Contributions from Computer Education Students to Game Learning Analytics: Insights from a Participatory Design

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Abstract. Introduction: *Although computer science has become mandatory in Brazilian schools, high failure rates still permeate higher education courses in the field. One alternative is educational game design combined with Game Learning Analytics (GLA), which can support the practice of computer science concepts. On the other hand, this strategy also allows students, acting as learning designers, to contribute to the field of GLA.* ***Objective:*** *We investigated the contributions of nine undergraduate Computer Science students from a public university to the field of GLA,* ***Steps:*** *through a Participatory Design session.*
Results: *The participants' interdisciplinary knowledge resulted in relevant proposals for GLA systems that incorporated computer science concepts.*
Keywords *Computer science, Game Learning Analytics, learning designers, Participatory Design.*

1. Introduction

According to Law No. 14,533/2023, the incorporation of computing content and other digital skills into Brazilian schools (elementary and secondary education), in alignment with the National Common Core Curriculum (BNCC), becomes mandatory [Brasil 2023]. This initiative highlights the importance of professionals such as Computer Science Education graduates, who are responsible for creating tools, methods, and techniques to disseminate computing concepts in schools [Brasil 2016].

However, higher education computing programs often have high dropout and failure rates [Alvim et al. 2024, Souza and Silva 2025]. This scenario is a reflection of the difficulties faced by students during their education, among which the following stand out: (i) the high level of abstraction of the concepts; (ii) the complexity of the content covered; (iii) demotivation; and (iv) the use of traditional methodology in the classroom [Gavaza et al. 2018, Arimoto and Oliveira 2019, Lima and de Menezes 2024]. In this context, although computing professionals are in high demand in the labor market, students in the field often face several obstacles during their academic formation.

The educational game design process can help mitigate these difficulties, especially when it involves implementing Game Learning Analytics (GLA): a set of techniques for collecting and analyzing interaction logs from serious games [Freire et al. 2016]. The main contributions of GLA to students refer to the development of technical and pedagogical skills [Honda et al. 2023], especially in the computing field, necessary in stages such as data modeling [Honda et al. 2025], and the exercise of abstraction, which requires a clear understanding of the game's content. Thus, we can appropriately design GLA variables to express evidence of learning in computing. Therefore, by acting as learning designers of educational games and implementing GLA techniques, students can practically practice computing concepts.

Additionally, students who act as learning designers can bring valuable insights to the field of GLA, especially considering that 70% of educational games are developed in universities [Oliveira et al. 2019]. Thus, this work presents the following research question (RQ): "What contributions to the design of GLA systems can we obtain from the involvement of Computer Education students as learning designers?". To answer this RQ, we conducted an empirical study that involved a Participatory Design session with a group of students. The main contributions of this research include: (i) an analysis of students as stakeholders in GLA, not only as consumers but as protagonists who take part in its implementation; (ii) the proposal of GLA systems that can guide the development of similar tools based on a Participatory Design approach; and (iii) a discussion of the importance of computing for the field of GLA.

2. Foundations and related works

GLA involves several stages, beginning with data modeling, which involves defining the data we will collect in line with the game's learning objectives [Hauge et al. 2014, Honda et al. 2025]. From this stage, we define the GLA variables and organize them into a data template for a tool to implement in a game engine. In the international literature, studies on GLA generally involve multidisciplinary teams with well-defined roles [Cano et al. 2017, Perez-Colado et al. 2018]. This scenario results in limited support materials for students who serve as learning designers, since this role typically involves trained, experienced professionals.

However, it is essential to consider the student as a learning designer, especially in Brazil, where universities develop most educational games [Oliveira et al. 2019]. By taking on multiple roles in game development, students can bring insights that integrate concepts from across project responsibilities. For example, because they understand the game code and participate in courses that encourage them to act as learning designers, where they must be responsible for defining the learning objectives, they may have greater ownership to propose GLA variables aligned with these objectives. In this sense, user-centered approaches, such as Participatory Design (PD), can help obtain insights from these students for the proposal of GLA systems. The related works we describe below highlight the contributions of these approaches.

Dairel et al. [2024] propose an architectural model for the development of web-based educational games that supports GLA techniques. The authors developed the proposal through literature reviews and refined it through a Participatory Design process with K–12 teachers. They collect data through focus group sessions, which helped identify requirements such as support for both online and offline operation, filtering mechanisms to organize modules and games, the reuse of existing games, and the definition of configurable parameters for game stages (such as difficulty level and completion time). The resulting model comprises modules for visualization, monitoring, and the dynamic creation of stages via a repository of games and reusable components.

Calvo-Morata et al. (2019) aimed to improve GLA dashboards to support teachers in generating insights into students' performance. To achieve this, the authors adopted an iterative development methodology, involving teachers who used, analyzed, and evaluated dashboard prototypes for the educational game "Conectado". This strategy enabled the identification of teachers' real needs and improved data interpretation, resulting in dashboards better aligned with this audience's needs. The study highlights that teachers' participation was essential for refining the requirements of the proposed solution.

Revano and Garcia [2021] use a user-centered design approach to develop a Learning Analytics dashboard for Higher Education. The author conducted Participatory Design sessions with undergraduate students from an Information Technology program, who worked in teams to discuss requirements and design dashboard prototypes. The results, obtained through qualitative analysis with thematic categorization, enabled identification of four main aspects to guide dashboard design: control over data access, the relevance of time-related metrics, support for students' transition to university life, and customization of dashboards by field of study.

The studies present evidence of the advantages of using user-centered approaches for requirements elicitation, particularly through Participatory Design (PD). Table 1 illustrates a comparison between the present research and the analyzed works. The study by Dairel et al. [2024] addresses all the listed aspects, but it did not focus on students. Revano and Garcia [2021], although they employed Participatory Design with undergraduate computing students, involved participants who did not act as learning designers, and the research did not address the field of GLA. Although related to GLA, the study by Calvo-Morata et al. [2019] adopted a user-centered approach, but not explicitly Participatory Design, and it focused on teachers. One of the innovative aspects of this work is that the students had previously modeled data for their games, an essential stage in GLA that is still underexplored in the literature. In addition to this experience, the participants were familiar with educational games and pedagogical and computing concepts, which contributed to generating relevant insights for the proposal of a GLA system. These competencies are primarily provided by the Computer Science Education degree program, underscoring their importance for students' training and for the field of GLA.

Table 1. Comparison between related works and the present research.

Study	**LA**	**Games**	**PD**	**Computer Education Students**
Dairel et al. [2024]	X	X	X	-
Calvo-Morata et al. [2019]	X	X	-	-
Revano and Garcia [2021]	X	-	X	-
Present research	X	X	X	X

3. Methods

This research aims to identify the main contributions to the field of GLA resulting from Computer Science Education students' involvement as learning designers. In this sense, we conducted an empirical study, involving a Participatory Design session to elicit requirements for a GLA system based on the emerging needs of the future users of this resource.

3.1. Context and participants

The context of this research is the Foundations of Educational Software (FSE) course in the Computer Science Education program at the Amazonas State University (UEA). This course involves creating learning objects, especially educational games, to address learning problems, requiring students to act as learning designers. In this regard, the course includes both the ideation and development (coding) of the game, as well as the implementation of GLA techniques to evaluate learning aspects through players' interaction data. In previous studies, students had their first contact with GLA through manual data modeling, in which they reported the main difficulties of this process [Honda et al. 2025]. Subsequently, they used "GLA Specialist", an agent in ChatGPT that assists with data modeling. They identified the main contributions of using Large Language Models (LLMs) to the field of GLA [Honda et al. 2025].

Therefore, the selection criterion for this study was participation in previous research involving data modeling for GLA. Nine Computer Science Education students were selected, who: (i) were either halfway through the program (n=4, 44%) or in the 6th semester (n=5, 56%); (ii) 56% already had experience in developing educational games; and (iii) all of them (100%) had completed the first three introductory programming courses. Thus, due to their prior participation in GLA-related activities, the knowledge acquired in the program (both pedagogical and computing), and the experience of some participants in developing educational games, they constituted a relevant group for the study. The participants were between 19 and 24 years old, of whom 67% (n=6) identified as male and 33% (n=3) as female.

3.2. Procedures

We chose to conduct a Participatory Design (PD) session with the selected students. PD is a user-centered approach in which the requirements for a tool are defined by individuals in its target audience, acting as experts in the context of use [Schuler and Namioka 1993]. Thus, the study's procedures correspond to the PD stages we described below.

Explanation of the requirements: Given the course context, we conducted the PD session in the classroom. In a slide presentation, we outlined the main requirements of the activity, which included proposing a GLA system. The system's focus should be data modeling, as this is an introductory stage that serves as the foundation for the GLA cycle, and, like the "GLA Specialist", should also be generic and applicable to any educational games. We asked the participants to split into groups of three or four. We informed them that the system design should be carried out through low-fidelity prototypes (on paper), containing the main functionalities and sketches of the screens. In addition, we informed them that the groups would present the proposals at the end of the activity. This stage lasted approximately five minutes.

Proposal development: Participants gathered in three groups and began drafting their proposals, conducting a brainstorming session to identify requirements. The teams developed the prototypes using materials we provided, including colored pencils, rulers, pens, brushes, glue, scissors, and sticky notes. Figure 1 shows records of the teams during the development of the proposals, which lasted approximately 30 minutes.

(a) Team 1. (b) Team 2. (c) Team 3.

Figure 1. Teams during the Participatory Design session.

Presentation of proposals: After completing the design, we asked the students to bring their prototypes to the front of the whiteboard and present them to the class. Each team explained its proposal in turn, with durations of 9 minutes (team 1), 4 minutes (team 2), and 5 minutes (team 3). During the presentations, we asked questions to better understand how the proposals worked, especially their data inputs. We present the proposals in Section 4. The PD session, considering all stages, lasted approximately one hour.

3.3. Data collection and analysis

The data collected in this study include: (i) the recordings of the proposal presentations, which one of the authors of the study later manually transcribed based on the analysis of the videos, recording in a text document the main information pointed out by the students about the functioning of the proposals; and (ii) the materials (prototypes) produced during the Participatory Design. We emphasize that the participants consented, through an online form, to the anonymous use of their data for research purposes. The Research Ethics Committee approved this study under CAAE number 85800424.8.0000.5020, as per approval report no. 7,465,500.

We employed a qualitative interpretive analysis based on the transcripts of the presentation recordings and the prototypes of the proposals produced during the Participatory Design session. Initially, one of the authors of the study read and analyzed the proposals (transcribed recordings and prototypes), identifying elements related to game design, computing, and GLA. This author was a Master's student in Informatics, had more than 8 years of experience with educational games and 3 years of experience implementing GLA (expert), and was building a system similar to the proposals. The expert considered the following criteria in the analysis: support for data modeling (guidance and applicability), computational feasibility, and potential for identifying evidence of learning. Based on these criteria, the expert defined categories of "advantages" and "caveats" for each proposal, resulting in a consolidated comparative table. The other authors acted as reviewers of this material, of whom: (i) 50% (n=4) also had more than 8 years of experience with educational games; (ii) 100% (n=4) had practical experience with Learning Analytics; and (iii) 100% were PhDs and worked in the area of Computer Science or similar fields.

4. Results and discussions

From the Participatory Design session, we obtained proposals for GLA systems designed by the Computer Science Education students, which we illustrated and described below.

Proposal 1: entitled DMBot (Data Modeling Bot), it consists of a model based on Generative AI to assist in data modeling for GLA. The model aims to address the high level of abstraction required for designing prompts for modeling, allowing not only text submissions but also images and videos of the game. Using computer vision, the model analyzes and triangulates the submitted data to propose GLA variables that correspond to the game's specific characteristics, creating a modeling table. When a user clicks a data item in the table, they receive a description of how to use it. The system is illustrated in Figure 2, featuring a chatbot area similar to ChatGPT, with a conversation history and an interaction environment with the AI. Each conversation in history is associated with a game, which can be registered using the "+" button. The icons next to the conversations represent the game's educational category (e.g., Computing). In addition to the modeling table, the model provides generic methods for collecting the variables in the code and requests additional information from the user about the game, if necessary.

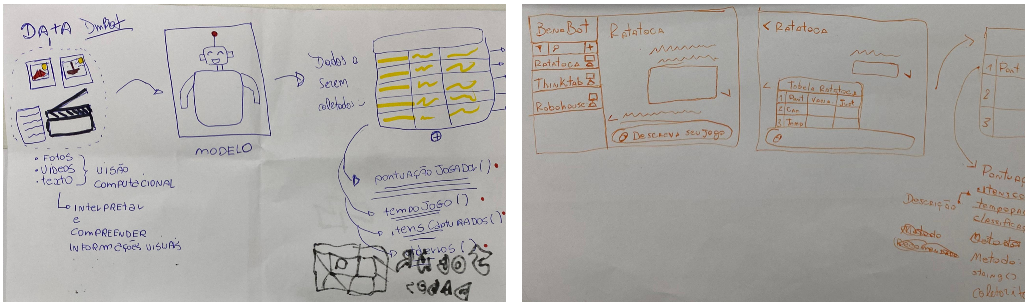


Figure 2. First proposal of a GLA system (Team 1).

Proposal 2: students designed as an extension of GLBoard [Silva et al. 2022], a model for capturing and analyzing educational games. The system includes a "Recommendation" option in the side panel, which redirects the user to a chatbot. The user can click on "Generate report" to build a data modeling table containing the variables to collect in the game. The intention is that this generation occurs after integrating the game with the GLBoard package in the Unity game engine. The model's role is to read the scripts and send them to an internal agent or an external LLM (such as ChatGPT) via a prompt. Based on the game's code, the model interprets related objects and entities, proposes corresponding variables, and generates a report for the developer to guide implementation. We illustrated the system in Figure 3.

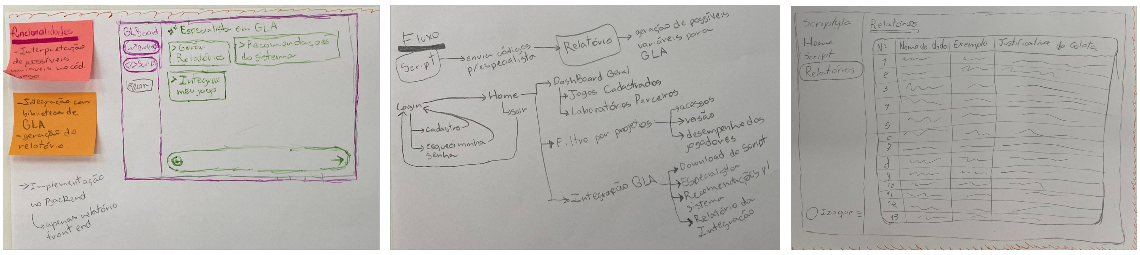


Figure 3. Second proposal of a GLA system (Team 2).

Proposal 3: focuses on predicting how the player evolves based on the collected data. The model assumes that the developer has previously implemented a GLA structure, acting as a tutor to support more efficient data modeling. In this sense, the user can interact with the system in two ways: (i) by submitting an already developed data capture structure in order to refine it; or (ii) by sending the game's data collection logs. In the second option, we submit the data records, and the model suggests either including or updating GLA variables. If it determines that the data are insufficient, the model acts directly on the data modeling process by suggesting or modifying new variables. We can see the system's prototyped screens in Figure 4.

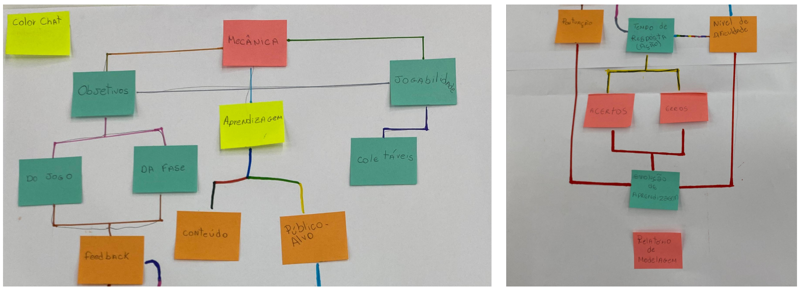


Figure 4. Third proposal of a GLA system (Team 3).

To identify the contributions of the proposals and their feasibility in the field of GLA, specialists in the field (the authors of this work) evaluated the proposals and produced Table 2. The columns present, respectively, the proposal number, its advantages, and its limitations.

Table 2. Analysis of proposals

No	Advantages	Caveats
1	Reduces the need for extensive textual descriptions by allowing the submission of images and videos. Addresses the difficulty of prompt design by providing structured fields for input and file uploads. Enables joint analysis with multimodal information, supporting the proposal of contextualized variables. Allows organizing data modeling by game, associating each project with a conversation in the chatbot. Suggests generic data-collection methods, guiding the developer in the initial implementation of GLA variables in the code	Although it can analyze visual files, the model still requires additional information to understand how level design elements are associated with learning aspects. Using computer vision requires training the model with datasets appropriate to the context. However, educational games have specific characteristics, which may make it difficult to create generalized models
2	Integrates GLBoard, a GLA model consolidated in the literature, as an extension. It uses the structure of the game's code to assist in data modeling through communication with an LLM. It proposes GLA variables aligned with the gameplay, taking into account implemented objects, entities, and mechanics. It supports the developer in implementing the variables	Requires the minimum implementation of the game to analyze the scripts. It is limited to game mechanics and code structure, which may not capture learning aspects and could lead to incomplete data modeling
3	Allows refinement of the data modeling based on logs collected from previous implementations. Acts as a tutor to guide the developer in proposing variables aligned with the learning objectives. Identifies missing information in the game that may be essential for obtaining evidence of learning	Does not contribute to the initial data modeling process, assuming that users already have prior knowledge of GLA and have previously implemented a data capture structure.

Overall, each proposal has its own specificities. We observed that they are complementary, even though the teams did not interact with each other: (i) the first proposal uses gameplay as the basis for analysis (texts, images, and videos), focusing on the design of variables; (ii) the second proposal uses the game's code as input data, mainly operating in the stage of guiding and implementing the variables; and (iii) the third proposal uses collected logs as input to support the analysis and refinement of the data modeling. Furthermore, we observed that all proposals make use of LLMs, an emerging technology. We consider this an innovative aspect, as the intersection between GLA and LLMs remains underexplored in the literature, especially in data modeling.

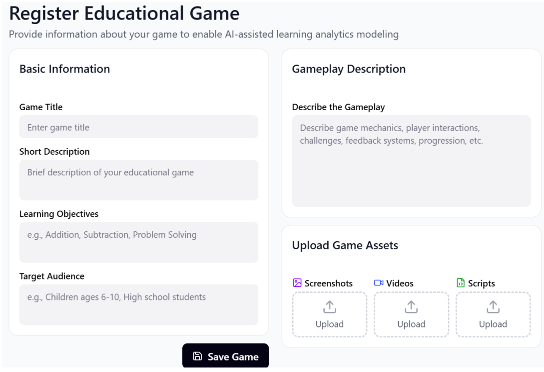
In response to the RQ, this research offers proposals for systems considered suitable for GLA from the perspective of specialists in the field. The study indicated that Computer Science Education students can act as relevant stakeholders in GLA, combining technical, pedagogical, and game design knowledge. This result highlights that students who act as learning designers are not only consumers of resources in the field but also co-creators of related solutions. The main functionalities of the student's proposed systems include: (i) the use of visual resources to understand the game more clearly; (ii) analysis of the game's code to assist in implementing GLA variables; and (iii) adaptation of the data capture structure according to the generated logs. Computing knowledge was fundamental for the development of these functionalities, especially when considering: (i) integration with LLMs; (ii) the suggestion of computer vision techniques; and (iii) the analysis of computational structures of the game to support data modeling, such as code and interaction logs.

To consolidate the students' artifacts, we used Figma Make[1] to generate a navigable prototype of a GLA system that integrates the functionalities of each proposal. We sent the prototype information and their drawings in a single prompt to Figma Make, which built the system. The model did not hallucinate; it only made minor visual adjustments, which we refined with simple commands. Figure 5 presents screens illustrating how we can articulate the proposals within a single system: (i) game registration, which contains textual information and fields for submitting images, videos, and game code/scripts (when applicable). This screen combines elements from proposals 1 and 2 (Figure 5(a)); (ii) an AI assistant, in which the user can interact with a chatbot to support data modeling. This functionality was suggested in all proposals (Figure 5(b)); and (iii) logs and analysis, allowing the visualization of players' interaction records collected after implementing a data capture structure. The screen displays the implemented variables, along with suggestions for refining the data model based on the collected data. This functionality is related to proposal 3 (Figure 5(c)).

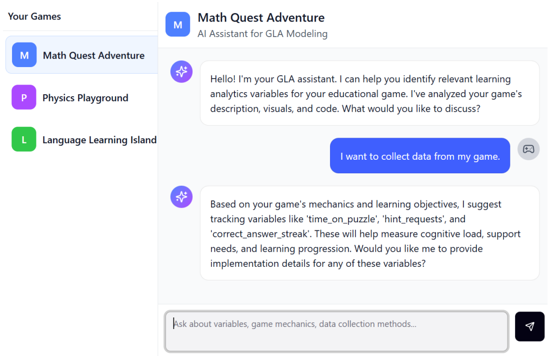
The link[2] provides access to the system prototype, which includes a home screen where the user can choose either to view fictitious data to explore the system's navigation or to access an area without registered data, simulating its real use. The consolidated GLA system highlights the relevance of Participatory Design with Computer Science Education students, enabling the elicitation of essential requirements for GLA. The proposal encompasses an initial, iterative field cycle, with functionalities for game registration, ini-

[1]A Figma feature based on Generative AI that allows building interactive interfaces from prompts and generating front-end code.

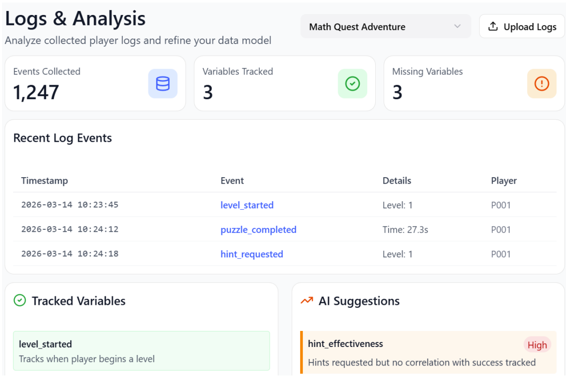
[2]https://bobbin-jog-93583880.figma.site



(a) Game registration screen.



(b) AI assistant screen.



(c) Logs & analysis screen.

Figure 5. Consolidated GLA system interfaces.

tial data modeling (which may use the game's code if a partial implementation already exists), and log analysis to identify evidence of learning and refine GLA variables.

The findings of this study align with results reported in other studies. In Dairel et al. [2024], the authors used PD with K–12 teachers to refine an architecture supporting GLA, whose results helped identify relevant requirements. Similarly, we used PD to identify requirements for a GLA system with Computer Education students, who contributed insights into multimodal data, code analysis, and log-based refinement. Calvo-Morata et al. [2019] sought to improve GLA dashboards through an interactive strategy with teachers who used, analyzed, and evaluated them. From this process, the authors identified the target audience's real needs and refined the dashboards. We also obtained this result in our study, mainly through the proposal of systems integrated with LLMs, suggesting that students consider this technology to be relevant for data modeling.

Among the limitations of this research, the following stand out: (i) the sample size, composed of only nine participants from the same class, which restricts the generalization of the findings; (ii) the previous classes on data modeling were not extensive, which might have stimulated the generation of more ideas; (iii) the participants had contact only with the GLBoard model, which may have limited the definition of requirements considering other GLA tools; (iv) since the participants had previously used a specialist agent for data modeling, this experience may have influenced the proposal of systems based on LLMs, reducing the exploration of other technologies; and (v) the authors of the study also acted as GLA specialists in evaluating the proposals, which may have introduced biases in the analyses. We intend to mitigate these limitations in future research. Even so, the study represents a significant step for both the field of GLA and Computing, especially Computer Science Education.

5. Conclusions

The field of GLA can benefit computing students by allowing them to practice core concepts in the area. On the other hand, these students can also contribute to advancing GLA, particularly through their interdisciplinary knowledge. In this context, we established the research question (RQ): "What contributions to the design of GLA systems can we obtain from the involvement of Computer Education students as learning designers?". To answer the RQ, we conducted an empirical study that included a Participatory Design session involving nine Computer Science Education students. The participants worked in groups of three, defining requirements and building prototypes of GLA systems. We recorded the teams' presentations with consent, and GLA specialists evaluated the proposals.

In response to the RQ, the students' contributions resulted in proposals aligned with the field of GLA and related to different stages of the process, including requirements such as the inclusion of images and videos as data inputs, analysis of the game's code to assist in the implementation of GLA variables, and interpretation of logs to refine the data modeling. We consolidated the proposals into a prototype of a GLA system, demonstrating its relevance for data modeling. Additionally, we observed that the students were able to apply computing concepts during the development of the proposals, such as suggesting the integration of the system with LLMs, including computer vision techniques, and analyzing the computational structures of games, such as code and interaction logs, to support data modeling.

The study provides evidence that computing students can contribute to the field of GLA while applying computing concepts in practice. In addition, it guides the development of GLA systems that consider emerging technologies. As future work, we intend to: (i) conduct Participatory Design with teachers and experienced developers of educational games to compare their requirements with those identified by the students; (ii) include additional data collection strategies, such as self-perception questionnaires and interviews; and (iii) implement a GLA system similar to the consolidated version in order to verify its technical feasibility.

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Statement on the Use of Artificial Intelligence

In this study, we used OpenAI's ChatGPT to generate code for graphs and tables in LaTeX format, aiming to reduce the time and effort required to construct these representations. We also used the tool to help reformulate sentences and translate sections of the text. The authors assume full responsibility for the review, validation, and final version of the work.

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