

Students as game creators: easing the game construction process by using a toolkit to game design

Pedro Beça¹, Mónica Aresta¹, Rita Santos¹, Ana Isabel Veloso¹, Gonçalo Gomes¹

¹ University of Aveiro
Campus de Santiago, Aveiro, Portugal
{pedrobeca, m.aresta, rita.santos, aiv, goncalo}@ua.pt

Abstract. In recent years, serious games and gamification strategies have been used in the education field and seen as highly motivating for educating and motivating younger people. As regard to games, and in the field of environmental education, they emerge as an innovative approach to raise environmental awareness among youths, namely by challenging students to develop their own games for learning. When research also mentions obstacles in involving students to explore educational contents through game design, this paper presents the Gamers4Nature Toolkit, an artifact developed to support the creation of digital environmental-related games by younger students with no experience in game design. The toolkit was used by 53 upper-secondary and 114 undergraduate students along several game creation sessions, leading to the development of 66 digital games. Findings indicate that the Toolkit was considered an engaging approach to game creation, making it a valuable resource to support educators in game design activities.

Keywords: Digital game making, Students' engagement, Toolkit, Authoring tools, Teaching/learning strategies

1 Introduction

In the last several years, serious games and gamification strategies have been used in the field of education, with its competitiveness being seen as highly motivating for educating, training and motivating younger people [1, 2]. In what concerns games, and specifically in the field of environmental and biodiversity preservation education, games emerge as an innovative approach to raise environmental awareness among youths [3], namely by engaging students in the development of their own games for environmental awareness learning [4, 5].

Challenging youngsters to create their own digital games for learning revealed a growth in engagement and motivation, promoted collaboration and exchange of ideas and enhanced the development of critical thinking skills [6, 7]. Moreover, research on this field indicates that inviting students to create games – and not only to play it – may lead to an increase on the interest in the programming and design field [7] and foster

the acquisition of the scientific concepts and digital literacy [8], making them more engaged with the coding and implementation process [6].

As young people feel inspired to create games similar to those they like to play [9], obstacles that may hamper the involvement of students in exploring educational subjects through game design should not be neglected: lack of skills related with programming and game mechanics [7, 10, 11], low interest in the educational subject [7], and a focus on storytelling and character development while disregarding gameplay mechanics and content integration [8, 9].

Working with publics that do not have the technological skills needed to develop digital games or are not familiar with the game creation process requires new strategies and approaches. In this line of thought, the Gamers4Nature project developed a Toolkit to Game Design to support users with or without experience in the digital game design field to conceptualize and implement digital games. This paper introduces the Gamers4Nature Toolkit to Game Design and presents the main outcomes that have emerged from its use along several game design sessions, organized within different typologies: 1) one-day and two-days sessions; 2) long term (one month) sessions; and 3) a 3-day online Game Jam. The paper is structured as follows: Section 2 presents previous works on digital game making, learning and the development of skills and introduces toolkits as a support in the development of digital games. Section 3 introduces the Gamers4Nature Toolkit to Game Design, and its use along several digital game design sessions is described in Section 4. The paper ends with some considerations and potential directions for future work (Section 5).

2 Background

The potential of digital games in enhancing motivation for learning, as well as its relevance in the educational field, has been recognized a few years to this part [12–14]. Nevertheless, the discussion on the negative and positive impacts of computer games persists [2, 15], games are for long seen as a way to present learning activities in significant contexts controlled by the learner, thus having the potential to trigger curiosity and interest towards the educational subject [16, 17].

As Information and Communication Technologies and the development of user-friendly programming tools such as Scratch [18] or Kodu [19] reduced the gap that for long separated game players from game creators, a complementary approach on digital games and education – more focused on the benefits of involving students in the creation of their own games for learning – is emerging. While designing their own games, students became more interested in the subject and acquired scientific concepts, developing technological and digital literacy and engagement during the design process [6, 20].

2.1. Digital game making, learning and the development of skills

While creating digital games, students developed technical competencies such as programming and design, became more interested and developed a better understanding of the educational addressed.

Ke [8] conducted a study with middle school children, engaging them in Scratch-based mathematic games development activities. Findings indicate that youngsters developed significantly more positive dispositions toward mathematics after creating the computer games and that the game design process helped them to wider their perspectives about mathematics in everyday experiences.

Øygardslia and Aarsand [21], in a study focused on the field of history conducted with sixth grade and seventh-grade classes, introduced software used by game developers into the classroom environments. Researchers, acknowledging the complexity of challenging students to engage in game creation activities, point out that this approach allowed students to explore the playful, narrative-focused aspects of games, and also to integrate knowledge associated with classroom learning into the created games.

Papavlasopoulou et al. [22], as part of a study based on a design-based approach, conducted several workshops where 8-17 years old students used block programming tools to collaborative create a game. Along with identifying nine design principals that can be used to foster student's engagement during the game creation activity, researchers concluded that by engaging students in the creation of digital games high motivation and a reduction of participants' cognitive load were achieved.

2.2. Digital game making, collaboration and engagement

Along with the acquisition of knowledge and the increase of the interest in the game design, coding and programming field, research points out that by developing their own games students can be encouraged to explore their limits, increased collaboration, and exchange of ideas among peers [23].

Actively involving students in the game design and production process can have further potential for empowering students, increasing their concentration and engagement, promoting higher order thinking and impacting on learning outcomes [24]. In a study that investigated the impact of digital game authoring on students' concentration, critical thinking skills, and academic achievement, Carolyn and Chang [24] analysed the involvement of 67 students in two seventh-grade classes participated along a 19-week-long experiment. Results indicate that engaging students in the digital game authorship process fostered student's engagement in the application of scientific content and improved concentration and fostered critical thinking.

Stating that digital game making is becoming more popular and present as a learning strategy in schools, Hughes-Roberts et al. [25] examined the potential impact of digital game making in formal teaching along two field trials held in a primary and a special education school along 8-weeks, concluding that, when compared to more traditional methods, digital game making was at least as effective in encouraging engagement and collaboration in learners.

Sjöberg and Brooks [26] conducted a study aiming to understand in what ways game design activities using mobile technology support children's collaborative interactions and problem-solving skills. Study's results indicate that children sense of community emerged while children were working on the solving the problem of designing and producing a collective digital game, with researchers pointing out that through collaboration participants created shared meaning and understanding.

2.3. Supporting students in the development of digital games: toolkits to game design

Nevertheless the positive impacts summarized above, research also points out some obstacles in involving students to explore educational contents through game design: lack of interest in the educational subject [7], low or undeveloped programming skills, a difficulty to integrate the educational contents into the game and a tendency to focus on the storytelling and character development, ignoring the gameplay mechanics and content integration [8, 10]. Falcão et al. [7], starting from the premise that engagement is essential for learning – namely with audiences that were born with technologies, i.e., younger students – analyzed the way high-school students interact and engage in game-creation practices, concluding that students' high expectations and the desire to master design and programming skills quickly may lead to frustration and personal disengagement. The same concerns are present in the work of Uğraş et al. [27], who discuss a new perspective on co-design techniques to be applied when designing narratives with children, but with the mentoring/guidance of an adult mentor. Introducing their Five Elements, Game Motif, and Superhero Enquiry approach, authors point out that children who participated in the game narrative design activities were more engaged and open to collaboration when adults were active team members, becoming more focused on the activities.

When aiming to engage students in the creation of educational games, toolkits can be a helpful tool in simplifying concepts, integrating new ideas and instigating creative exploration of concepts and solutions [28–30]. In the educational field, where teachers and educators strive for engaging students with the educational subject and contents, teachers started to integrate information and communication technologies (ICT) to aid and ease the teaching and learning process [31, 32]. In this context, toolkits – because of its problem-solving features and support materials and resources – are seen as powerful tools able to transmit valuable insights about the production of interactive artefacts, allowing faster prototyping and supporting creative design [29, 33, 34].

3 The Gamers4Nature Toolkit to Game Design

Creating a game requires a rich and extensive set of knowledge and skills, and game designers are often asked to think about end-users, the user-game interaction, and reflect on the impact their games may have in relation with other media [35]. Aware of this fact and taking into consideration that many students do not have the skills and knowledge needed to design and implement a digital game, the Gamers4Nature project developed a Toolkit to Game Design, to be used by upper secondary and undergraduate students during game development sessions.

The Gamers4Nature project aims to develop and operationalize a set of strategies that encourage younger audiences (i.e. upper-secondary and undergraduate students) in game creation activities, while promoting knowledge about environmental preservation and biodiversity conservation. The Toolkit (Figure 1), developed within the project, comprises several resources designed to support the game creation process and is available both in physical and digital format. All resources were developed following a User-Centered Design approach and followed the iterative design method [36], with

experts in the game design field and potential users being involved in the design and validation process.



Fig. 1. The Gamers4Nature Toolkit to Game Design

The toolkit is composed by a game construction cards set, a rapid game design document, thematic cards with curated information about a specific environmental problem (e.g. microplastic pollution, endangered species, invasive species, coastal erosion) and a set of cards with guidelines on how to develop mobile game interfaces.

The game construction cards (12 cards sized 7x10 cm) are based on Fullerton's approach to game design [37], and were developed with the aim to give young students with no previous knowledge on the game design field basic information of a game's different elements: players, objectives, procedures, rules, resources, conflicts, outcome, challenge, premise, characters, story and dramatic arc. Thus, on the front side, it presents information about each game element (name, brief description of the element) and on the back side a small contextualization about the game element and a few examples of its presence in games is provided (more details about the process of developing the game construction cards set can be found in [38]).



Fig. 2. Example of two cards from the Gamers4Nature Toolkit to Game Design Game Construction Cards Set

As for the rapid game design document - printed in the A3 format and designed taking into consideration information collected during the game construction cards set

validation cycles, where researchers were able to identify several problems faced by participants while exploring the several game elements – it presents a path to explore the game construction cards set and the relations between the different game elements (more information about the validation of the rapid game design document can be found in [38, 39]).

Considering the project’s main goal - to promote the development of environmental awareness in younger audiences through the creation of digital games – and acknowledging that one of the main obstacles in engaging students in the design of educational games mentioned in the literature was the low interest in the educational subject [7], thematic cards sets were developed in order to support construction of the game’s narrative, thus providing users curated information about these themes and avoiding the cognitive load and effort of collecting information on the topic, expectedly easing the game narrative construction process.

Following the “trigger question” approach taken for the game construction cards, the topics addressed in those resources are presented as questions, along with a brief explanation of the addressed concept. Thematic cards set comprise sets of 20 thematic cards, sized 7x10cm and printed in color. Figure 3 shows examples of the microplastic pollution thematic cards set, one of each category. All cards were printed in recycled paper, without plastic coating (more details about the development and validation of the microplastic pollution thematic cards set can be found in [38]).



Fig. 3. Example of two categories of the microplastic pollution thematic cards set

Finally, the mobile game mobile game design guidelines cards (Figure 4) have as main goal to support users during the mobile interface design process.



Fig. 4. Example of two category of the mobile interface design guidelines cards set.

The 28 cards, sized 7x10cm and printed in colour, each one addressing a specific guideline for developing mobile games interfaces, are articulated in four categories: interface, interaction, performance, and promotion. They summarize the essential guidelines about mobile game design that are mentioned both in literature and in industry, from fundamental design principles to UI design elements (more about the cards' validation process can be found in [40]).

4. Students as game creators: Gamers4Nature digital game design sessions

The toolkit was used along several game design sessions with different typologies: short-term (one-day and two-days) sessions; long term (one month) sessions; and a 72-hour online Game Jam. Participants were invited to create a game addressing a specific environmental awareness theme, using the Gamers4Nature Toolkit to Game Design as a support for the game narrative creation process.

4.1. Method

The Gamers4Nature Toolkit to game design was used by undergraduate and upper-secondary students with and without experience in creating games throughout different game narrative design sessions: one-day and two-days sessions, long term (one month) sessions and a 72-hour online Game Jam. Along the sessions, participants were invited to define a narrative of a game addressing a specific environmental awareness theme by using the Gamers4Nature Toolkit to Game Design. The Toolkit's efficiency in supporting the design of digital games was assessed through a questionnaire focused on the Toolkit's features and resources and its impact on the game design process.

Participants. 167 upper-secondary and undergraduate students used the toolkit to game design along the game creation sessions. The number of participants was distributed as shown in Table 1.

Table 1. Distribution of participants for the game creation session.

Participants' profile	Session's typology	Participants (N=167)
Upper-secondary students	One-day game creation sessions	26
	Two-days game creation sessions	27
Undergraduate students	Long term (1 month) game sessions	105
	72-hours online game jam session	9

Upper-secondary students (N=53, 37 males, 16 female) were students from a science-humanities and from a vocational course. Undergraduate students (N=114, 53 males, 61 female) were students attending a Higher Education course in the Information

and Communication Technologies (ICT) field. Although all students already had basic programming skills, none had specific knowledge about game design.

Settings. The 2 one-day and the 2 two-days game creation sessions held with upper-secondary students (Fig 5.) were organized as follows: after a short presentation of the activity by the research team, participants were invited to create a game narrative using the Gamers4Nature Toolkit to Game Design and then proceed with the game implementation activity, using the programming language they were more familiar with. The sessions took place during school time, and ICT teachers were present to help students, if needed, during the implementation/programming phase. As for undergraduate students, long-term game creation sessions (2 sessions, one month length) were included in the last modules of the ICT course, when students were asked to create a digital game addressing a nature-related theme. As for the 72-hours online Game Jam session, it took place along a weekend. After introducing the nature-related theme and the Gamers4Nature Toolkit to Game Design (distributed only in its digital format), participants were left alone to create their digital game.

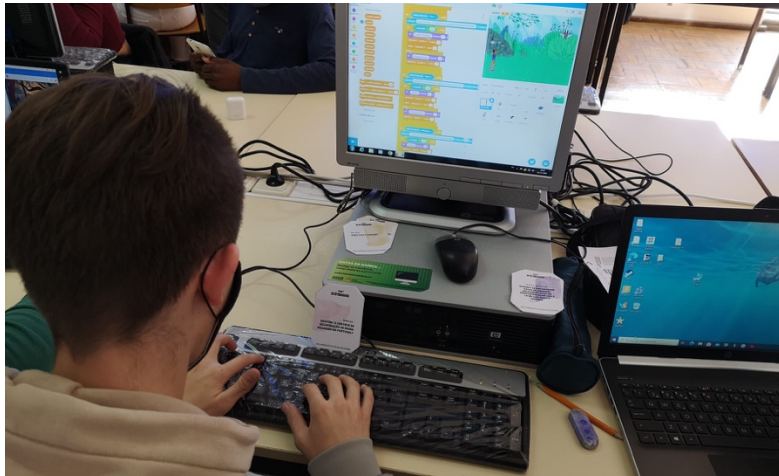


Fig. 5. Game Design session organized with upper-secondary students

As result of the game creation sessions, 66 digital games prototypes were produced. All games developed by the participants, whether upper-secondary or undergraduate students, focused on the theme of sustainability and environmental conservation presented in the thematic cards.

All sessions took place from December 2019 to January 2021 and, with exception to the online game jam, all sessions were held in-person. Data was collected through direct observation and a questionnaire designed to assess the Toolkit's contribute to support the design of digital games. Questionnaire was composed by 13 statements addressing aiming to evaluate the Toolkit, with participants being asked to indicate how much they agreed/ disagreed with each statement using a 5-point Likert scales (1 = strongly disagree, 5 = strongly agree); one question asking if they enjoyed using the toolkit and why; and a final question asking if they would recommend their teacher to use the

toolkit during classroom activities and why. The questionnaire was paper-based, voluntary and totally anonymous, with the only personal information collected being the respondent's gender. The first section of the questionnaire focused on the toolkit's contribute along the game narrative construction process and consisted of five statements: the toolkit helped in organizing ideas; the toolkit alerted to important points when defining the game; the toolkit eased the narrative construction process; the toolkit helped understand how to build a game; and the toolkit limited creativity.

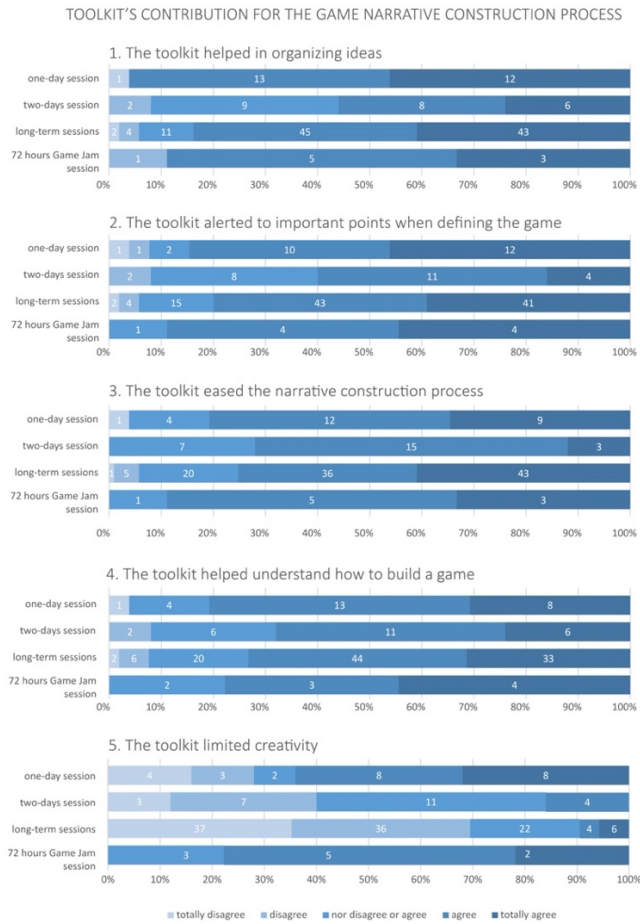


Figure 6. Toolkit's contribution for the game narrative construction process.

4.2. Results

During the sessions, participants used the information provided in the Gamers4Nature Toolkit's game cards to create the game's structure (e.g. player mode, challenge, characters, outcome) and the thematic cards to define the game's narrative.

Toolkit's contribution for the game narrative construction process. From the upper-secondary students participating in the one-day and two days game design sessions (N=53), 74% (n=39) agreed or totally agreed that the toolkit helped to organizing ideas and eased the narrative construction process, 72% (n=38) considered that it helped to understand how to build a game and 70% considered that the toolkit alerted for important points when defining the game. In what concerns the statement “during the game narrative construction the toolkit limited creativity”, 40% (n=21) agreed or totally agreed with this statement.

As for the undergraduate students who participated in the long-term game design sessions (N=105), 84% (n=88) considered that the toolkit helped in organizing ideas and 81% (n=85) considered that the Toolkit alerted for important points when defining the game. 76% (n=80) considered that the Toolkit eased the narrative construction process, and 74% (n=78) considered that it helped to understand how to build a game. Only 9% of the participants (n=10) agreed that the toolkit limited creativity. Eight of the nine Online Game Jam participants considered that the toolkit helped in organizing ideas, that it alerted for important points when defining the game and it eased the narrative construction process. 7 considered that it helped to understand how to build a game, and none considered that the toolkit limited creativity.

Results are summarized in Fig. 6.

Participants perspective on the toolkit's different resources. When asked to give their opinion about the Gamers4Nature toolkit's different resources, 79% (n=42) of upper-secondary students that participated in the one and two-days game design sessions considered that the texts presented were clear, and 77% (n=41) considered that the questions provided on the front of the cards helped to understand the concepts. 43% (n=23) considered that too much information was presented in the Toolkit's resources, and 43% (n=23) considered that in order to understand the cards, previous knowledge was needed. 23% (n=12) considered that effort was needed to understand the information provided in the toolkit's resources.

78% (n=89) undergraduate students considered that texts present in the toolkit were clear, and 72% (n=82) considered that the questions provided on the front of the cards helped to understand the concepts. 13% (n=15) considered that there was too much information. 12% (n=14) considered that effort was needed to understand the information, and 10% (n=11) considered that in order to understand the cards, previous knowledge was needed.

In what concerns the nine Game Jam participants, 7 considered that the questions in front of the cards helped to understand the concepts, 3 considered that texts were clear, and one considered that too much information was presented. Results are summarized in Fig. 7.

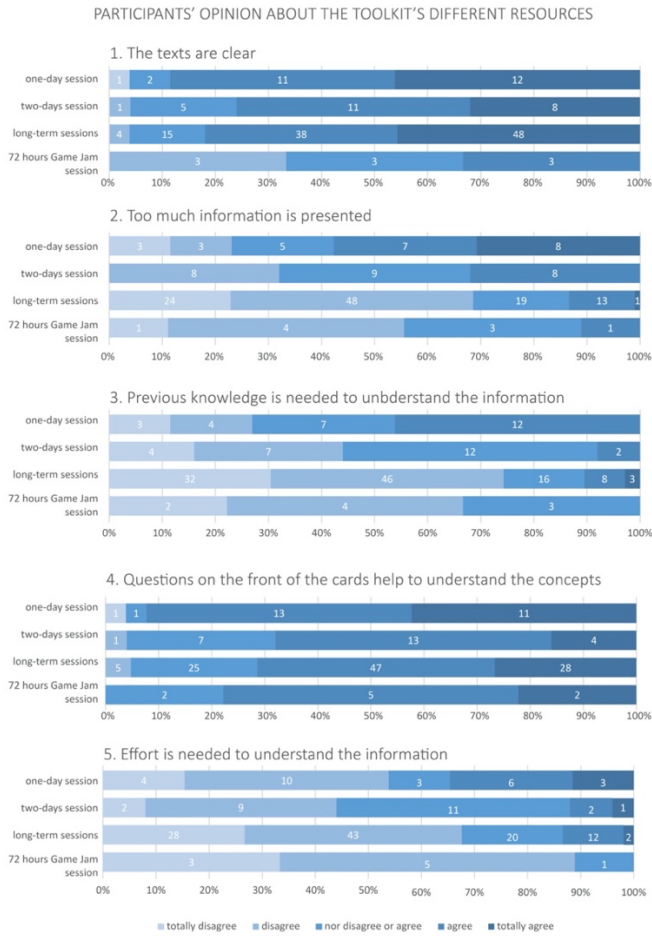


Figure 7. Toolkit’s contribution for the game narrative construction process

Participants’ overall opinion about the toolkit. Finally, and in what concerns participant’s overall opinion about the toolkit, upper-secondary students considered that the toolkit was useful in the process of designing a game (62%, n=33), that its format was easy to use (57%, n=30) and that it provided a good experience when designing the game (58%, n=31). 82% (n=93) of the undergraduate students that have used the toolkit along the long-term game design sessions considered that the toolkit was useful in the process of designing a game. 80% (n=91) considered that its format was easy to use, and 76% (n=87) considered that it provided a good experience when designing the game. Six online Game Jam participants considered that the toolkit was useful in the process of designing a game, and 3 considered that its format was easy to use and provided a good experience when designing the game.

Asked to say if they recommended the toolkit to their teachers, to be used along classes, 98% of the upper-secondary students said that they would recommend it namely because it was easy to understand and a good way to learn for the class, and it would be a good way to wake them up to programming and to understand class contents. As for undergraduate students, 87% said that they would recommend the toolkits to their teachers to use along classes, namely for helping to better document the iterations of the game creation process, being a dynamic and innovative resource, very intuitive to use and able to drive good ideas. According to these participants, the Toolkit would help to structure ideas and would be a good help for projects since it would make brainstorming and idea formation much easier. In the opinion of one participant, the toolkit would be a great tool for starting the specification and production of the game content.

In what concerns the 72-hours online Game Jam participants, no questions were asked about if they would recommend the toolkits to their teachers to use along classes. Results are summarized in Fig. 8.

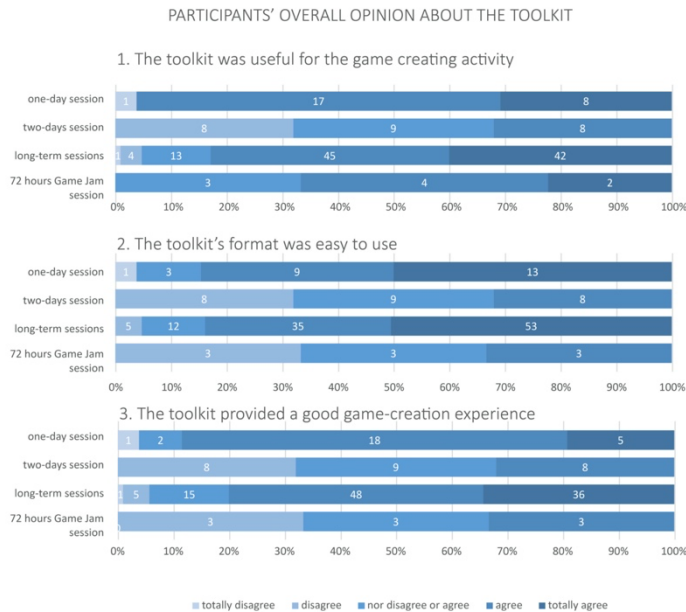


Figure 8. Toolkit's contribution for the game narrative construction process

5. Conclusions and Future Work

As the development of critical thinking and creativity become more important in the XXI century, challenging students to explore and interact with educational content

through the design of digital games may lead to more interest in the addressed theme and a better acknowledgement of the importance of what is learned.

This paper presents the Gamers4Nature Toolkit to Game Design, an artifact created to support the creation of mobile digital games. Results indicate that the Gamers4Nature Toolkit to Game Design was seen, by students as an interesting and valuable resource to be used in classroom environments, namely to promote discussion about specific themes, to promote collaboration and to support the creation of the digital games' structures. Data also indicate that the learning curve required to use the toolkit will not be too long, thus suggesting that the Toolkit can be easily integrated in classroom contexts.

As result of the game creation sessions, 66 digital games prototypes were produced. All games developed by the participants, whether upper-secondary or undergraduate students, focused on the theme of sustainability and environmental conservation presented in the thematic cards. By using the Toolkit, upper-secondary and undergraduate students were able to develop game narratives and implement digital games related with an environmental awareness theme.

Developed games - which were also assessed in terms of gameplay and game dynamics - included environmental-related quizzes (endangered species and the protection of local biodiversity), role play games where characters interacted with environmental threat scenarios (game on the control of pampas grass, an invasive species, and games on microplastic pollution), and endless runner games where players had to capture and/or avoid specific pollution agents (microplastics, pampas grass, endangered species). Games are available in the project's online platform, to be downloaded and player by the wider community.

In a scenario where games are seen as an innovative approach to raise environmental awareness among youths, findings indicate that the Gamers4Nature Toolkit can be seen as an engaging approach to game creation and an effective support for digital game creation activities, namely in educational settings. In fact, and besides the digital game design sessions described in this paper, the Toolkit is also being used by twelve secondary school teachers from four different nationalities, who are at the time participating in a training course. Preliminary data collected through semi-structured interviews and short questionnaires indicates that teachers - who are familiar with gamification and game-based learning but who have not used game creation activities as learning strategies - see the toolkit as a useful tool to be used in a classroom context, not only to promote creativity and looking at problems from a different perspective but also in order to engage the students in the exploration of subjects through digital games creation. As future work, additional game design sessions (e.g. Game Jams) are being organized with upper-secondary and undergraduate students, in order to strength the Toolkit's adequacy or to uncover points yet unconsidered. Additional sets of thematic cards and a new set of "unblocking creativity cards set" are also being produced.

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