Scratch-Based Game Development Resource Set for a Toolkit to Game Design

Pedro Beça , **Sofia Ribeiro** , **Mónica Aresta** , **Rita Santos** , **and Ana Isabel Veloso**

Abstract Games are engaging activities for students that can be applied in classes worldwide. Simultaneously, toolkit's potential has been rising over the years due to its ability to encompass relevant tools on specific subjects. Moreover, toolkits can be applied as authoring tools transforming students into game designers, motivating the creation of digital and/or mobile games, and knowledge acquisition and engagement. The Gamers4Nature (G4N) project has been researching on environmental-themed games' development, involving students in game development sessions. Aiming to support the whole game design process for upper-secondary and undergraduate education, the G4N project conceived a Toolkit to Game Design that has been used in formal and informal contexts of education fostering the creation of digital games on environmental themes. The G4N Toolkit, addressing both experienced and novice students, was design in a User-Centered approach with iterative sessions for validating aesthetics and contents. As it was understood that students sometimes lacked the skills to develop their games, preventing them to accomplish a finished product, a complement to the already produced resources (Game Construction cards, Rapid Game Design Document, environmental-themed cards, and Mobile Game Design Guidelines), was developed: the Development Cards Set. This chapter introduces the Development Cards Set creation process, to be validated through expert review (by experts in the game development field) and by end-users who will test and validate the development cards along dedicated workshops and game creation sessions.

P. Beça (✉) · S. Ribeiro · M. Aresta · R. Santos · A. I. Veloso
Department of Communication and Art, University of Aveiro, Aveiro, Portugal
e-mail: pedrobeca@ua.pt

S. Ribeiro
e-mail: saribeiro@ua.pt

M. Aresta
e-mail: m.aresta@ua.pt

R. Santos
e-mail: rita.santos@ua.pt

A. I. Veloso
e-mail: aiv@ua.pt

1 Introduction

Games are an important part of human existence, with the human's interaction with games being found in various fields, from leisure activities to education [1]. In the Education field, games have the potential to be used as a teaching strategy, either by recurring to game-based learning approaches [2], or by engaging students in game-creation activities—an approach that also allows them to develop specific programming knowledge and skills [3, 4]. The creation of games, however, requires a specific set of competencies and skills that sometimes may not-existe or be underdeveloped, specially with younger audiences. In this scenario, the non-linearity that—sometimes—pertains the game design process may push prospective creators away, forfeiting the chance to nurture from non-experience users' involvement.

In the field of game design, toolkits, namely authoring toolkits, can support students to create artifacts by integrating the necessary tool for them to develop a determine activity [5, 6].

In this scenario, and aiming to engage upper-secondary and undergraduate students in active participation in game creation activities, the Gamers4Nature (G4N) project, developed and validated a Toolkit to Game Design [7–10] that aims to provide, in a single component, the necessary tools to allow any student to create a full gaming experience: from the game narrative definition to its coding implementation. The G4N Toolkit addresses the several dimensions of game design: (1) the game narrative is supported by the game construction cards set—that provide information about the different elements that compose a game—by the rapid game design document—that suggests a path to explore and articulate the game construction cards–, and by sets of thematic cards, that present information about specific environmental-related themes and thus allows students to grow their knowledge and awareness on the environmental field whilst creating games [3, 4]; (2) the game aesthetics, with a set of mobile game design guidelines that provide support in the design and aesthetics of a game considering literature and industry best practices [10] and finally, (3) the game implementation/coding, with a set of cards that aids the implementation process of a game, not only by suggesting an intuitive platform for (non-)experienced programmers but also by tutoring (i.e. step by step) that platform's usage in the context of game development.

In this chapter, we present the game implementation cards development process, from the theoretical background that supported its creation to its prototyping and validation process. Furthermore, we introduce the theoretical background that supported the Development Cards Set creation process as well as the methodological approach to be taken to validate through expert review (by experts in the game development field) and by end-users who will test and validate the development cards along dedicated workshops and game creation sessions is also introduced.

2 Theoretical Background

2.1 Games: How Can We Define Them?

Games and play can be adjacent concepts, and indeed complexly related, they are distinct: games can be board games, card games, sports, computer games, among others; play can be either an activity involving games, or subset within the game design field [11].

Games, as a fundamental part of human existence, are a complete and self-sufficient "formal system that subjectively represents a subset of reality" [12, p. 8]: formal since it has rules and a system due its parts that interact between themselves. They can also be defined, in a more ludic or "ludological" approach, as a goal-directed and competitive activity conducted within a framework of agreed rules [13].

According to some authors [14], games can create habits, sustain changes, and indicate civilization's preferences, weaknesses, and characteristics, hence games have the potential to—applied in diverse approaches—promote knowledge development and/or behavior change. In fact, students can benefit from their involvement in games' development process [15]. Despite minor variances in game's definition, there is a consensus that games consist of components within a framework of rules [16].

2.2 Creating Games: Is There a Process?

Artifacts derive as a product of a design methodology that guides the creative process and ensures the artifact's quality [17]. Games, as artifacts, are created from scratch [11], nonetheless, there is no fixed design process (only best practices [18]), in fact, new approaches may lead to innovative designs. Nevertheless, we should never overlook some game design basics, such as game mechanics and materials, and a theme [11].

In a more general approach, a game—to be created—needs to be conceptualized, written, built, and examined, consisting of the decision on what the game should be (e.g. design, rules, mechanics, scenarios, setbacks) by defining each of the game's elements [18]. Notwithstanding, diverse authors consider different approaches to this process: while Werbach & Hunter follow the Mechanics, Dynamics, Aesthetics (MDA) framework [19], Fullerton uses game elements to build a game, and Duke depicts a process of nine steps [18]. These diverse approaches to game design emphasize that this process can be rethought according to the applied strategy to foster game implementation and the target audience that is going to be the game designer.

There are some resemblances between game design process approaches: a conceptualization concerning the dimensions of the game narrative (e.g. what is the game

about, the theme, what and how to achieve), the game aesthetics (e.g. visual appearance, graphical content), and the implementation as in making the game work [15, 17, 18].

2.3 Toolkits to Support the Game Creation Process

Purely theoretical education is proven not to be enough to teach in any design education field, as learners indeed need to be involved in more practical experiences in order to achieve and acquire knowledge regarding design processes [11]: in fact, and when engaged in game design training courses, students must create games.

Having this into consideration, toolkits may have the potential to involve students in design processes: on the one hand, due to their capacity of facilitating activities [20], on the other hand because they are suitable for novice and experienced users, and enhance creativity [5, 9].

Practical teaching in games, without disregard to its contiguity with computer games, does not necessarily require game programming classes and exercises [11]. Therefore, besides the digital games rising, initiatives to develop games should not be narrowed to digital approaches. Authoring toolkits have huge potential to users since they are placed as creators and designers whilst nurturing and grasping the advantages of having the required tools to execute a process, fulfilling its goals.

Toolkits have the ability to transpose abstract and complex concepts into practical and clear definitions that may allow students to operationalize those abstractions into concrete games [21]. Concerning games, there are multiple examples of toolkits or card approaches to game ideation/brainstorming, narrative, and implementation. As for game ideation: the Grow-A-Game cards uses conscious design and analysis of digital games[22]; GameSeekers is played similar to UNO and uses cards in a collaborative game to visually build a game idea likewise in a mindmapping process [23]. Regarding game narrative: through a book, (even non-experienced) game designers are able to access a stepwise game development process [24, 25]. Finally, for game implementation: digital songlines game engine toolkit supports the development of Australian Indigenous storytelling in a sensitive manner by creating virtual cultural landscapes in 3D game environment [26]; practical instruction on creating world-class games that will be played repeatedly with over 100 lenses of fundamental principles of game design [27].

3 Supporting the Game Creation Process: The Gamers4Nature Toolkit to Game Design

The Gamers4Nature (G4N) project aims to promote students' engagement with environmental themes (e.g. microplastics, invasive species), hence fostering knowledge

on climate preservation and the earth's biodiversity by encouraging their participation in the development of environmental mobile games [7]. Since 2017, this project has been working with upper-secondary and undergraduate students through a series of workshops and game creation events, motivating them to create their own digital games in game jam sessions and events.

In order to incite students' participation, whilst nurturing collaboration and engagement between peers and with the educational subjects, the G4N project has implemented several strategies to support the game creation process. One of those strategies consists of a toolkit to support the whole process of game creation, from game narrative to game implementation, to be used even by novice users—those with no previous experience in game design or game development. The G4N Toolkit to Game Design (Fig. 1) comprises several resources: a game construction cards set with 12 cards approaching an adapted version of Fullerton's game elements [8, 18]; a rapid game design document presenting a path to explore the game creation cards and building the game narrative; sets of thematic cards addressing nature and environment preservation (e.g. microplastics, stag beetle, dune systems); and a Mobile Game Design Guidelines cards set [10] that aims to help users when creating the game interface.

As the G4N Toolkit intends to be used even by novice users—those with no previous experience in game design or game development–, and as there was a purpose to create a comprehensive resource that would support users all along the digital game creation process, from narrative to implementation, a new set of cards—the Scratch Development cards set was developed. With this new set of cards, the G4N Toolkit to Game Design emerges as a resource able to support the whole game design

Fig. 1 The Gamers4Nature toolkit to game design: on the left the rapid game design document; on the right, (in order) the game construction cards set, the thematic cards (the microplastics theme example), the mobile game design guidelines cards set, and the new cards set: scratch development cards

process (from narrative to implementation), along its main stages: (1) conceptualizing the game; (2) designing the game interface; and (3) implementing (coding) the game.

Along the game design sessions fostered by the G4N project, whilst students used the G4N Toolkit to create and design their games, it became visible that some students struggled when the time to implement the game arrived, stressing the need to support (also) this stage of the process.

Conceptualizing and Writing the game. Game Design is a relation between the game design/development output and the players' experience [11]. Thinking as a game designer requires a solid process from the game's initial concept to its creation to create a playable and satisfying experience [18]. For many people, the ideation stage—which can be considered the beginning of the game design process—can be an immediate barrier [18]. Furthermore, this process can be innovated, still it must concern game design basic principles, such as mechanics, materials, and themes [11]. The G4N project aims to innovatively answer this context, providing and motivating students to be designers and creators of their own games, by providing them with tools to be involved in this process consciously. To support the game's narrative construction, the G4N Toolkit encompasses three main elements: the game construction cards set, the rapid game design document, and the thematic cards. The game construction cards and the game design document can be used together, comprising cards clarifying the game's main elements and the document suggesting a path to explore and articulate the cards [4, 8]. As the intent is to create games addressing environmental awareness themes, the G4N Toolkit also provides cards set addressing several environmental-related themes. By challenging students to create games on these topics, their engagement and interest is being prompted and motivated [4]. Sessions held with upper-secondary and undergraduate students emphasize the G4N Toolkit's usefulness and value [3, 9], while the plasticity of these resources was pointed out by game design experts, who mentioned that it transmits different perspectives on game design, supports ideas' systematization and exploration, and guides the game construction [9, 10, 12].

Designing the game interface. Games are nothing more than an idea when they are limited to a narrative. Therefore, it is essential to design the game within an environment where players can experience the game narrative connected with graphics. Likewise any other field, the graphical appearance of any output constraints the overall experience with it, hence it is crucial to design a game complying with game standards, avoiding that the gamers' experience is affected by a bad design.

Along the game design sessions held with students, some barriers related with interface design were identified, hence an additional set of cards was added to the G4N Toolkit: the Mobile Game Design Guidelines Cards set [10]. Validated with experts in design and in games, the set included 28 cards approaching essential guidelines for mobile game design, from interface to interaction, performance and promotion categories. While the previous resources help to define the game narrative, the MGDG cards filled a gap on the G4N Toolkit by bridging the game narrative with the interface design implementation.

Implementing (coding) the game. Nevertheless of the Toolkit's efficiency in supporting the game design process (see [3, 4, 7–10]), to fulfil the whole game creation process students still must implement the game themselves.

Following the approach taken for the Toolkit's development—to create resources able to guide users with and without experience in game design to create digital games—a set of cards with examples and instructions on how to implement a game using programing visual languages was created. Research suggests that, amongst the several visual programming languages that can be used to create games, Scratch is one of the most used in schools and is already integrated into computer science formal and informal education in schools and universities, due to its programming teaching potential combined with its usability [28–30]. Taking this into consideration, Scratch was chosen to exemplify the coding process, due to its block-based approach, suitable for both experienced programmers and non-experienced users.

4 The Development Cards Set for Scratch

Aiming to synthesize in a single tool the ability to support the entire game creation process—from the idea to its materialization in Scratch–, the G4N research team created a new set of cards to fulfil the last step in the game creation process: developing, i.e. coding, the game.

Scratch was the software chosen due to its easy learning curve, hence supporting non-experienced students in both game design or the software itself. The block-based approach integrated in Scratch is easy to learn and self-explanatory: e.g. a student does not need to have previous teaching concerning loop events to understand that by inserting any block into the "forever" block that that event will occur indefinitely. Although there are several resources to aid Scratch's use, this cards set is pertaining since it completes the G4N Toolkit, allowing it to—in a single resource, aggregating several components—support the **entire** game design process.

This new set encompasses 29 cards divided into seven separate categories approaching different stages of the game development process. Each category groups multiple cards on similar or related topics: before starting the game; start the game; move; visual appearance; sprites and backdrops; audio; repetition and decision structures; variables and messages. The category titles were defined to be explicit and clear regarding its objectives, and also the cards' title (see Table 1) were denominated and written in a way that would be evident for even non-experienced users.

The cards were designed in a way so that they can be used separately or as a group. For example, one card explains—by itself—how to start the game, while another card depicting how to move a sprite, mentions the card to start the game, and then answers its propose. This way, users can form a sequence of cards and thus building the hole code structure for their game.

In order to be easily distinguished from the G4N Toolkit's card sets addressing game narrative, and following the same design approach taken for the development of the mobile guidelines cards, the development cards set follows a tutorial format

Table 1 Development cards set: scratch orientations divided into seven categories

| Category	Cards title
Before starting the game	Clean game scenario
Start the game	Start the game with the scratch flag
	Start the game with broadcast of a message or word
	Start the game with a button click
Sprites and Backdrops	Create new sprite
	Insert sprite
	Create new backdrop
	Insert backdrop
	Change backdrop
Move	Move sprite with keyboard
	Move sprite automatically
	Collisions between objects
	Collision with specific color
Variables and messages	Create variable
	Show or hide variable panel
	Scoring points
	Change variable value
	Broadcast message to the whole game
Sound	Choose a sound from scratch's gallery
	Play background music throughout the whole game
	Play sound in backdrop change
Repetition and decision structures	Repeat an event forever
	Count the game's time
	Create conditions to execute events
	Logic operators: This *and* that?
	Logic operators: This *or* that?
Visual appearance	Buttons
	Animate game buttons
	Add sequential texts
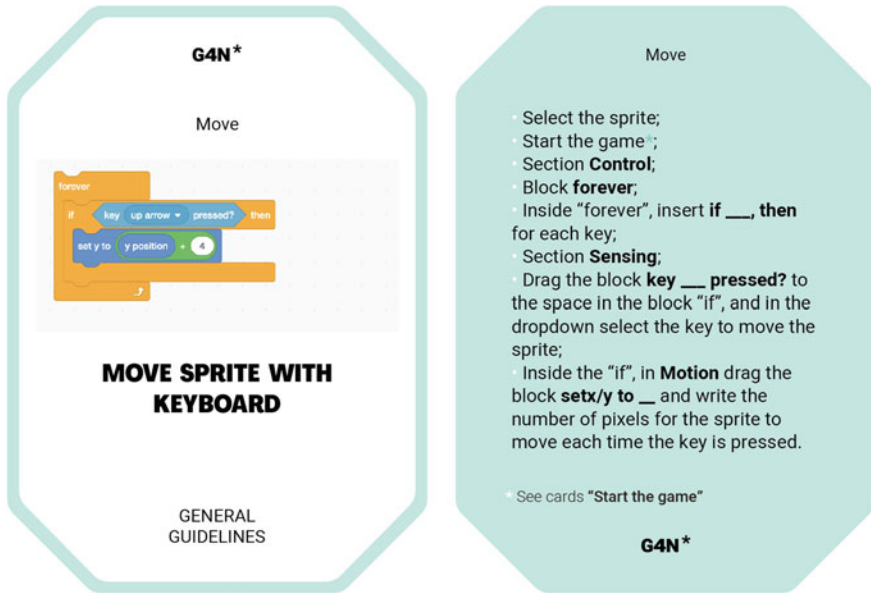
Fig. 2 "Move sprite with keyboard" card from the move category: a model of the development cards set

by integrating an image that visual represent the code block (card's front) and step by step instructions that can be read and followed to build that block (card's back). In fact, the image aids in the block's replication and the text specifies the groups where each block can be found (see Fig. 2).

The development cards set is composed by 29 cards divided into 7 categories approaching different objectives and actions of a game: before starting the game; start the game; move; visual appearance; sprites and backdrops; audio; repetition and decision structures; variables and messages.

As for the cards' layout, the card's front is composed of the G4N project's logotype, the category's title, an image with the built Scratch blocks, the card's title, and the title of the card set. In what concerns the aesthetics, the card has a border that reflects the card's content category—common to all the cards in this set-, each category having a different color, and the layout is similar to the other card sets in the G4N Toolkit. The cards' back comprises topics, each one regarding a specific step of the Scratch function's construction. Furthermore, it includes the category's title and the G4N project's logotype as well as, when needed, a reference—marked by an asterisk—to other related cards in the set.

5   Conclusions

The acknowledgment of the games' potential in formal and informal contexts has been prompting researchers to develop work in this field. Furthermore, there is a worldwide recognition concerning the capability of toolkits to aggregate useful resources, specifically for games, as well as to convey relevant information enhancing students' understanding of subjects and their motivation towards them.

In this line of thought, the Gamers4Nature project, allying two slopes—games and environmental preservation and awareness–, has developed a Toolkit to Game Design encompassing a full approach to the game design process. Throughout this development cycles, in a User-Centered approach, the project's research members have conducted iterative sessions with experts and end-users in order to evaluate the resources' aesthetics as well as the theoretical knowledge provided and the integration in real-life scenarios of these resources. From the G4N studies' empirical evidence, the project has scaffolded the need to provide support for both experienced and non-experienced students in game design field, aiding them with tools to create games—from scratch—games concerning a specific theme. Hence, in this context, by successively producing decks of cards for each step of the game design process, the project as now achieved a full version of the Toolkit, which contains: Game Construction cards, a Rapid Game Design Document, environmental thematic cards, Mobile Game Design Guidelines, and Development Cards to create games resorting to Scratch.

This project hopes that, by providing a full toolkit addressing the multiple stages of game design, can assist even non-experienced students to create their own games, whilst promoting environmental awareness. The conducted sessions, in which more than 160 students were already involved [3], shown the G4N Toolkit's potential and how one tool can support the development and creation of so many diverse results.

5.1   Future Work

Similarly to previously developed components of this Toolkit, the research team aims to validate these cards with end-users in order to execute possible required adjustments and improvements, and make available this resource to support game ideation, creation and implementation. Following the same approach taken for all the other toolkit's resources [3], this new set of cards will be validated by experts in the game development field (expert review) who are familiar with this coding language and are used to work younger audiences, and by end-users who will test and validate the development cards along dedicated workshops and game creation sessions.

Future work also includes the development and validation of other sets of Scratch cards, designed to be used in the specific creation of environmental-related games. These cards will follow the design aesthetics and approach of the introduced Development Cards.

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