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ABSTRACT: The learning process may involve the development of cognitive and metacognitive strategies. And for this development, several artifacts can be inserted in the educational context, such as digital games. From this context, including when games are increasingly present in higher education, we realize that they can provoke enthusiasm and engagement. These behaviors favor learning. Based on this context, the purpose of this study is to present the validation process of a data collection instrument designed to measure the use of these strategies in digital games. The methodology followed the procedures recommended in the literature, with validation by experts and internal validation, with application of the instrument in a pilot test. The questionnaire items were designed and validated based on the hypotheses about cognitive and metacognitive learning strategies and the theory of Game-Based Learning. Eight experts participated in the content validation procedures and 32 respondents participated in the internal validation. From the analysis of the collected data, the results indicate that the questionnaire is suitable for measuring the latent information factors related to mobilizing learning strategies in digital games. The result of this study contributes to the literature by presenting a data collection instrument that can be tested and validated for Anglo-Saxon populations.

Keywords: Higher education, digital games, cognition and metacognition, learning, questionnaire.

ESTRATÉGIAS COGNITIVAS E METACOGNITIVAS EM JOGOS DIGITAIS: UM INSTRUMENTO DE PESQUISA

RESUMO: O processo de aprendizagem pode envolver o desenvolvimento de estratégias cognitivas e metacognitivas. E para esse desenvolvimento, diversos artefatos podem ser inseridos no contexto educacional, como os jogos digitais. A partir desse contexto, inclusive quando os jogos estão cada vez mais presentes no ensino superior, percebemos que eles podem provocar entusiasmo e engajamento. Esses comportamentos favorecem a aprendizagem. Com base nesse contexto, o objetivo deste estudo é apresentar o processo de validação de um instrumento de coleta de dados elaborado para medir o uso dessas estratégias em jogos digitais. A metodologia seguiu os procedimentos recomendados na literatura, com validação por especialistas e validação interna, com aplicação do instrumento em um teste piloto. Os itens do questionário foram elaborados e validados com base nas hipóteses sobre estratégias cognitivas e metacognitivas de aprendizagem e na teoria da Aprendizagem Baseada em Jogos. Oito especialistas participaram dos procedimentos de validação de conteúdo e 32 respondentes participaram

da validação interna. A partir da análise dos dados coletados, os resultados indicam que o questionário é adequado para medir os fatores de informação latentes relacionados à mobilização de estratégias de aprendizagem em jogos digitais. O resultado deste estudo contribui para a literatura ao apresentar um instrumento de coleta de dados que pode ser testado e validado para populações anglo-saxônicas.

Palavras-chave: Ensino superior, jogos digitais, cognição e metacognição, aprendizagem, questionário.

ESTRATEGIAS COGNITIVAS Y METACOGNITIVAS EN LOS JUEGOS DIGITALES: UN INSTRUMENTO DE INVESTIGACIÓN

RESUMEN: El proceso de aprendizaje puede implicar el desarrollo de estrategias cognitivas y metacognitivas. Y para este desarrollo, varios artefactos pueden ser insertados en el contexto educativo, como los juegos digitales. A partir de este contexto, incluso cuando los juegos están cada vez más presentes en la educación superior, nos damos cuenta de que pueden provocar entusiasmo y compromiso. Estos comportamientos favorecen el aprendizaje. Partiendo de este contexto, el objetivo de este estudio es presentar el proceso de validación de un instrumento de recogida de datos diseñado para medir el uso de estas estrategias en los juegos digitales. La metodología siguió los procedimientos recomendados en la literatura, con validación por expertos y validación interna, con aplicación del instrumento en una prueba piloto. Los ítems del cuestionario fueron diseñados y validados a partir de las hipótesis sobre estrategias cognitivas y metacognitivas de aprendizaje y de la teoría del Game-Based Learning. Ocho expertos participaron en los procedimientos de validación del contenido y 32 encuestados participaron en la validación interna. A partir del análisis de los datos recogidos, los resultados indican que el cuestionario es adecuado para medir los factores de información latentes relacionados con la movilización de las estrategias de aprendizaje en los juegos digitales. El resultado de este estudio contribuye a la literatura al presentar un instrumento de recogida de datos que puede ser probado y validado para poblaciones anglosajonas.

Palabras clave: Educación superior, juegos digitales, cognición y metacognición, aprendizaje, cuestionario.

INTRODUCTION

One of the great possibilities of growth that technological advances have been providing is the exploration of various digital resources in educational activities or environments. This incorporation requires understanding that this transformation is not just about adding these technologies to the classroom, being essential to consider how they are explored.

In the context of higher education, empirical research seeks to clarify how digital technologies, including digital games as cultural artifacts, can be associated with educational processes in formal, non-formal and informal contexts of education (Alves, 2012; Alves; Coutinho, 2017; Egenfeldt-Nielsen, 2010; Kapp; Blair; Mesch, 2014; Pombo; Marques, 2020). Digital games can mobilize players' competencies, which include knowledge, capabilities, skills, and attitudes, providing experiences that are mostly engaging and challenging. Thus, it is acknowledged that games tend to influence cognitive and metacognitive development, although studies that specifically address this issue in the Brazilian context have not been identified (Pimentel, 2020).

This study's authors consider that research's focus should be on how to learn and what is learned with digital games, namely regarding mobilized learning strategies. However, these studies require the development of instruments to analyse the potential of games in promoting this type of strategies. In this context, the present work aims to present the development of a data collection instrument, a questionnaire, which aims to collect information about the cognitive and metacognitive learning strategies that university students mobilize while playing digital games. This instrument is useful in studies such as

the one currently conducted with university students from a Brazilian university, the Federal University of Alagoas, and a university in Portugal, the University of Aveiro.

The following parts of this manuscript include: (1) a theoretical framework on learning strategies, their relationship with digital games and metacognitive assessment instruments; (2) the methodological process of development and validation of the questionnaire section that aims to measure the mobilization of cognitive and metacognitive strategies in digital games; (3) the results and discussion of their significance; and (4) final considerations, including work limitations and future work.

The analysis of the mobilization of cognitive and metacognitive learning strategies in digital games is relevant for the advancement of a quality education permeated by the use of digital technologies. In this sense, the aim is to contribute to a empirically grounded integration of digital game-based resources in teaching in university contexts.

LEARNING STRATEGIES

To understand the learning concept is a task that must be undertaken by all those involved in educational activities, as this understanding is essential to reflect on education, methodologies, approaches and strategies.

Learning, on a cognitive level understanding, can be defined as a change in someone's knowledge due to experience (Mayer, 2011). This definition comprises three parts: (1) learning involves a change in the individual; (2) what changes is the learner's knowledge; and (3) the change is caused by the learner's experience. This change also implies the development of new capacities, skills, and attitudes. In the case of digital game-based learning, according to Mayer (2019), change is caused by a specific type of experience, namely playing a digital game, whether on the computer, on mobile devices or on a console.

Considering the formal learning context, the ability to learn can be directly modified based on how the relationships between students and their teachers occur (Wood, 2003). This can be affected by the way the classroom is conducted, which can influence what students will or can learn and how they will think or learn about a certain topic. Several other factors affect teacher-students' relationships, such as nutrition, breathing, drug and alcohol dependence, and even the sleep quality (Trocmé-Fabre, 2016). Evidently, the interactions that students carry out with each other and the interactions with the artifacts around them also influence the ability to learn.

Authors such as Trocmé-Fabre (2016) and Góes and Boruchovitch (2020) argue that teachers should use different strategies in the classroom, creating different possibilities and allowing more students to learn effectively.

For Silva (2012, p. 24), learning strategies are "the tools used by the learner to deal with information aiming at the best way to store it and retrieve it when necessary", as they are essential elements for information processing. The literature usually divides the learning strategies into cognitive and metacognitive.

Cognitive strategies are focused on primary or basic learning, directed to activities that aim to help the learner to organize, elaborate and integrate the information to which he/she is exposed in daily experiences, spontaneously or in a systematic way in classes (Silva, 2012). Such strategies can be subdivided into rehearsal, elaboration, and organization strategies. Table 1 summarizes the characterization of each type of cognitive strategy and presents some examples of actions that fit into each one.

Table 1. Cognitive learning strategies characterization and action examples

Type	Characterization	Action (examples)
Rehearsal	Marked by the repetition of learned information	To repeat keywords aloud or in writing, underline, take notes, ...
Elaboration	Marked by the association of new information with previously learned information	To rewrite, summarize, paraphrase, write notes, create rhymes or abbreviations, ...

Organization	Marked by the structuration of the information to be learned	To form categories, create concept networks, make concept maps, ...

Note: adapted from Silva (2012).

Rehearsal strategies are marked by repetition of the information, through actions such as repeating new words or taking notes during a class. In turn, elaboration strategies aim to associate new information with previously learned information, through actions such as rewriting a text or creating rhymes. Organization strategies, on the other hand, structure the information to be learned, through actions such as forming categories or creating concepts networks.

Rehearsal and elaboration cognitive strategies can also be understood as memory strategies and they "are planned and carried out with the purpose of achieving an end: the subsequent evocation" (Madruga; Lacasa, 1995, p. 207). For these authors, cognitive strategies usually appear spontaneously, but they can be trained.

Metacognition as a learning strategy can be understood as: (a) the knowledge that the individual can achieve about their own mental processes (planning actions of how an activity is carried out, monitoring and evaluation); or (b) the effect that this knowledge will have on his/her conduct (Madruga; Lacasa, 1995). As for Silva (2012, p. 51), metacognition "presents itself both in the form of reflection and action, as it comprises the learner's ability to become aware of their own knowledge, reflect on it and the factors that influence it", thus, metacognitive strategies aim to manage and control learning experiences.

Understanding that the concepts of metacognition are varied, we chose to accept the concept of Flavell, Miller and Miller (1999) when defining it as the ability to assess, regulate and organize mental processes on the cognitive objects that are studied to achieve a goal or objective. According to these authors, and also supported by Magalhães (2009), metacognition implies awareness, when the individual is able to judge his/her metacognitive activities and, in view of this judgment, to decide how to carry out the same activities or to modify the way of carrying out the activities. Table 2 summarizes the view of metacognitive strategies adopted in this work.

Table 2. Metacognitive learning strategies characterization and action examples

Type	**Characterization**	**Action (examples)**
Planning	Marked by the analysis of the learning process itself and by the establishment of goals to be achieved.	To become aware of the values and beliefs about learning, set goals to achieve, decide ways to achieve goals, …
Monitoring	Marked by the observation, reflection, and experiencing of cognitive processes to identify what is being learned and what is not.	To reflect/think about the individuals' own thinking, evaluate what best supports the learning process, …
Motivation regulation	Marked by the modification of some behavior to obtain a better result or performance in learning.	To think on the learning rewards, eliminate distractions, gather the resources needed for the targeted learning, …

Note: adapted from Góes and Boruchovitch (2020)

For Gómez (2015, p. 119), metacognition "is the fundamental axis of personalized education" considering that it promotes the individual, as well as postulated by Connectivism Theory, valuing and recognizing human diversity and multiplicity, and rejecting pedagogical uniformity.

RELATIONSHIP BETWEEN LEARNING STRATEGIES AND DIGITAL GAMES

To understand the relationship between learning strategies and digital games, it is important to clarify the concept of digital games adopted in this work. The difficulty in defining a game has been identified in the literature, even having been argued that it is not possible to reach a consensual definition in academia (Arjoranta, 2019; Stenros, 2017). However, one of the most referenced efforts in this regard is the one of Juul (2010), which includes in the concept: (1) a set of rules in the game; (2) obtaining a variable and quantifiable outcome, (3) assigning different values to the different outcomes that it is possible to obtain in the game; (4) the player's effort to influence the outcome; (5) the player's emotional connection to the outcome; and (6) the real consequences of the game are optional and negotiable. Digital game will then be a system that integrates several of these elements, supported by digital technologies, such as computers, mobile phones, or other similar devices.

In digital culture, digital games can be used to develop cognitive or metacognitive learning strategies, being directly related to the pedagogical use of these artifacts. Games can mobilize cognitive activities of information rehearsal, elaboration and organization, as well as providing opportunities for the metacognitive actions of planning, monitoring and regulating self-motivation (Pimentel, 2017).

Considering digital games contribution to learning at a cognitive level, the study by Chuang; Chen (2007) revealed that children playing digital games promotes the establishment of fact-recall processes, as well as the development of competencies of problem solving.

Digital games have been used even in medical education. According to the literature review conducted by Bigdeli and Kaufman (2017), many games which specifically aim at training in the health area, such as the Geriatric Medication Game or Grays Anatomy, promote learning at a cognitive level and cognitive abilities. These authors also identified examples that aim at the promotion of attitudes.

In the relationship between metacognition and digital games, we highlight the investigation by Monem (2015), which aimed to understand the role of Massively Multiplayer Online Role-Playing Games (MMORPGs) in stimulating metacognitive functions and improving scaffolding abilities (self-scaffolding skills) in a teenage player. The results show that the interactive, multimodal, multisensory and graphical characteristics of the MMORPGs stimulated the player's metacognitive functions.

Venancio (2020) analyzed manifestations of metacognitive thinking by students, who were frequent, casual, and non-players, when submitted to a situation of mathematical learning mediated by a digital game. The research results showed that students made use of metacognitive processes while playing the game, either because the game has the potential to stimulate these processes, or because they are part of the students' routine. Metacognitive strategies proved to be diversified and they were manifested through knowledge about self-cognition, meta-attention strategies, meta-memory strategies, self-monitoring strategies, metacognitive regulation, and feedback.

To understand the impact of metacognition and of student goal orientation on problem solving, Liu and Liu (2020) carried out a study on undergraduate students' metacognition, relating a serious game to problem-based learning. The results showed that both student metacognition and goal orientation affected problem solving. They provided evidence of how student characteristics impact problem solving in serious games environments with problem-based learning.

On the other hand, in a study on the relationship between digital games and metacognitive competence in children between 6 and 10 years of age, Ricker and Richert (2021) conclude that it is not clear whether exposure to games with great opportunities for metacognitive reflection leads to a better metacognitive awareness, inferring the need for further research to deepen the theme. Meanwhile, the results provide a refined examination of time spent in games with two distinct interactive environments and explore how these distinct environments are differently associated with metacognitive awareness. Furthermore, the results highlight the importance of considering the quality and content of interactive games rather than just exposure time.

METACOGNITIVE ASSESSMENT INSTRUMENTS

Scientific literature presents several instruments to perform metacognitive assessment. One of the most used ones, the Metacognitive Awareness Inventory (MAI), was developed by Schraw and Dennison (1994) as an inventory with 52 items to measure adults' metacognitive awareness. Items were classified into eight subcomponents grouped under two broader categories: (1) knowledge of cognition; and (2) regulation of cognition. To validate the instrument, the authors performed two experiments that supported the two-factor model.

The second experiment revealed that the knowledge of the cognition factor was related to judgments of monitoring ability and to the performance on a reading comprehension test, but it was not related to monitoring accuracy. This instrument has become a reference in metacognition studies, and it is also the basis for this study.

In Brazil, Lima Filho (2013), aiming to raise elements that show this relationship in entrepreneurial professionals and in Administration students, used the MAI as part of his data collection instrument. For translation and validation, the author followed Pietro's (1992) back translation methodology. Subsequently, Lima Filho and Bruni (2015) published the translation and validation process based on a confirmatory factor analysis.

Bártolo-Ribeiro, Simões and Almeida (2015) also carried out a process of translation and adaptation of the MAI to the Portuguese population. The items were translated by Portuguese experts fluent in English and back translated by a Portuguese professional residing in an English-speaking country. The internal consistency in the knowledge and regulation of cognition dimensions was 0.82 and 0.90, respectively. The authors performed a confirmatory factor analysis that suggested a second-order factor based on the correlation of results in the two dimensions. The declarative knowledge subscale showed better criterion validity compared to the other subscales. The authors argue that the MAI is an instrument adapted to the Portuguese reality, both for the global measurement of metacognition, as in its main dimensions, allowing to support research on the performance in learning and training processes in the adult and adolescent population.

Another instrument was developed by Pimentel and Sales Junior (2021). An adaptation of the Schraw and Dennison (1994) MAI was made for the domain of digital games. Descriptive statistical, reliability and validity analysis were performed. Reliability was measured by Cronbach's alpha coefficient, with a result of 0.957 for the 52 questions that make up the questionnaire adapted for the games use. For the authors, this version can be used to identify the metacognition level of individuals who use digital games.

METHODOLOGY OF CONSTRUCTION AND VALIDATION OF THE DATA COLLECTION INSTRUMENT

In view of the presented theoretical framework, and with the purpose of implementing a robust data collection instrument, in this section we present the process for the construction and validation of a questionnaire section. This instrument aims to collect data regarding the mobilization of cognitive and metacognitive strategies by university students while using digital games.

The instrument is self-administered, developed in the form of self-report, when the respondent must fill in the answers. The questionnaire consists of three parts: (a) metacognitive awareness inventory; (b) cognitive and metacognitive strategies in relation to digital games; and (c) respondent profile. Each step is described below.

Part I: Metacognitive Awareness Inventory

In developing the instrument, it was necessary to make some methodological choices. To compose the first part of the instrument, we proposed the use of the MAI (Schraw; Dennison, 1994), translated and validated into Portuguese by Lima Filho and Bruni (2015) in Brazil, as it met the needs of

the study in question. In Portugal, the version by Bártolo-Ribeiro, Simões and Almeida (2016) was chosen, already used in other studies (Quintela; Almeida; Costa-Lobo, 2017; Silva, 2018).

This first step of the instrument aims to identify the predominant profiles and it is presented on a five-point Likert scale. Thus, there are no answers that indicate patterns of right/wrong or better/worse type.

At the end of the first part of the instrument, a guiding and conditioning question was inserted, being asked whether the respondent usually plays digital games. In the positive choice, the participant is directed to the second part of the instrument. In the negative choice, the participant is directed to the 3rd and last part of the instrument, which presents profile questions, as explained in subpart (c).

Part II: Cognitive and metacognitive learning strategies in relation to digital games

The second part of the instrument was developed based on readings of Madruga and Lacasa (1995), Lima Filho and Bruni (2015), Pimentel (2016), Zumbach, Rammerstorfer and Deibl (2020), and Góes and Boruchovitch (2020). In this part, the items point to the reality of digital games (Table 3) and seek to identify the participants' relationship with digital games.

This part includes 20 items answered on a 5-point Likert scale, in a frequency perspective. Each item of the instrument should be answered taking into account the scale: (1) very often; (2) frequently; (3) occasionally; (4) rarely; (5) never.

Table 3. Instrument's items - Cognitive and metacognitive learning strategies in relation to digital games

1. I read the game instructions carefully before starting to play.
2. When playing, I repeat out loud the game's key words (or core ideas),
3. I make notes or observations about the game. I share my game notes with other players.
4. I participate in forums or online communities to discuss the game.
5. I categorize my games using my own criteria or other players' criteria.
6. I read summaries, reviews, comments about the games I usually play.
7. I watch game tutorials, made by other players.
8. I post game tutorials for other players.
9. In the game, I think of various ways to resolve a situation and I try to choose the best one.
10. I focus on the overall sense of the game rather than on the details.
11. I consider several alternatives when I run into a problem in the game.
12. When I play, I try to use strategies that have worked in the past.
13. I am aware of my talents and of my limitations during the game.
14. When I finish playing, I usually know how I did in the game.
15. I consciously focus attention on important strategies for playing.
16. At the end of the game, I wonder if there would be an easier way to accomplish the game challenge.
17. When I play, I have control over how far I'm on the right track.
18. I use my intellectual talents to compensate for my limitations while playing.
19. I change my strategy when the one I'm using isn't working.
20. I often wonder how I'm doing while I'm making a new strategy in the game.

Source: Research data (2021)

After the elaboration of the second part of the instrument, the next step was its validation. We chose to analyze content validity and Cronbach's alpha (1951) reliability, two distinct but complementary steps.

Content validation was performed through analysis by expert judges. According to the literature, the recommendation is that this process is carried out with five to ten judges. In this decision, the characteristics of the instrument, the training and qualification of the judges, as well as the availability of each one must be considered (Alexandre; Coluci, 2011).

In the case of this instrument, content validation was carried out by a committee consisting of eight judges, who were teachers and experts in the field of Education and with studies in the context of digital games. One was specialist, five were masters, and two were doctors (one also with a post-doctorate). The evaluation by judges was carried out at a meeting of the Working Group formed by researchers from the Edumídia Research Group, from the Federal University of Santa Catarina (UFSC). The meeting took place virtually, using Google Meet, and was divided into three consecutive moments. This committee, made up of professionals linked to education and with a research profile in digital games, is highlighted in this process (Prado; Ramos, 2020).

At first, the judges answered the questionnaire individually (based on Table 3). It was sent through WhatsApp, and it used in a self-report approach. This moment aimed to allow the judges an experience as respondents of the instrument, having an initial contact, avoiding pre-judgments.

The second moment occurred right after completing the questionnaire, when the judges received a validation questionnaire, using a five-point Likert scale, to be returned to the researcher after filling it out. The judges were asked: considering the items' formulation, and considering the characteristics of this questionnaire target population, do you believe that the language of each item is sufficiently clear, understandable, and adequate for this population? On what level? The answers could vary on the scale, using the following guidance: (1) very inappropriate; (2) inappropriate; (3) average; (4) appropriate; (5) very appropriate.

After completing the validation questionnaire, the judges participated in a focus group session (Kitzinger, 1994), where they expressed their perceptions of the instrument.

After this phase of content validation, internal validation was conducted through a pilot of the questionnaire and Cronbach's alpha calculation (1951). Reliability is related to the degree of confidence of the results that can be obtained, involving the stability and consistency of the scores obtained (Cohen; Manion; Morrison, 2018). More specifically, the internal reliability of a questionnaire considers whether the statements used consistently measure the dimension to be assessed (Vieira, 2009).

In this work, Cronbach's alpha was used. It is recommended to analyze the internal reliability of an instrument composed of scalar response alternatives, such as the Likert scale. This alpha is based on the average of all correlations between the items that make up the questionnaire, dividing it into all possible halves (Souza; Alexandre; Guirardello, 2017; Vieira, 2009).

Despite some controversies in the literature, the result of the calculation of Cronbach's alpha coefficient can be interpreted considering the following guidelines: greater than 0.90, the instrument is considered to be very highly reliable; between 0.80 and 0.90 we have a highly reliable instrument; between 0.70 and 0.79, the instrument is reliable; between 0.60 and 0.69, the instrument is considered to be minimally reliable; and when we have a value less than 0.60, we have a low and unacceptable reliability (Cohen; Manion; Morrison, 2018).

To calculate Cronbach's alpha coefficient, the instrument was applied online as a pilot in a group of Brazilian university students who were players and composed a convenience sample of 32 respondents. The analysis was performed using the SPSS software (Statistical Package for the Social Sciences 24) and considered the responses of 29 respondents who indicated that they were digital game players.

Of the students who participated, 41% indicated being between 16 and 20 years old, 45% between 21 and 25 years old, 7% between 26 and 30 years old and 7% 31 years old or more. Of these participants, 55% indicated they are a digital game player in their spare time (occasionally), 7% indicated that they are players with some experience and 38% consider themselves gamers.

Part III: Respondents' profile

The third part of the instrument aims to identify the profile of respondents. It initiates with a question of what types of digital games the respondent plays and how often, using the following scale as a reference: (1) I don't play; (2) occasionally or (3) frequently. The following options were given for the type of game: RPG, adventure, emulation, simulation, strategy, action, and puzzles, offering the opportunity to indicate other types as well. A question on which types of digital games the respondent plays the most was also included.

At the end of this third part of the instrument, there is a question on how much time he/she plays, on average, per day. The following options were given: (1) 1 to 2 hours; (2) 2 to 3 hours; (3) 3 to 4 hours; (4) 4 to 5 hours; and (5) more than 5 hours a day.

Once this profile part is completed, it is questioned which university or college the respondent is enrolled in, as well as which area of knowledge fits the course he/she is enrolled in and which period/semester he/she is attending. For age, the following options are presented: (1) 18 to 22 years old; (2) 23 to 27 years old; (3) 28 to 32 years old; (4) 33 to 37 years; and (5) 38 years or older.

All ethical procedures were followed, in accordance with the Brazilian and Portuguese legislation, requesting the participants' informed consent, ensuring anonymity and confidentiality. This study is conducted with adult and healthy participants, capable of giving informed consent, having received a favorable opinion from the Research Ethics Council (Brazil) and the Ethics and Deontology Council of the University of Aveiro (Portugal).

RESULTS AND DISCUSSION

In this section, the results obtained with the validation process of the data collection instrument presented in subpart (b) are presented and discussed. In this way, this section starts with the results obtained during the content validation process, moving on to the results obtained during the internal validation process.

Content validation

In the instrument's content validation procedure, one judge considered it globally as "Good" and seven other judges considered it "Very good", corresponding to 88% of the total (Table 4).

Regarding the understanding of the instrument, there was 100% agreement that it is easy to understand by the target audience. With the evaluation procedure, the judges indicated whether the instrument's items were clear, understandable, and adequate for the intended target audience: higher education students.

Table 4. Percentages of judgment of items in relation to their clarity, understanding and adequacy

Item	(1) Very bad	(2) Mad	(3) Average	(4) Good	(5) Very good
1				13%	87%
2			12%	12%	76%
3	14%	14%		14%	57%
4					100%
5			25%	25%	50%
6					100%
7				25%	75%
8				25%	75%

9				100%
10		13%	25%	62%
11*	14%	14%	14%	58%
12				100%
13			25%	75%
14*			14%	86%
15		12%	13%	75%
16			13%	87%
17		13%	25%	62%
18		25%	25%	50%
19*				100%
20			25%	75%

* Items 11, 14 and 19 had one answer less
Source: Research data (2021)

In the comparison of the judges' observations, carried out through the focus group, the following adjustments were implemented: item 3 was subdivided into two items, and item 7 was excluded. Item 11, despite receiving 14% of indication of poor adequacy, was maintained considering that 86% indicate that it serves its intended purpose.

Internal validation

The pilot of the questionnaire allowed the calculation of the Cronbach's alpha coefficient, through the use of SPSS, which resulted in the value of 0.84, for the 20 items that make up the scale of part II of the questionnaire. This value reveals that the instrument is highly reliable. In table 5 it is possible to observe the statistics related to the items.

Table 5. Statistics related to item analysis-total

Item	Scale average if item is excluded	Scale variation if item is excluded	Total Item Correlation Corrected	*Cronbach* alpha se if item is excluded
1	67,6207	84,744	,284	,845
2	68,1379	77,695	,557	,830
3	68,7241	82,421	,412	,838
4	68,7586	85,547	,297	,843
5	67,7931	79,527	,494	,834
6	67,5517	75,113	,569	,830
7	68,8621	82,980	,428	,837
8	69,3448	85,163	,483	,835
9	66,4138	86,180	,380	,839
10	66,4138	82,894	,548	,832
11	66,5862	88,037	,267	,843
12	66,2069	88,670	,313	,841

13	66,6207	86,887	,360	,840
14	66,4483	87,685	,299	,842
15	66,6552	84,591	,550	,833
16	66,7586	81,118	,543	,831
17	67,0000	85,714	,398	,838
18	66,6552	87,448	,358	,840
19	66,3793	84,815	,554	,834
20	66,7931	82,313	,530	,832

Source: Research data (2021)

Although a variation was observed in the corrected total item correlation, reaching less than 0.3 in item 1, 4 and 11, the exclusion of each of these items does not substantially modify the Cronbach's alpha coefficient, which remains above 0.8 in all item analyses. Thus, the internal validation of the items was found, not requiring any item to be adapted or excluded. After the three moments presented, the instrument validated for part II of this instrument is shown in Table 6.

Table 6. Validated instrument items

1.I read the game instructions carefully before starting to play.
2. When playing, I repeat out loud keywords or the main ideas of the game.
3. I take notes or observations about the game.
4. I share my game notes with other players.
5. I read summaries, reviews, comments, about the games I usually play.
6. I watch game tutorials, made by other players.
7. I participate by interacting and discussing games in forums or online communities.
8. I post game tutorials for other players.
9. In the game, I think of various ways to resolve a situation and try to choose the best one.
10. I focus on the overall objective of the game.
11. I consider several solution alternatives when I encounter a problem in the game.
12. When I play, I try to use strategies that have worked in the past.
13. I am aware of my talents and my limitations during the game.
14. When I finish playing, I usually know how I did in the game.
15. I consciously focus my attention on effective playing strategies.
16. As I play, I wonder if there would be an easier way to accomplish the game challenge.
17. When I play, I know how much I am on the right track.
18. I use my skills to compensate for my limitations while playing.
19. I change strategy when the one I am using is not working.
20. I wonder how I am doing when using a new strategy in the game.

Source: Research data (2021)

FINAL CONSIDERATIONS

Studies on digital games in the formal educational context, specifically in Higher Education, require empirical research to provide coherent and robust data, so that it is possible to understand the phenomenon, and also to reflect on the contribution of these artifacts in cognitive and metacognitive development.

In this article, we present the process of elaboration and validation of a research instrument, which resulted in a three-part questionnaire, adapted to the reality of university students in Brazil and Portugal. This instrument aims to collect data that allow the analysis of how cognitive and metacognitive learning strategies are mobilized in digital games. After the theoretical and methodological options, the content validity and internal validation procedures were carried out. The results obtained indicate that the developed questionnaire is suitable to measure the mobilization of cognitive and metacognitive strategies, whether in the context of research includes Brazilian or Portuguese university students in digital games, or in other investigations.

As limitations to this study, one can point out the fact that other complementary procedures, such as test-retest, were not included in the instrument validation process. However, the difficulties in recruiting participants for this type of study determined the option for the selected validation processes. Future work may involve conducting other validation procedures for the questionnaire presented in this study. With this new instrument, systematic measures can be taken in relation to cognitive and metacognitive strategies and their relationship with digital games, allowing to support research on the theme and reflection on the possible consequences in teaching-learning.

This study contributes to the literature by presenting a data collection instrument which, although it has been validated for the Brazilian and Portuguese populations, is already translated into English and may be tested and eventually validated for Anglo-Saxon populations.

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REFERENCES

ALEXANDRE, N. M. C.; COLUCI, M. Z. O. Validade de conteúdo nos processos de construção e adaptação de instrumentos de medidas. **Ciência & Saúde Coletiva**, 16, 2011. p. 3061-3068.

ALVES, L. Videojogos e aprendizagem: mapeando recursos. In: CARVALHO, A. A. A. (Org.). **Aprender na era digital*:*** jogos e mobile-learning. Portugal: De Facto Editores, 2012. p.11-28.

ALVES, L.; COUTINHO, I. J. (Orgs.). **Jogos digitais e Aprendizagem: Fundamentos de uma prática baseada em evidências.** Campinas: Papirus, 2017.

ARJORANTA, J. How to Define Games and Why We Need to. **The Computer Games Journal,** 8, 2019, p. 109–120. Available at: DOI: 10.1007/s40869-019-00080-6 Accessed at: 20 dez 2021

BÁRTOLO-RIBEIRO, R.; SIMÕES, M. R., ALMEIDA, L. S. Metacognitive Awareness Inventory (MAI): Adaptação e Validação da versão Portuguesa**. Revista Iberoamericana de Diagnóstico y Evaluación e Avaliação Psicológica. RIDEP**, 2016, 42(2), 143-159. Available at: https://aidep.org/sites/default/files/articles/R42/Art12.pdf Accessed at: 18 fev 2021.

BIGDELI, S.; KAUFMAN D. Digital games in medical education: Key terms, concepts, and definitions. **Med J Islam Repub Iran**. (2 Sep); 2017, p. 31-52. Available at: https://doi.org/10.14196/mjiri.31.52 Accessed at: 18 fev 2021.

CHUANG, T. Y.; CHEN, W. F. Effect of digital games on children's cognitive achievement. **Journal of Multimedia**, 2 (5), 2007, p. 27-30. Available at: https://doi.org/10.4304/jmm.2.5.27-30 Accessed at: 28 fev 2021.

CRONBACH, L. J. Coefficient alpha and the internal structure of tests. **Psychometrika** 16, 1951, p. 297–334. Available at: https://doi.org/10.1007/BF02310555 Accessed at: 28 fev 2021.

COHEN, L.; MANION, L.; MORRISON, K. **Research methods in education.** 8th ed. New York: Routledge, 2018.

EGENFELDT-NIELSEN, S. The challenges to diffusion of educational computer games. **Leading Issues in Games Based Learning**, 2010. v. 141.

FLAVELL, J.; MILLER, P.; MILLER, S. **Desenvolvimento cognitivo**. Porto Alegre: Artmed. 1999.

GÓES, N. M.; BORUCHOVITCH, E. **Estratégias de aprendizagem**: como promove-las. Petrópolis, RJ: Vozes, 2020.

GÓMEZ, Á. **Educação na era digital.** Porto Alegre: Penso, 2015.

JUUL, J. The Game, the Player, the World: Looking for a Heart of Gameness. **Plurais Revista Multidisciplinar**, 1 (2), 2010. Available at: DOI: 10.29378/plurais.2447-9373. 2010.v1.n2.%p Accessed at: 01 fev 2021.

KAPP, K; BLAIR, L; MESCH, R. **The gamificacion of learning and instruction fieldbook**: ideas into practice. San Francisco, Wiley, 2014.

KITZINGER, J. The methodology of focus group: the importance of interaction between research participants. **Sociol Health Illn.;** 1994. 16(1):103-20. Available at: https://onlinelibrary.wiley.com/doi/pdf/10.1111/1467-9566.ep11347023 Accessed at: 01 may 2021.

LIMA FILHO, R. N. **Empreendendo sobre o empreender e pensando sobre o pensar***:* um estudo sobre características empreendedoras e metacognição. 2013. 145 f. Tese (Doutorado em Administração). Escola de Administração. Universidade Federal da Bahia, Salvador.

LIMA FILHO, R. N.; BRUNI, A. L. Metacognitive Awareness Inventory: Tradução e Validação a partir de uma Análise Fatorial Confirmatória. **Psicologia: ciência e profissão**, v. 35, n. 4, 2015. p. 1275-1293.

LIU, S.; LIU, M. The impact of learner metacognition and goal orientation on problem-solving in a serious game environment. **Computers in Human Behavior**, v. 102, 2020. p. 151-165. Available at: https://doi-org.ez9.periodicos.capes.gov.br/10.1016/j.chb.2019.08.021 Accessed at: 28 fev 2021.

MADRUGA, J.; LACASA, P. Processos cognitivos básicos nos anos escolares. In: COLL, C.; PALACIOS, J.; MARCHESI, A. (org). **Desenvolvimento psicológico e educação**. Porto Alegre: Artes Médicas, 1995. p. 205-218.

MAGALHÃES, A. **Mapas conceituais digitais como estratégia para o desenvolvimento da metacognição no estudo de funções**. 2009. Tese (Doutorado em Educação Matemática) - Pontifícia Universidade Católica de São Paulo, São Paulo.

MAYER, R. E. **Applying the science of learning**. Upper Saddle River, NJ: Pearson, 2011.

MAYER, R. E. Cognitive Foundation of Game-Based Learning. In: PLASS, JAN L.; MAYER, R. E.; HOMER, B. D. (Ed.). **Handbook of Game-Based Learning**. Mit Press, 2019.

MONEM, R. Metacognition and self-scaffolding in MMORPGs: case study of an adolescent male gamer. **The Qualitative Report,** 2015. vol. 20, no. 4, p. 454+. Gale Academic OneFile, Available at: link.gale.com/apps/doc/A449545369/AONE?u=capes&sid=bookmark-AONE&xid=2cf5b9f7. Accessed 2 June 2021.

PIETRO, A. J. A method for translation of instruments to other languages. **Adults Education Quartely,** v. 43, n. 1, p. 1-14, 1992. Available at: https://doi.org/10.1177%2F0741713692043001001 Accessed 2 June 2021.

PIMENTEL, F. S. C. **A aprendizagem das crianças na cultura digital**. 2ª ed. rev. e ampl. Maceió: Edufal, 2016.

PIMENTEL, F. S. C. **Estudo Bibliométrico sobre Games e Educação nos anos 2010 a 2018.** Relatório Projeto de iniciação Científica. Maceió, UFAL, 2020,

PIMENTEL, F. S. C.; SALES JUNIOR, V. B. Avaliação da consciência metacognitiva de usuários de jogos digitais. In: PIMENTEL, F. S. C. (Org.) **Aprendizagem baseada em jogos digitais:** teoria e prática. Rio de Janeiro, BG Business Graphics Editora, 2021.

POMBO, L; MARQUES, M. M. The potential educational value of mobile augmented reality games: The case of EduPARK app. **Education Sciences**, 2020. v. 10, n. 10, p. 287.

PRADO, L.; RAMOS, D. Construção e validação de um instrumento para avaliação de jogos digitais para o desenvolvimento da consciência fonológica no processo de alfabetização. In.: MATTAR, J. **Relatos de pesquisas em aprendizagem baseada em games** [livro eletrônico]. São Paulo: Artesanato Educacional, 2020.

QUINTELA, B. R. S.; ALMEIDA, A.; COSTA-LOBO, C**.** ***Programa de resolução de problemas no ensino secundário:*** PRPES, 2017.

RICKER, A. A.; RICHERT, R. A. Digital gaming and metacognition in middle childhood. **Computers in Human Behavior,** 2021 v. 115, p. 106593. Available at: https://doi-org.ez9.periodicos.capes.gov.br/10.1016/j.chb.2020.106593 Accessed at: 28 jul 2021.

SCHRAW, G.; DENNISON, R. S. Assessing metacognitive awareness. **Contemporary Educational Psychology**. 1994. 19(4), 460-75.

STENROS, J.; The Game Definition Game: A Review. **Games and Culture.** 12(6):499-520. 2017. Available at: DOI:10.1177/1555412016655679 Accessed at: 28 fev

SILVA, L. **Estilos e estratégias de aprendizagem de estudantes universitários**. 2012. Dissertação (Mestrado em Psicologia Escolar e do Desenvolvimento Humano) – Universidade de São Paulo, São Paulo.

SILVA, P. F. **Preditores da metacognição**: estudo exploratório com estudantes do ensino secundário (Master's thesis), 2018.

SOUZA, A. C.; ALEXANDRE, N. M. C.; GUIRARDELLO, E. B. Propriedades psicométricas na avaliação de instrumentos: avaliação da confiabilidade e da validade. **Epidemiologia e Serviços de Saúde,** Brasília, 2017. v. 26, p. 649-659. Available at: https://www.scielosp.org/article/ress/2017.v26n3/649-659/. Accessed at: 28 fev 23 jan. 2021.

Trocmé-Fabre, H. **Aprendo, logo existo***:* introdução à neuropedagogia. Haute Goulaine: Editions Opéra, 2016.

VENANCIO, M. A. S. **Metacognição: um estudo exploratório com o game educacional A Fazendinha Matemática aplicado em estudantes do ensino fundamental.** 2020. Vitória da Conquista, 116 f. Dissertação (Mestrado em Ensino). Programa de Pós-graduação em Ensino, Universidade Estadual do Sudoeste da Bahia, Vitória da Conquista, BA.

VIEIRA, S. **Como elaborar questionários.** São Paulo: Atlas, 2009.

WOOD, D. **Como as crianças pensam e aprendem:** os contextos sociais do desenvolvimento cognitivo. São Paulo: Loyola, 2003.

ZUMBACH, J., RAMMERSTORFER, L.; DEIBL, I. Cognitive and Metacognitive Support in Learning with a Serious Game about Demographic Change. **Computers in Human Behavior**. Available at: 2019. 103. 10.1016/j.chb.2019.09.026. Accessed 20 June 2021.

AUTHORS CONTRIBUTION

Author 1 - Project coordinator, active participation in data analysis and revision of the final text.
Author 2 - Supervised the research, analyzed the data and wrote the text.
Author 2 - Data collection, data analysis and writing of the text.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with this article.

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