytes of the spaces, but I still haven't managed to do the proper comes to be; I wouldn't say reasoning, I don't like the word memory, to memorize things, I like to understand, I still haven't managed to understand. OK, I know what's in the liquid in the electrolyte here and there, but I still haven't managed to study a lot and enough to understand the disorders and what causes them; I have to sit down more and study." (Opereta)

Source: Prepared by the authors. *Hydroelectrolytic Disorder.

Chart 4. Process and control characteristics during the game with metacognitive operations related to the phases of "reflective self-regulation."

Phases of reflective self-regulation	Process and control characteristics during the game with metacognitive operations
Anticipation (following available schemes and prototypes)	1.1) Emergence of metacognitive experiences related to success and failure.
	1.2) Checking for access to metacognitive knowledge about the task.
	2.3) They access memory content to search for available knowledge, applying metacognitive knowledge.
Performance control (attention to the situation)	2.1) Requirement of integrating the metacognitive experience with metacognitive knowledge.
	2.2) Emergence of the broader perception about the task's difficulty level.
Self-regulation (reflection on behavior, reflection on the environment, self-evaluation, and correction of thoughts)	3.1) Increasing task complexity brings out the metacognitive experience of feeling difficulty, allowing one to assess processing fluency.
	3.2) Expanded use of metacognitive control and monitoring skills.
	3.3) Planning regulation to direct attention to relevant information and diagnose the electrolyte disturbance.
	3.4) Correction in the flow of actions to achieve goals by the metacognitive skill of conflict regulation.
	4.1) Metacognitive experiences are developed for monitoring and controlling thinking.
	4.2) The student evaluates the effort required to achieve the proposed goals.
	4.3) Self-evaluation as "successful" or "unsuccessful" in the task and search for ways to correct any perceived problems.
	4.4) Dynamically integrates metacognitive knowledge, skills, and experiences.
	5.1) Once the game is over, the student retrospectively evaluates their steps using his metacognitive skills integrated with metacognitive knowledge.
	5.2) The student performs a self-assessment by appreciating their metacognitive experience.

Source: Prepared by the authors. Note: numbers refer to the timing of the game (e.g., 1 = presentation of rules and game structure) and the characteristics of process and control elements (e.g., 1 = emergence of metacognitive experiences related to success and failure), as seen in Chart 2.

In a way, the feeling of difficulty that clearly stands out in the third stage, although understood as an expression of a challenge to cognitive fluency in problem-solving, also proved to be an incentive aspect to students to apply monitoring and metacognitive control and to plan and conduct metacognitive operations that would help achieve the goal. The feeling of difficulty is characterized by the lack of fluency in processing the task, that is, when the subject feels uncomfortable or distressed when performing certain conduct, for example, due to lack of theoretical and practical grounding.[26,32,33]

Furthermore, the insertion of challenges in the game required expanding the list of strategies focused on control and monitoring. A study conducted with medical students solving a clinical case also improved metacognitive knowledge as the case resolution progressed to the final stages.[34] The authors found that in the initial third of case solving, students proportionally applied more conceptual and strategic knowledge than metacognitive knowledge.[34]

In Zimmerman's model,[29] the next phase is self-reflection, in which students apply metacognitive operations linked to judgments about success and failure in the task.[29]

In both the fourth and fifth stages of the game, the participants made judgments compatible with the self-reflection phase. Nevertheless, in addition to the elements of decision-making and evaluation, one can see from the students' excerpts a prominent imbrication of the metacognitive properties of knowledge, strategies, and experiences, as well as motivational and affective traits.

This trait seems to express the relationship between different elements of human cognition and affection, which should not be limited to nursing students. In the elucidation of a model for complex problem-solving in medicine, it was found that most students applied two to three cognitive actions simultaneously when trying to solve a clinical case.[35]

CONCLUSIONS AND IMPLICATIONS FOR PRACTICE

This study evidenced the presence of metacognitive activity by identifying operations and metacognitive events arising from participating in an educational game focused on learning in the

nursing process. It was also possible to observe how the study of metacognitive trajectories highlights learners' thinking in teaching situations. Moreover, metacognitive trajectories were shown to corroborate other models of learning self-regulation that make explicit the operations performed in tasks and contexts relevant to nursing. Therefore, further research in this field may clarify the mental processes and procedural features dependent on reflective self-regulation during nursing diagnosis and clinical decision-making.

Beyond an apparent ludic advantage with benefits in building interaction with content and collaboration with partners, educational games can be organized to produce evidence of how and when higher-order mental processes may emerge in the task, facilitating teaching and learning assessment. For the professor or in-service nursing education personnel, knowing the characteristics of a more common metacognitive pathway can promote their role as a mediator and facilitator of learning in specific aspects. Likewise, modeling reflective self-regulation allows one to verify which types of metacognitive operations are more or less required in the phases and, thus, evaluate students' difficulty in solving the task.

As a limitation, this study did not correlate the metacognitive pathway with task performance, which may be limiting for some educators in the field interested in academic performance. Assessments about "right or wrong" can communicate more about the outcome of a process, whereas, in this study, we focused on recognizing the metacognitive operations that may influence the outcome. While teaching assessment encompasses achieving an objective outcome, it is more challenging to identify the subjective dimensions linked to mental processes.

From the results, one can estimate that the game is a highly relevant tool to encourage cognitive monitoring and control through metacognition. Nonetheless, further studies can explore experimental designs, including comparing the performance of diagnostic accuracy when using the reflective self-regulation model in the design and development of the educational game versus modeling educational games not focused on metacognitive properties.

AUTHOR'S CONTRIBUTIONS

Study design. Mauricio Abreu Pinto Peixoto. Débora Lucy Santos Saraiva.

Data collection or production. Mauricio Abreu Pinto Peixoto. Débora Lucy Santos Saraiva.

Data analysis. Mauricio Abreu Pinto Peixoto. Marcos Antônio Gomes Brandão.

Interpretation of results. Mauricio Abreu Pinto Peixoto. Marcos Antônio Gomes Brandão. Jaqueline da Silva Soares Souto. César Silva Xavier. Luciana Rocha dos Santos.

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