African Educational Research Journal
Vol. 11(3), pp. 269-292, July 2023
DOI: 10.30918/AERJ.113.23.030
ISSN: 2354-2160
Full Length Research Paper

Design and development process of a digital game to acquire preschoolers' self-care skills: a model practice

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Accepted 15 June, 2023

Abstract

This study aims to clearly describe how to design and develop a digital game with a concrete example for preschoolers to acquire Self-Care Skills (SCS). The study is in the model of design-based developmental research and includes such participants as subject-matter experts, practitioner teachers, and preschoolers in the development steps. RETRO game development model was adapted and followed in the game development process by integrating Digital Game-Based Learning (DGBL) approach with entertainment game development. Each step of the model involves gathering, analyzing data and yielding informative findings that guide the next step. The views of participants indicate that some behaviors in SCS can be cognitively acquired and internalized by the game with latent learning. While realizing learning outcomes, the developed game succeeded in motivation, engagement and design features as in commercial entertainment games. As the model recommends, if all the bases are covered, the design and development process may be executed right. Since the study reports the entire process of the concrete example, it can help guide novice digital game developers (can be a teacher, a trainer as well) repeat the game development or develop a new one based on DGBL.

Key words: Digital games, digital game-based learning, early year's education, mobile games, self-care skills.

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INTRODUCTION

Recent research indicates that in preschoolers nearly all (over 95%) have access to mobile devices and the internet. Also, mobile device ownership of preschoolers increases rapidly over the years (Castillo, 2019; Konok et al., 2021). They prefer the most mobile devices for being online. When being online, they spend time the most watching online TV shows and videos (28 minutes a day), and also mobile gaming (13 minutes a day). Overall gaming time of them is nearly 30 minutes a day. It is seen that the habit of social gaming (playing online with others) is also increasing rapidly (Ofcom, 2019; Rideout and Robb, 2020). Preschoolers interact with a wide range of environments where Information and Communication Technologies (ICT) –especially mobile devices– are used and are exposed to intensive information –especially via digital games. Digital games have clear learning outcomes related to the real world and are engaging, motivating and interesting (Yusny, 2013; Chow et al., 2020), so they can provide active learning for preschoolers. The main teaching approach that explains how games can be used in education is DGBL. DGBL is described as a form of experiential engagement in which people learn by trial and error, by role-playing and by treating a certain topic not as 'content' but as a set of rules, or a system of choices and consequences (Perrotta et al., 2013). The interactions that today's learners experience in digital environments change their learning patterns (Prensky, 2001). Different learning approaches, like DGBL, popular recently (Hooshyar et al., 2018; Zou et al., 2021), can be used as facilitators for kids' learning in cognitive, affective, and psychomotor domains. Recent studies about the effect of DGBL show a positive impact on knowledge acquisition, motivation, and on related behaviours and emotions in early childhood. Despite

many studies related to educational games, there are not enough studies to analyse the essential features, disadvantages, and advantages of DGBL at the preschool level (Behnamnia et al., 2022; Lazarinis et al., 2020). More, a comprehensive study is needed to demonstrate the effectiveness of the games in early childhood learning (Lin et al., 2020). DGBL can be needed to meet Basic SCS, it is important for preschoolers to acquire SCS and to make them into their habits so that they do not have any physical, psychological and social difficulties in their lives. Therefore, important duties and responsibilities fall on the family and educators in the acquisition of SCS-related behaviors. DGBL studies aimed at getting preschoolers to acquire SCS are theoretically and experimentally few and inadequate (Peirce, 2013). In parallel with the world, digital games developed for preschoolers in Turkey are inadequate in terms of quantity and quality (Güler et al., 2017a). Most studies in Turkey are on game-play habits, frequency and duration (Arnas Aktaş, 2005; Akçay and Özcebe, 2012; Balcı and Ahi, 2017), addictions and effects (Aral and Doğan Keskin, 2018; Budak and Işıkoğlu, 2022), and students and teachers views on games (Aral and Doğan Keskin, 2018; Cömert, 2020; Güler et al., 2017c; Hazar, 2018; Karaoğlan Yılmaz and Yıldız Durak, 2019). However, they are very few on the effect of the DGBL approach on education, academic achievement or motivation, especially for preschool children (Güler et al., 2017b). Studies in the literature focus largely on those with special educational needs, such as preschoolers with intellectual disabilities, autism, cerebral palsy or down syndrome (Dinçer et al., 2017). On the other hand, while many DGBL studies for preschoolers focus on knowledge acquisition and motivation, few focus on behaviour change and soft skill outcomes (Behnamnia et al., 2022). The development of qualified digital games with the DGBL approach addresses these deficiencies and offers them a supportive/complementary educational opportunity. It this sense, it is necessary to carry out studies on DGs for different age groups, to help teachers use game-based learning more often, to develop DGs that students and teachers can use, and to inform families to disseminate educational games (Uslu, 2022). The primary step of DGBL is game/s to use; two options exist for that. The first one is to use available games by adapting educational content or to develop a game/s supporting an educational objective. (like serious games). The second one is to develop suitable DGs with a DGBL approach. Many commercial and educational game development models exist in the literature (Horvat et al., 2022). The model we use and adapt stands out compared to other models in that it is parallel to the design-based development model and describes the process steps from the beginning to the end and the developers' roles. In this sense, the study aims to design and develop a game for preschoolers to acquire SCS, and to clearly describe the management processes of developing the DG with a concrete example.

THEORETICAL FRAMEWORK

Self-care Skills (SCS)

According to Havighurst (1972), SCS are behaviors that are not innate but acquired later. Freud says problems and obsessions that may arise during early childhood development are important in the formation of neuroses (McLean and Syed, 2015). Piaget mentions mental processes happen to establish a balance between a new situation and previous experiences. Similarly, Erikson mentions psychosocial crises in each personality period continue in the later stages of life (Zgourides, 2000). SCS that started to be acquired from a very early period play an important role in maintaining a quality and healthy life and affect directly a child's physical, mental, emotional and social development. In this context, negativities experienced in SCS in preschoolers' development lead to nutrition, health, cognitive and personality problems in the later periods (Smith and Hart, 2011). For that, the SCSs being tried to be gained in the family have a wide place in preschool education as well (TEGM, 2013).

Digital Game-Based Learning (DGBL)

Digital Game-Based Learning (DGBL) approach was introduced in the early 2000s by pioneers such as Marc Prensky, James Paul Gee, and Clark Aldrich. Perrotta et al. (2013) describe the principles of DGBL as (1) Intrinsic motivation; playing games is usually a voluntary and self-performed activity, (2) Learning through intense enjoyment and fun, (3) Authenticity; not abstract but goal-oriented and contextualized learning, (4) Self-confidence and autonomy; passions and interests that lead to the desire to specialize and (5) Experiential learning; learning by doing. They state the mechanisms of DGBL as (1) Rules; need for simple and binary (if/then) or more complex decision-making process, (2) Clear, but challenging goals, (3) A fictional setting or fantasy that provides a compelling background, (4) Progressive difficulty levels, (5) Interaction and a high degree of player control, (6) Immediate and constructive feedback and (7) Provides players with a range of opportunities to share, interact and pursue interests and passions.

The new generation, defined as digital natives, resists traditional learning because they want multiple streams of information, prefer inductive reasoning, want to interact with content frequently and instantly, and are extraordinarily visual literate (Eck, 2006). Due to the fact that digital natives use various media intensively, are constantly connected to the Internet and often play digital games, their interaction potential with them has been

noticed. Presently, educators have brought up the use of digital games as a serious learning and evaluation tool, especially in their formal education. In this context, DGBL can be a cost-efficient, high-quality supportive or complementary teaching method in overcoming the problem of students' lack of interest in traditional teaching methods (All et al., 2015; Dobrescu et al., 2015).

DGBL studies have increased due to the spread of the COVID-19 pandemic and online learning (Behnamnia et al., 2022). In the research examples related to DGBL, the subject areas are generally mathematics, history, language teaching, science, and social studies at primary, secondary, and higher education levels (Connolly et al., 2012; Tay et al., 2022). On the other hand, DGBL studies for preschoolers focus on knowledge acquisition, and few focus on behavior change and social and soft skill outcomes (Behnamnia et al., 2022). The math-related studies in early childhood education showed that games or DGBL could help children improve numerical knowledge and comprehension (Siegler and Ramani, 2008; Scalise et al., 2017), enhance numerical skills and competencies (de Chambrier et al., 2021; Gasteiger and Moeller, 2021), and increase awareness of numeracy-related content (Vandermaas-Peeler et al., 2012). Some studies showed that some skills or knowledge that are hard to learn or develop, such as computational thinking abilities (Lin et al., 2020), the construction of probabilities (pattern prediction) (Nikiforidou and Pange, 2010), and computer science concepts and language programming (Martinez et al., 2015) could be transferred to kids by games. Moreover, some showed that games could be beneficial to the assessment of young children's informal mathematical abilities (Doig and Ompok, 2010). Some language learning-related studies indicated the positive effect of using DGs in teaching English (Aghlara and Tamjid, 2011), vocabulary growth in children (Schuurs, 2012), and English vocabulary acquisition (Tang, 2020). The studies to help preschoolers improve children's cognitive development and motor skills (Hsiao and Chen, 2016), improve children's distinction between thematic and taxonomic relationships (Sung et al., 2008), and understanding of rational actions (segregation of false belief understanding) (Priewasser et al., 2013) have found positive results. In another study, the game benefited the recognition of letters with sounds and enhanced the kindergarteners' ability to learn categorised content and practice uncategorised content (Samur, 2019). Raziunaite et al., (2018) found that preschoolers are interested in exploring and creating musical sounds with an educational game-based process. Chen et al. (2019) showed that games have great potential as an evaluation tool to clarify difficulties associated with autism. Some studies also reveal that games can effectively deliver nutrition information to kids (Putnam et al., 2018), or a fruit-related game stimulates fruit intake among kids (Folkvord et al., 2016).

Since such concepts as active participation, discovery learning, gaming, individualized learning environment, process evaluation, and creativity are inherent in DGBL, it supports and complements traditional learning methods and accords with the basic characteristics of the Turkish Early Childhood Education Program (TECEP) as with others in the world. According to Katz (2015), it is necessary to provide a wide range of experiences, opportunities, resources and environments that stimulate, promote and support the innate intellectual potentials and characteristics of preschoolers. So, learning with DGs or the DGBL approach has the power to provide preschoolers with some of them.

This study's contributions to the field can be highlighted as (1) it presents an adapted Digital Game Development Model (DGDM) to manage the development process which is suitable for design-based developmental research, (2) following the adapted model makes strong the game's entertainment and pedagogical aspects owing to including not only the designer but also both the practitioner teachers and their students, (3) it examines the applicability of DGDM to provide new learning experiences for the children and teaching material and method for teachers, and (4) it helps novice educational digital game developers to follow and to repeat the process through a concrete example, as it reports the entire process. To illustrate the application of the adapted RETRO game development model or DGDM, the research questions of this study are specified as follows:

1. What are the views of Subject Matter Experts (SME) on using digital games with DGBL approach in teaching SCS for preschoolers?
2. What are the views of SMEs on game development process to support preschoolers' acquisition of SCS?
3. What are the views of the practitioner teacher on instructional design and game design in terms of appropriateness to preschoolers?
4. What are the preschoolers' views on and reactions to the beta version of the game?

METHOD

Research Design

This study is a design-based developmental research model. Developmental research is defined as a systematic study of the design, development and evaluation of processes and products for instructional programs and aims to create generalizable conclusions or rules or to generate *context*-specific knowledge that provides problem solving function (Seels and Richey, 1994). Various stakeholders such as designers, developers, evaluators, field experts, teachers, pre-service teachers and preschoolers are involved in this process (Richey and Klein, 2005). This study is

"*pragmatic*" since it contributes to practices of SCS education by employing DGDM and DGBL, it is "*grounded*" since it is based on theory and practice, it is "*interactive*" since researchers' study together with the participants, it is "*iterative* and *flexible*" since it follows an iterative process in phases and steps, it is "*integrative*" since it uses mixed methods, and it is "*contextual*" since the entire process is documented. In addition, the focus and implementation of the research include product design and development (Type 1) and model use (Type 2), amongst the types of developmental research (Richey and Klein, 2004).

Digital Game Development Model

Lucas Blair's "RETRO Game Development Model" (Kapp et al., 2014) was selected to manage the digital game development process and adapted to serve the purpose of this research. In the digital games industry, (1) Waterfall Model, where development stages from concept development to testing are linear and sequential, and (2) Agile Model, which allows rapid and incremental development, is widely used (Keith, 2010). Unlike the waterfall model, the agile model is executed properly as it is constantly updated with feedback from customers involved in the process (Sivak, 2013). The models for developing educational digital games reached in literature are as follows: (1) EFM: A model for educational game design (Song and Zhang, 2008), (2) fuzzified instructional design/development of game-like environments (Akıllı and Çağıltay, 2006), (3) game object model (Amory, 2007), (4) experiential game model (Kiili, 2005), (5) spiral model for game development (Akgün et al., 2011), and (6) digital games-based learning-teaching design model (Zin et al., 2009). These models can be considered inadequate in terms of model and process management in designing and developing digital games (Akgün et al., 2011; Korkusuz, 2013). The existing balance problem between components of educational digital games and commercial ones (Kapp et al., 2014) was tried to be solved by integrating components of commercial ones (mechanics, dynamics, story, etc.) with instructional design (coordinated-cyclic execution). In other words, as in the agile model, the game development process is continuously updated with iterative feedbacks. Therefore, in addition to SEMs, real practitioners and users were involved in the game development process and they were consulted on the steps of the RETRO model. With adaptations done from the model, detailed reporting exists throughout the development process.

As in Appendix-1, the adapted model includes the following two basic phases: (1) *Pre-production phase* is the basis of the development process; thus, it is the most important and time-consuming part of the process. At this phase, a conceptual framework is created in the light of theoretical knowledge, the development process is planned with the DGBL approach and the outlines of the process are created. Instructional design (target audience analysis, learning goals, learning outcomes and outcomes assessment designs, etc.) and game design (game story, mechanics and elements, game art assets design, etc.) are completed. In addition, at the end of this phase, documents are produced to serve the game development team throughout the life cycle of production. Most of the contents of this document consist of the best estimates, the team continuously updates the document. In *production phase* (2), the game and its artistic assets (auditory and visual elements) are digitized, encoded and tested to reach its final version. In both phases, updates are made cyclically according to the target audience's feedback. For all steps of the process, developers have responsibilities for (1) production, (2) instructional and game design, (3) software and programming, and (4) art design. The model clearly states the digital game development team tasks and the relationship between them (who, what to do, how to proceed and how to share data) (Kapp et al., 2014).

Participants

User analysis is carried out in the pre-production phase of the model. For this purpose, data about preschoolers were collected from their parents. Determined with convenience sampling, 322 preschoolers (161 girls and 161 boys: 31 of them aged four, 192 of them aged five, 84 of them aged six, and 15 of them didn't state their age) participated in the survey. In addition, a questionnaire was applied to 52 voluntary female preschool teachers working in 17 different preschool education institutions in Kilis province. Considering the findings of this survey, a volunteer preschool teacher was involved in the process. This teacher, as a participant, is 26 years old, has 4 years of teaching experience, is open to the use of digital games in education, is especially knowledgeable and experienced in digital games, and believes that the games can contribute to preschoolers' SCS education. Behnamnia et al. (2022) say that educators provide strategies for interacting and creating content for young children. According to the user's analysis and the teacher's opinions, five preschoolers (five years-old 3 girls and 2 boys) were selected from the teacher's class who had their age developmental characteristics and played digital games with a tablet. They participated in the beta test of the game. Other participants of the process are SMEs, three from the field of Instructional Technology (IT) and one from the field of Early Childhood Education (ECE) (Figure 1).

Data collection tools

The following data collection tools for the preschool

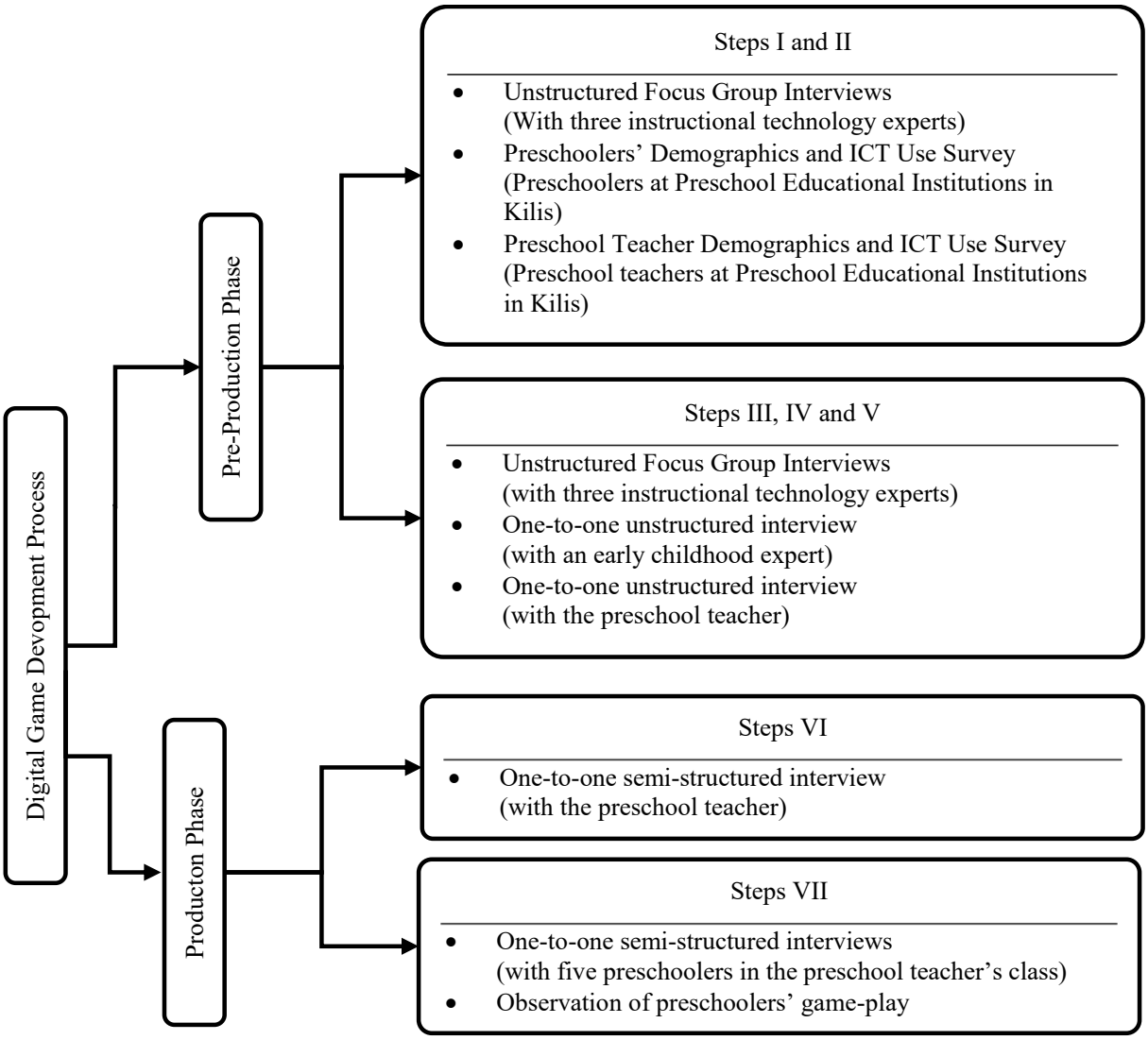

Figure 1. Data collection process.

teacher and preschoolers have been developed based on the related literature and opinions of SMEs.

Preschoolers' Demographics and ICT Use Survey: This survey includes closed and open-ended questions about the preschoolers' demographics, ICT use types, ICT use purposes, digital game preferences and factors affecting the preferences.

Preschool Teacher Interview Guide: The guide contains core questions to assess and amend the first prototype (alpha version) of the developed digital game.

Preschooler Interview Guide: The guide contains core questions to assess and finalize the second prototype (beta version) of the digital game. These mainly focus on instructional design (ID) and game design (game elements, game playing, etc.).

Data collection process and data analysis

The survey was developed based on the literature. The experts' opinions and related literature were conferred on construct and content validity. Qualitative research focuses on validity rather than reliability since comments are emphasized (Creswell and Clark, 2018). Therefore, member checking, triangulation and academic advisor auditing strategies were just conducted for qualitative validity. Data from the participants was collected voluntarily and guaranteed to be kept confidential. The analysis and reporting of the data were objective, and the researchers carried out this process in cooperation. Game content and visuals were designed in accordance with TECEP and preschoolers' developmental characteristics. All data collection tools and parental consent forms for preschoolers were checked and approved by the Ethics Board of Hatay Mustafa Kemal

University and the Ministry of National Education.

Preschoolers' Demographic and ICT Use Survey was conducted to volunteer children at public preschool education institutions in Kilis province in the Spring semester of 2016-2017 academic year with the help of their parents (450 questionnaires were distributed, 322 of them returned). Collected quantitative data were analyzed with descriptive statistics such as frequency, percentage, cross table, and qualitative data were analyzed by content analysis. During the game development process, interviews were held with subject matter experts, a voluntary preschool teacher and five preschoolers. Unstructured focus group interviews were conducted with the experts in steps I and II of the pre-production phase. In the interviews in steps I, II and III of the pre-production phase, problems were identified with brainstorming, requirements were determined, and draft game scenarios and final game scenarios were developed for instructional and game design. Then within *steps III, IV and V* focus group interviews with the experts and one-to-one unstructured interviews with the teacher were conducted. In one-to-one interviews, the participants' views about the game scenario were asked. With these interviews, possible problems in the game scenario have been resolved. *In step VI,* another interview was conducted with the same teacher to amend alpha version of the game. *In step VII,* 10–15 minutes interviews were conducted with five preschoolers in the activity classroom to evaluate the beta version of it. In addition, preschoolers' playing behaviors were observed. Permission was obtained from the authorities for the audio recording of these interviews and observation of the preschoolers in the activity classroom. Qualitative data from these interviews and notes kept in observations were analyzed with content analysis technique.

In this study, tablets with Android OS were preferred because it is common and affordable for children in the world (Güler et al., 2017a). Unity game engine was preferred to develop digital games because 2D and 3D games can be developed with its free version for different target platforms (Windows, iOS, Android, etc.). For the creation of characters, visuals, and animations, Blender software was preferred because it is free and 2D and 3D designs and animations can be developed. GIMP software was preferred as graphic processing software since it is free and user friendly.

Limitations

There may be some possible limitations in this study. Data collected in the game development process of alpha and beta steps is limited to one preschool teacher and her five preschoolers in her class in Kilis province. The game is limited to the selected SCS learning objectives. Although the game was designed as three stages, only the runner parkour could be developed due to time and budget limitations.

RESEARCH FINDINGS AND DISCUSSION

Pre-production phase

In the ***Startup step***, several unstructured sessions were held with three experts from the IT field, and answers were sought for the first two research questions about why SCS education should be given to preschoolers with digital games and DGBL. Developing digital games begins with the ideas and matures with brainstorming sessions in which participants' ideas can be generated, criticized, abandoned, improved or matured and accepted (Brathwaite and Schreiber, 2009). The raised implications were given in Appendix-2. The concept development continued to mature with the same participants and answers to some questions were sought. Those all were answers to the second research question of the study as well. Thematic implications from generated opinions were given in Appendix-3. The findings from the sessions are parallel with the meta-analysis that reports three types of scaffolding, namely, success/failure, answer/solution, and enhanced one (personalized) that can remarkably influence learning (Clark et al., 2016).

In the ***User analysis*** step, research and analyses were conducted for the questions of who plays, how to play, and what kind of requirements are concerned, etc. The findings from the analyses guided both instructional and game design. Commercial or educational digital games are player-oriented and centered. Also, it is important to attract children's interest, to keep them engaged and inflow (Eck, 2006). Implications based on the findings and interpreted data are seen in Appendix-4.

In the ***Data parsing*** step, the detailed task plan was examined to determine instructional and DG design based on the data and to ensure a controlled production process by identifying the technologies to be used. Therefore, the interpretation of the data within the framework of responsibilities was done. The learning objectives of SCS education were examined. Instructional objectives of the digital games were determined from those of critical importance: "skills related to dressing" and "skills related to protection from dangers and accidents". Since too many learning objectives create confusion, their number should be manageable (Kapp et al., 2014). Thus, one of the most common mistakes, such as trying to teach everything at once, would be avoided. According to Bloom's Taxonomy, a table of specifications for designated learning objectives is given in Appendix-5. ID and in-game performance goals for these objectives were determined, by considering the opinions of the teacher and SMEs. In these views, the point which was underlined about SCS is:

> *"Top of the problems that preschoolers experience about their SCS is not that they do not know or can't do these behaviors, but that self-regulation skills related to these behaviors are inadequate (that they don't do them on time and when needed)".*

For this reason, latent learning mechanics in digital games can execute these behaviors to be learned and internalized by preschoolers.

Game design step looks for answers to the question "How can game elements and learning objects be placed into the game?". Considering data from the previous steps, the first draft of the game design (Appendix-6) was created and SMEs were consulted. Then, in light of their views and suggestions, one-page designs (Figures 2 and 3), characters, cinematic (intro animation) and runner parkour were drawn in Figure 4.

Production phase

Game core step, mechanics that form the game core functionality and that are critical for designers (Brathwaite and Schreiber, 2009), were created. This process is cyclic and iterated by adding new mechanics. This enables us to make a pretest of the game on paper. Scenarios, mechanics, dynamics, stories, rewards and feedback were created based on data from previous steps. Also, digitization of game elements and game coding was initialized. The digital game scenario and its explanation are given in Appendix-8 and scenario-based flowcharts are shown in Appendix-7.

Alpha version step, a playable game was obtained. Digitization of art assets (character, environment and interface elements, sounds, animations etc.) and game coding were performed. The first screen, runner parkour and game playing interface visuals that were developed with rapid testing cycles are seen in Figure 5. Frames from sneakers tying and coat zipping animation are seen in Figure 6.

The teacher made a playing test of the alpha version developed by considering the views of SMEs and herself in the previous steps. After that, the digital game was improved by considering the criticisms and suggestions obtained from the semi-structured interview with the teacher about the alpha version. This interview's data were answers to the third research question of the study as well. Thematic findings obtained from this interview are given in Table 1.

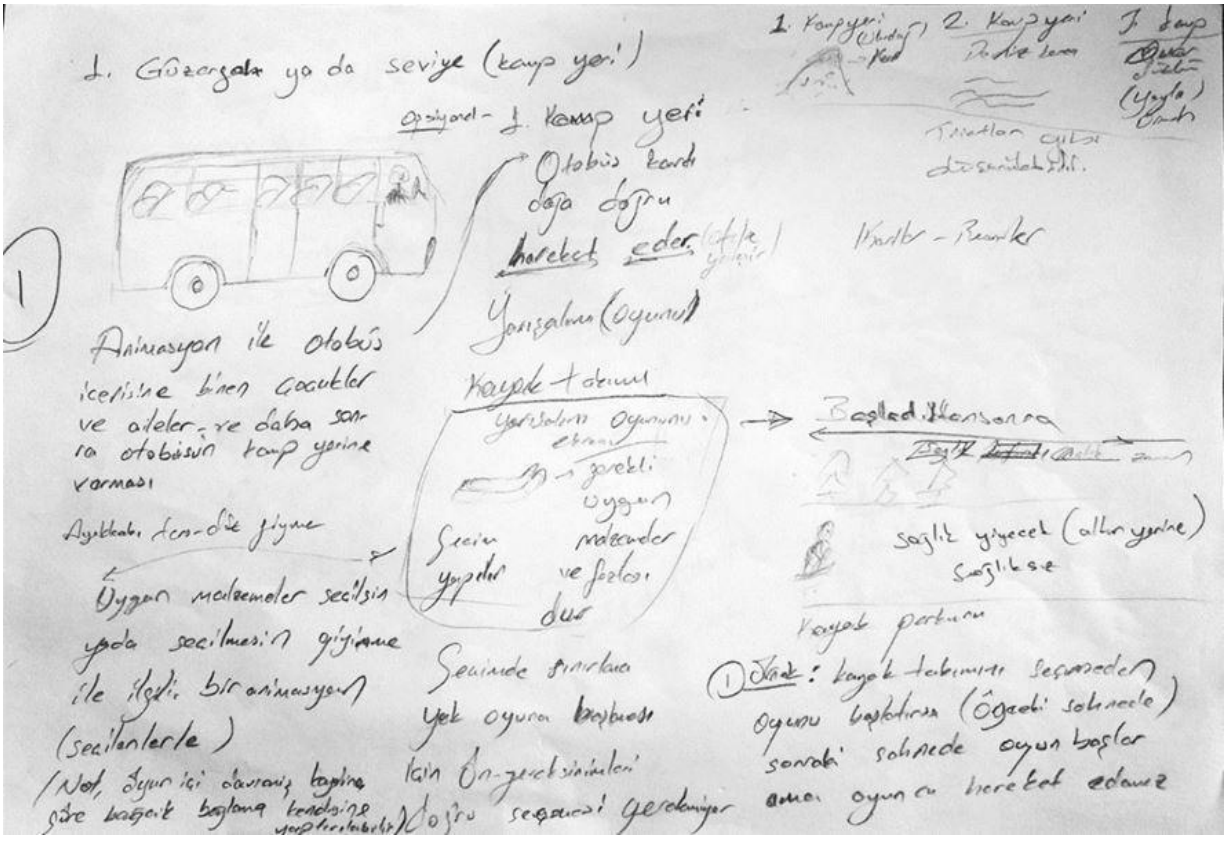

Figure 2. First one-page design for the game.

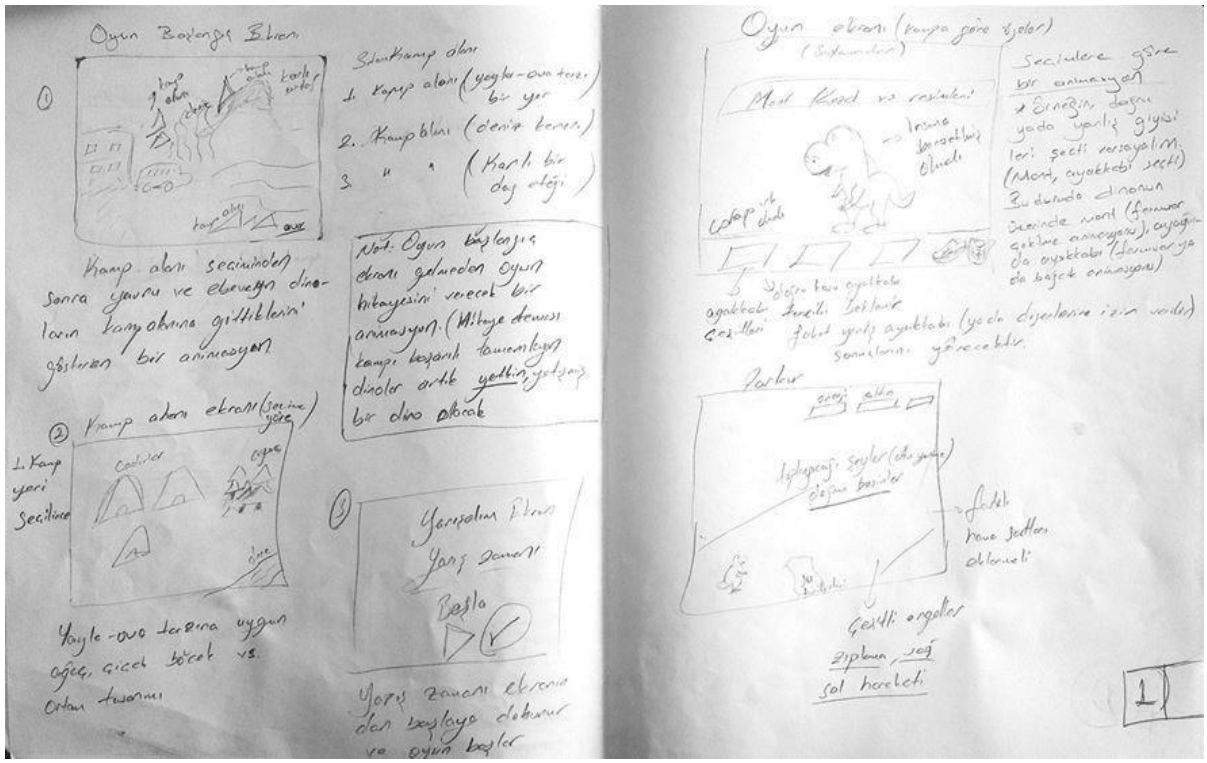

Figure 3. Second one-page design for the game.

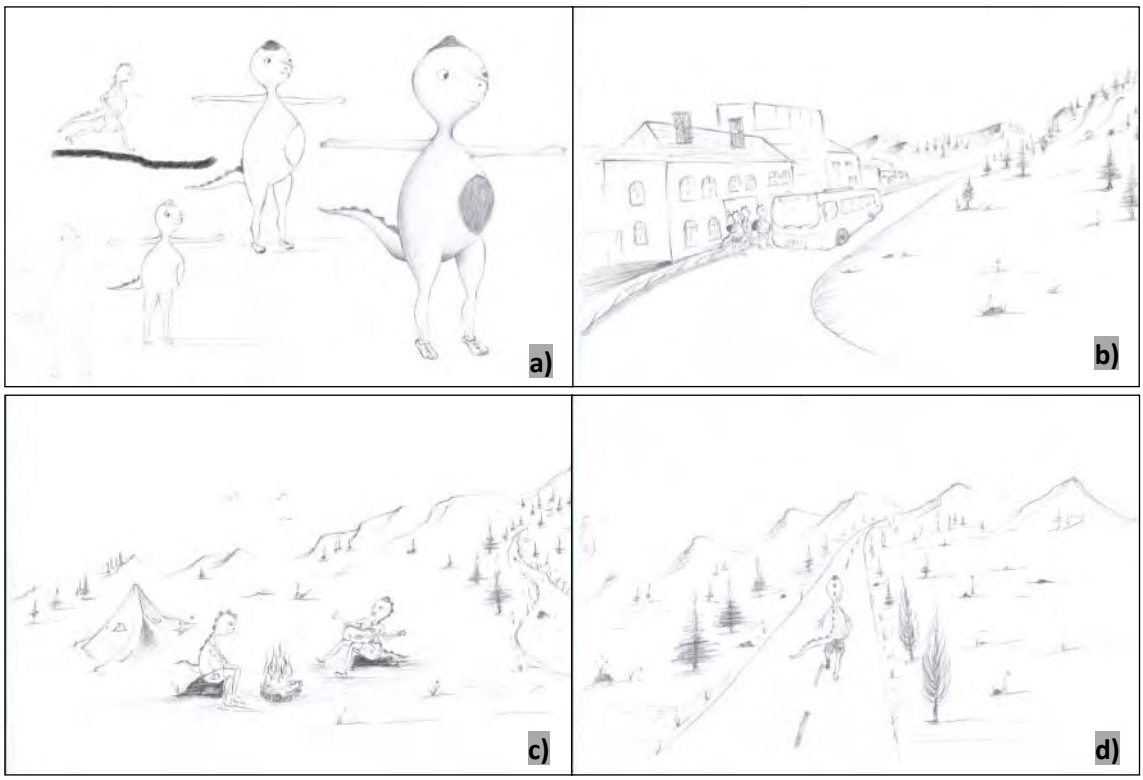

Figure 4. (a) Character, (b and c) cinematic and (d) runner parkour drawings .[1]

[1] These were drawn by Veysel ÇİFTÇİ, Lecturer in Department of Handicrafts.

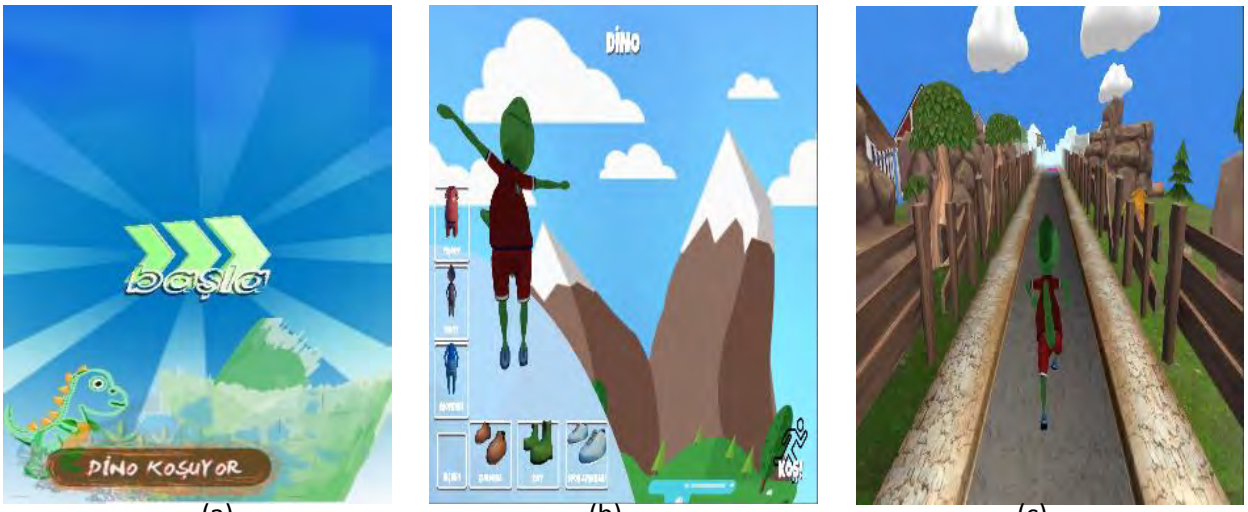

Figure 5. (a) Alpha version start screen, (b) parkour and (c) game playing screenshots.

Figure 6. (a) Frames from sneakers tying and (b) coat zipping animations.

During beta version step, the game was improved based on the teacher's game playing test and the findings obtained from the interview with her (Table 1). Clark et al. (2016) noted the design features of a game such as environments, visuals, narratives and mechanics that includes the actions to explore the game, need to be aligned with learning objectives for providing better affordances. Clark's statement corroborates the teacher's views in terms of making the game more qualified. The first screen, game playing screen, clothes and coat zipping animation of the beta version, which has been redesigned and improved taking into account the views in Table 1, are shown in Figure 7.

Children's suggestions can help designers make the game more effective as instructional material (Brathwaite and Schreiber, 2009). Beta version game playing tests were performed with five preschoolers from the teacher's class. Then, one-to-one semi-structured interviews were conducted with each preschooler accompanied by their teacher, and the teacher was asked for her observations on preschoolers' reactions to the game. The aim of conducting game playing test for preschoolers is to evaluate the playability of the game, to explore their views about the game, to evaluate visual and audio elements of the game in terms of design, and to assess the appropriateness of mechanics and dynamics for SCS learning objectives in instructional design. Hence, after the playing tests, the teacher asked them a few simple

Table 1. The results of interview with preschool teacher for alpha version.

	View	Suggestion/Expectation
Content	SCS can be cognitively acquired with the game, and its content is suitable for preschoolers	Add game mechanics regarding SCS [such as pulling a zipper] expected from them.
Character	In terms of ID, the character and attires are suitable,nice and cute for the preschoolers.	Increase the diversity of attires. Design them to attract preschoolers' attention more.
Game environment items	The visuals of game environment items were designed for adults.	Design game environment items simpler for preschoolers.
Bonuses	The visuals and effects of bonuses are nice and serve the game goal.	Bonuses can be diversified in each game playing.
Feedbacks	More voice feedbacks make the game didactic.	Feedbacks may be visual and non-verbal audio stimulants that evokes what the child does right or wrong. No need for coin indicator. An indicator is enough for the points. Add five points to the total score for each coin. After Dino runs barefoot a little, let its energy run out. Then let his feet get pink and red, and make him hop in the same place as if his feet swollen. Let camera focuses on his feet and the sound of suffering is given.
Game playing	It's not noticeable for the character to wear attires, there's no effect or sound to evoke it.	After selection, feedback animations should play and then Dino should be seen dressed. Redesign animations appropriately for preschoolers to watch them full screen.
	There's no problem with game playing. There are problems with game speed and character energy, resulting from selections and collecting bonuses.	Slow down the game speed and increase character energy and game duration.
	In this game, preschoolers can learn how to play with experiencing the game a few times.	Just for first playing, train preschoolers about how to play with various visuals and audio instructions.
Music and sounds	Sound is important to get attention. Some sounds in the game achieve well. Besides, in animated movies, all emotions can be conveyed to the players with only [non-verbal] sounds.	Improve music and sounds in the game for preschoolers to like more.

questions. The findings based on the interviews done with preschoolers and the teacher's observations (tagged as PS1, PS2, PS3, PS4, PS5) are given below.

All preschoolers who played the game expressed that they liked it. Two preschoolers answered the question "What else do you want to happen in the game?" regarding game environment items. It seems that these preschoolers liked environment elements:

[Teacher: There was something on the sides while playing, remember them?] –There were grasses and flowers. [Teacher: Would you like something else?] –*Yes, roses (PS2).*

[Teacher: How were trees and houses on the sides?] –*Nice.* [Teacher: What else would you like there?] –*I think I would like nothing. It was nice as it is* (PS4).

All preschoolers stated that they liked the character, Dino. For example, two of them expressed it as follows:

–*Yes, I liked it, Dino was very cute, but it would be better if not fat* (PS3).

–Different, nice. *[Teacher: Could it be nicer?]* –I think not.

Figure 7. (a) Beta version intro, (b) game playing interface, (c) designed clothes and (d) coat zipping animation.

[Teacher: Is this the best?] –*Yes* (PS4).

One preschooler stated that he could not see bonus items due to Dino being big:

[Teacher: There are a lot of apples on the road that come across you] –*But I can't see it because of the dinosaur* (PS3).

Some researchers reported the game design features and kids' awareness is significant (Bullock et al., 2017; Moyer-Packenham et al., 2019). As they stated, it is important how preschoolers perceive characters' attires (clothes and shoes) for instructional design in the study as well. Because they are expected to relate these to the ones in the real world and make sense of them. Therefore, the items should evoke their real forms and be easily perceived. Preschoolers' views on attires showed that they didn't have difficulty recognizing them and they liked clothes. However, two preschoolers couldn't distinguish between coats and jackets, and one didn't recognize t-shirt:

[T-shirt chosen – Teacher: What this looks like?] –*Anything.* [Does it look like t-shirt?] –*It doesn't* (PS5).

It is important how preschoolers perceive the animations on the game start screen and whether they can make sense for them. Understanding the game elements and their relations with each other plays an important role in the game in terms of sense-making as stated by Moyer-Packenham et al. (2019). On the start screen, they were able to make sense of the actions in the animations according to the garment they chose. All preschoolers stated that Dino pulled the zipper up when they choose a coat or tracksuit and it tied the laces when they choose boots or sneakers.

Preschoolers achieved educational goals with digital in-game performance goals and game elements (mechanics, dynamics, feedback, etc.). For example, if the game started with the wrong shoe selection, Dino's energy decreased rapidly and accordingly the game was over in a short time and then a feedback animation played (Dino suffered from its red and throbbed feet). In this case, preschoolers are expected to establish a cause-effect relationship in order to achieve the instructional objective "do not run with the wrong shoes". On the other hand, instant feedback in the game is a measurement tool with a self-assessment mechanism in terms of the information it gives to the players about their performance (Johnson et al., 2011; McClarty et al., 2012; All et al., 2015). The latent learning mechanism was used. The consequences of their choices are immediate feedback regarding game mechanics executing latent learning. Feedback (especially with the animations) increases their understanding of the content and learning process and supports their performance by creating interest and motivation (Behnamnia et al., 2022). Allowing for experience and even failure, the game acquires players the productivity skills (in other words, sense-making) to succeed (Johnson et al., 2011; Perrotta et al., 2013). The teacher's views are in line with Attard's (2018) view on the design elements of purposeful feedback as well. One preschooler understood that in the first game playing without any clues, while the others were able to comprehend it through simple hints provided by the teacher.

[Teacher: How quickly did you slow down? What happened?] –*It might have been due to sweating.*

[Teacher: Why did you think so?] –*I think, because we dressed Dino in tracksuit* (PS3).

[Teacher: Why did Dino's feet turn red? Not comfortable?] –*Yes.* [Teacher: Which shoes are more comfortable?] –*Blue ones.* [Teacher: Sneakers?] –*Yes* (PS1).

[Teacher: Why did Dino slow down? realize that?] –*Yes.* [Researcher: Dino's feet suffered due to running with boots? Could it have reddened for that reason?] –*Yes, it could.* [Teacher: Which shoes should Dino run with? Which is the most comfortable? with sneakers?]. –*Yes.* [Teacher: Weather is hot. What will you wear Dino, a tracksuit or a t-shirt? You get Dino dressed in a t-shirt, don't you?] –*Yes* (PS5).

Another example is that Dino's energy increases on picking up apples and decreases picking up cola. Preschoolers should understand the educational goal of "unhealthy foods should not be consumed" which is an in-game performance goal. As Quinn and Bliss (2021) state, game quality features allowed preschoolers to understand the goal of the game without any explanation. Learning objectives and game objectives should be parallel to each other in educational games. To achieve the game goals in those, you have to achieve the educational goals, that is, to learn from the educational material (Zyda, 2005). Three preschoolers were easily able to understand this with simple clues:

[Teacher: Apples came out and you ate them. Does your power increase or decrease when you ate an apple?] –*I think it increased, after drinking cola the energy decreases, after eating apple the energy increases.* [Teacher: Why?] –*Because, cola is unhealthy.* [Teacher: Apple?] –*It is healthy* (PS4).

[Teacher: You picked up two apples or two bottles of cola? Which was right?] –*Apples*. [Teacher: What about colas?] –*We did not pick up*. [Teacher: Why do we eat apples and do not drink cola?] –*Because cola slows Dino down*.

[Teacher: Why can Dino still run after eating apples?] –*Because vitamins in apples speed it up* (PS5).

Just like in entertainment games, this game also has game mechanics and dynamics to make preschoolers keep in the flow such as jumping not to hit obstacles, moving to the left and right, and decreasing energy on colliding. Most of the preschoolers were easily able to realize these functions:

[Teacher: Try to find out, why your energy goes down?] –*Because of collision* (PS1).

[Teacher: What could slow us?] –*Stones, water and wooden pieces* (PS2).

[Teacher: What slowed you?] –*Obstacles* (PS5).

Quinn and Bliss (2021) express that the qualified instructions, scaffolding and the ability to maintain the user's focus are more in multi-component games that provide a more intuitive gaming experience for kids to learn. In this sense, the study successfully achieved this when considering the findings of interviews held with preschoolers accompanied by the teacher. In brief, the implications could be summarized as follow:

• The participant preschoolers liked the game, the character, the character's clothes, and the game environment items.
• The preschoolers had no difficulty in playing the game. Just one of the preschoolers had difficulty in collecting bonus items due to big-sized character.
• With simple hints, preschoolers were able to make sense of the introduction and feedback animations, mechanics and dynamics regarding IDs.
• The game provided motivation and flow for preschoolers.

In the ***final version*** step, in the light of these implications, the character' size was reduced a little and the final version of the game was reached.

CONCLUSION AND RECOMMENDATIONS

The study aims to describe the application of the adapted RETRO game development model in developing a digital game for preschoolers to acquire SCS. It is in the model of design-based developmental research and RETRO model was adapted and followed for management of the game development process. Adding a detailed reporting component into the model provided monitoring of the whole process. Experimental studies conducted at low educational levels report that educational goals are achieved more efficiently and quickly if educational digital games' design elements –motivation, narrative context, goals and rules, interaction and multi-sense cues (Dondlinger, 2007; de Freitas, 2006)– are appropriate (Boyle et al., 2014). Additionally, restructuring and integrating educational content into digital games that children currently play provides significant advantages (Brathwaite and Schreiber, 2009). In this context, to develop a more qualified digital game for preschoolers in SCS education, amendments were made on the game, considering not only the teacher's suggestions but also the 'preschoolers' reactions to the draft game. The participants' views indicate that the game has a promising instructional design and game design for the

selected learning objectives from SCS. Also, the game elements in terms of design principles are appropriate for preschoolers and the game provided motivation and flow. The study shows that some behaviors can be cognitively learned and already known behaviors can be *internalized* by the game through latent learning. The games, related to cognitive, behavioral (Dobrescu et al., 2015) and affective outcomes (Connolly et al., 2012), contribute to the reinforcement of abstract, creative thinking, high-level thinking and problem-solving skills and the realization of positive behavior change (Charles and McAlister, 2004; Dondlinger, 2007; Kapp et al., 2014). Additionally, it was seen that the model used for game development is suitable for design-based developmental research and has guided the management of the development process. As the study reports the entire process in detail, it helps novice digital game developers follow and repeat the process through a concrete example. The strategies pursued in this model can lead researchers not only in the design and development of any DG, but also in the creation of interactive learning environments or e-contents. It would be beneficial to increase the number of e-content for SCS and especially the things related to the affective domain such as digital games and to involve real users and practitioners in the e-contents' developments. Most importantly, benefiting from the potentials of digital games, DGBL and child-centered approach (Scott, 2017) may be one of the most appropriate pedagogies in SCS education, as it prepares preschoolers for the 21st century.

NOTE

This study is from the first author's doctoral dissertation, supervised by the second author.

ACKNOWLEDGEMENT

This study was supported by the Coordination of Scientific Research Projects of Hatay Mustafa Kemal University (Project No: 16769). The authors appreciate the University for the financial support.

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Citation: Güler, H., Şahinkayasi, Y., and Şahinkayasi, H. (2023). Design and development process of a digital game to acquire preschoolers' self-care skills: a model practice. African Educational Research Journal, 11(3): 269-292.

Appendices

Appendix-1. Adapted Digital Game Development Model (DGDM)*

Phases and Steps of Digital Development									
		Documentation							
						Production Phase (Digitization and Testing)			
		Pre-Production Phase (determination of requirements)							
		I. Step: Initial →	**II. Step: User Analysis** →	**III. Step: Data Parsing** →	**IV. Step: Game Design** →	**V. Step: Game Core** →	**VI. Step: Alpha** →	**VII. Step: Beta** →	**VIII. Step: Final**
	Tasks	Create a timeline and determine stakeholder expectations	Determine who, how and with what to play	Set and improve the project with detailed business plan (including technical specifications)	Place learning objects into game, i.e., create a scenario	Create basic game mechanics and functions and test the game frequently by adding new mechanics	Develop a game demo based on detailed business plan	Optimize game-based on detailed business plan	Complete the game and artistic assets
Responsibilities	Production responsibilities	Determine calendar and budget	Plan communication	Work coordinately with stakeholders to obtain all data (Meetings, interviews)	Work coordinately with stakeholders to obtain all data (Meetings, interviews)	Work coordinately with stakeholders to obtain all data (Meetings, interviews)	Perform alpha deployment and digital games tests	Perform beta deployment and digital games tests	Create a final version and result report
	Digital game design and ID responsibilities	Generate ideas	Needs analysis and Learner analysis	Create learning objectives with Bloom's taxonomy	Create game design document and one-page designs	Make repetitive improvements for functions and mechanics	Improve ID and game design based on feedbacks	Improve ID and game design based on feedbacks	Improve ID and game design based on feedbacks
	Software and programming responsibilities	Take notes	Do research requirements for user needs	Make a detailed business plan based on requirements	Plan forward with on-hand data based on the design process	Code for functions and mechanics	Combine mechanics and functions with game elements and debug	Improve mechanics and functions based on feedbacks and debug	Improve mechanics and functions based on feedbacks, debug and finish-up
	Art design responsibilities	Generate ideas	Review user analysis for art works	Review a detailed business plan based on requirements	Create startup sketches and examples	Create game draft items for the game core	Create basic game elements	Improve game elements based on feedbacks	Improve game elements based on feedbacks and finish-up

	Key:	Heavily tasked	Moderately tasked	Lightly tasked	

*This model was adapted from RETRO Game Development Model proposed by Lucas Blair (Kapp et al., 2014).

Appendix-2. The Raised Implications of startup step.

- What is the academic problem leading to teaching with digital games? Why should we teach with them?
  - *Failure to bring SCS into action after learning them (for example, even though preschoolers know how to brush their teeth or wash their hands, but they don't perform these behaviors when needed and on time.)*
  - *Need of improving preschoolers' ability to establish a cause-effect relationship in SCS especially related to safety (e.g., danger, they may get hurt when playing with a knife or when not wearing a seat belt in the car travel, etc.)*
  - *The game is a tool that intrinsically and inherently motivates preschoolers.*
  - *Preschoolers already spend time by playing games so this should be turned to advantage.*
  - *Lack of enough research studies in the literature for teaching SCS with digital games in Turkish.*

- What are the expected learning outcomes after preschoolers interact with *digital games*?
  - *SCS should in fact be acquired with training. However, digital games can be effective in their abilities to establish cause-effect relationship with SCS and to internalize them (for example, why they should brush their teeth twice a day and what consequences they will have if they don't, these all can be taught with digital games).*

- What are preschoolers expected to know and be able to do in order to acquire self-care skills? What are their readiness levels?
  - *For this study, it is not important whether they are able to perform SCS or not. However, they need be in appropriate development stage in terms of psychomotor, cognitive and affective.*

- How can preschoolers acquire SCS with *digital games*?
  - *Preschoolers may reply visual questions in-game.*
  - *Preschoolers can collect the right objects in-game.*
  - *Preschoolers can acquire SCS with in-game animations, latent learning mechanics, and the game story.*

- What can be the indicators of preschoolers' SCS acquisitions?
  - *For some of the SCS included in early childhood education program, questions can be asked to preschoolers or their parents, or preschoolers can be observed or sample-case scenarios can be conducted (such as fire drill).*

- What are the technical requirements for digital game development? Should the game be in 2D or 3D?
  - *Game can be in 2D or 3D. One of the game engines will be enough to develop the game.*

- On which platform should digital games be available to preschoolers?
  - *Considering preschoolers' psychomotor skills and ICT access and familiarity, it would be appropriate to be a mobile game.*

Appendix-3. Thematic Implications from the Generated Opinions in Startup Step.

Questions for ID related to preschoolers' knowledge and skills levels:

- Do preschoolers know how to read and write? What are their levels?
  - *No, this age group's education program does not include literacy instruction.*

- What is about their subject-matter knowledge?
  - *SCS education are already started formally to teach in preschools.*

- Do they know how to play *digital games*? How much do they know?
  - *The vast majority of today's preschoolers –almost all of them– knows how to play digital games.*

Questions about DGBL practice:

- What kind of device, platform or technology will preschoolers play with?
  - *They can play on mobile devices (smartphones or tablets), the vast majority of preschoolers can play games with their parents' smartphones.*
  - *Since the most common mobile operating system for smart devices used in Turkey is Android operating system, it*

will be more appropriate to primarily develop the game compatible with Android operating system mobile devices.

- When should preschoolers play this digital games?
  - *Preschoolers can play it in their spare time with their parents' or teacher's permission since it includes latent learning mechanics. It is assumed that the entertainment aspect may be a reward for them.*

- How much time should preschoolers spend for this game?
  - *They can play 1-2 hours a week. Since PSTs are practitioners in the classroom, planning by them would be more accurate.*

- Where should preschoolers play this game?
  - *They may play at school or out of school. Assuming that digital games is a supportive or complementary material, they can play it anywhere at any time. However, it is assumed that success will be higher with controlled playing at school under the teacher guidance.*

Questions about programming and artistic assets:

- Where to get help when technical support is needed in digital games development?
  - *Forums, YouTube videos and SMEs can be utilized.*

- Should it have communication and/or social interaction over the internet?
  - *Social interaction and communication (i.e., being connected) may yield better outcomes.*

Appendix-4. Implications Based on the Findings and Interpreted Data in User Analysis Step.

- Almost all preschoolers have access to and use ICT (smartphone, tablet and desktop/laptop). They play the most commercial (entertainment) and educational digital games with these devices. They play these games more with smartphones and tablets than other technologies. Then, *it is plausible to develop digital games compatible with mobile devices.*

- Preschooler boys and girls watch cartoons for an hour a day on average and prefer cartoons, namely Pepee, Keloğlan, and Rafadan Tayfa the most, through the ranking changes. These cartoons are animations designed in 3D. Therefore*, it would be appropriate for the digital games to be in 3D, and animations that will attract the attention of preschoolers should be placed in the digital games. In addition, in Pepee cartoon, there is interaction and friendship of main character with animals, while in Keloğlan there exist mythical characters. It would be useful to consider them when designing characters and media.*

- The fact that characters in cartoons are cute, good, and helpful, and the cartoons are entertaining or the music is beautiful, which are the decisive factors in choosing cartoons. In this context, *it would be appropriate for the character in digital games to be cute and helpful and for the digital games' music to be prepared considering music in those popular cartoons.*

- Boys prefer sports games the most, while girls prefer baby games (dressing, feeding, washing, etc.). Therefore*, it would be appropriate to determine game mechanics with regard to preschoolers' game preferences. In the game, both sports and baby game elements -mechanics, visuals, etc.- should be used.*

- It seems that preschoolers who already play digital games on mobile devices do not benefit from digital games educationally. Although all preschool teachers have a smartphone, two-thirds dislike playing digital games and teaching with digital games was not in their suggestions of alternative instructional materials and approaches. For this reason*, a teacher who uses technology as a supportive tool in preschoolers' education, has a familiarity with digital games, and has a positive attitude towards using animations and games as an instructional tool was chosen amongst the preschool teachers responding to the questionnaire.*

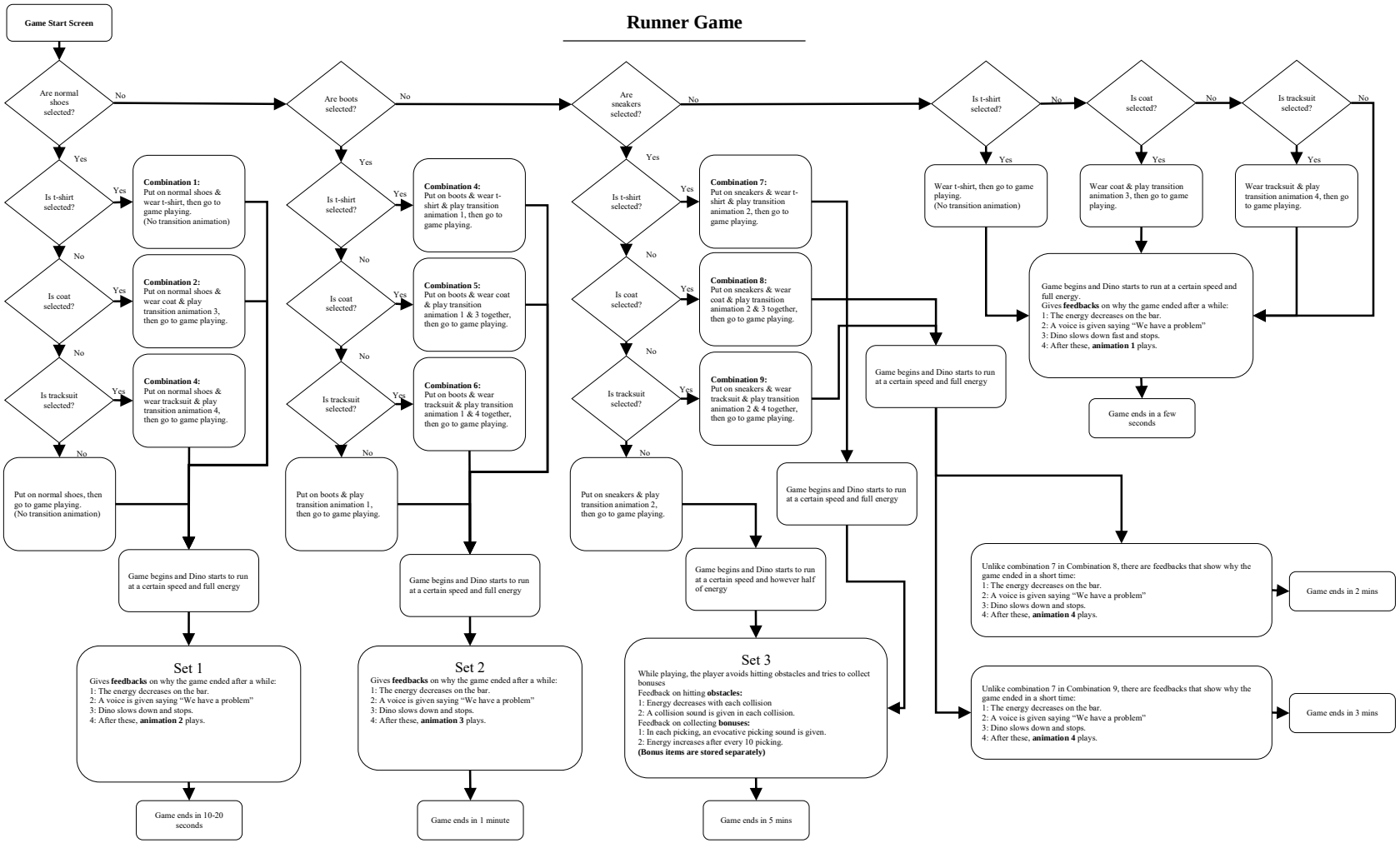
Appendix-5. Table of Specifications (for Runner Parkour).

	Cognitive Domain						Psychomotor Domain							Affective Domain				
Acquisitions and Indicators	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Perception	Set	Guided Response	Mechanism	Complex Overt Response	Adaptation	Origination	Receiving	Responding	Valuing	Organizing	Values Internalizing
S/he does duties related to dressing.																		
S/he takes off/wear his socks	X	X	X	X	X		X	X						X	X	X	X	X
S/he takes off/wears his beret.	X	X	X	X	X		X	X						X	X	X	X	X
S/he takes off / wears cardigans / coats.	X	X	X	X	X		X	X						X	X	X	X	X
S/he takes off / puts on pants.																		
S/he buttons / unbuttons.	X	X	X	X	X		X	X						X	X	X	X	X
S/he pulls up/down zipper.	X	X	X	X	X		X	X						X	X	X	X	X
S/he opens/closes snap fastener.																		
S/he takes off/put on shoes.	X	X	X	X	X		X	X						X	X	X	X	X
S/he unties/ties shoelaces.	X	X	X	X	X		X	X						X	X	X	X	X

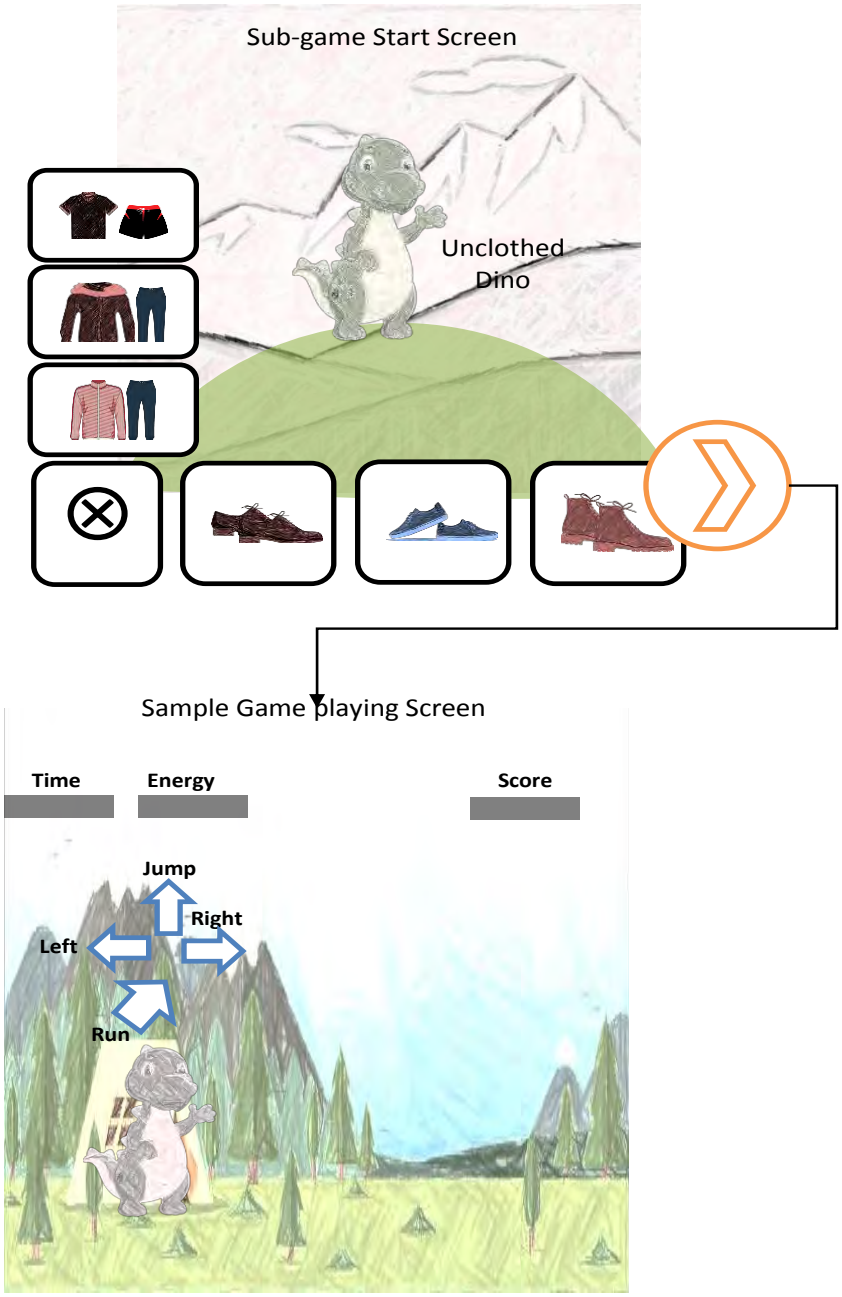
Appendix-6. First Draft of Game Scenario (for Runner Parkour).

Concept:	Regarding the SCS of preschoolers, the aim is to develop a digital game, which is engaging, provides personalized learning and runs in mobile devices. In game it is evaluated what preschoolers discover, how they set cause-effect relationships and what solutions they produce. The game has different genres at different levels within itself, but for contextuality, the scenario covers these genres. Open and latent game mechanics are used.
Characters:	Child are able to choose characters and customize that character by choosing different attires. Child's choices determine their game performance.
Environment:	The game consists of parkour competitions in nature camp (forest, etc.). Preschoolers go from school to the campsite by bus. There are tents, trees, etc. in the campsite.
Game playing:	Each parkour game can be customized (outfits, etc.). After the child customizes the character, an animation appears based on customization. For each parkour game, there are game mechanics and dynamics based on child choices. For example, for the runner parkour, in a sunny weather in nature, child's choices determine how long to stay in the game and so it determines success or failure of the parkour. At this parkour, the character runs forward constantly, meanwhile the child drags the character right, left and up to overcome obstacles and collect bonuses.
Reward and feedback:	The scores in this game are based on two variables: (1) the distance traveled while running on the parkour and the bonuses (golds) collected, (2) feedbacks in the game are provided with sounds, changes in health bar, hint animations and instructive animations based on child's choices.

Appendix-7. Runner Game Flowchart.



Appendix-8. The Digital Games Scenario and The Explanation of Algorithm (for Runner Parkour).



Digital Game Start Algorithm (Switching to Playing screen)

1. The player is allowed to choose for the attires provided. The player may not choose anything or can choose any one or make a combination (one from shoes and one from clothes).
2. What is chosen in each accessory selection (boots, tracksuit, etc.) appears on the character (Dino).
3. Clicking on the Play button, it switches to the game play screen. However, some transition animations are played based on the attires chosen (given below).

Transition Animations

- *Transition animation 1 (When boots are selected):* On the full screen, Dino is shown wearing boots and tying his laces.
- *Transition animation 2 (When sneakers are selected):* On full screen, Dino is shown wearing sneakers and tying his laces.
- *Transition animation 3 (When coat is selected):* On the Tam screen, Dino is shown wearing the coat and pulling the zippers.
- *Transition animation 4 (When tracksuit is selected):* On the full screen, Dino is shown wearing the tracksuit and pulling the zippers.

Game Playing

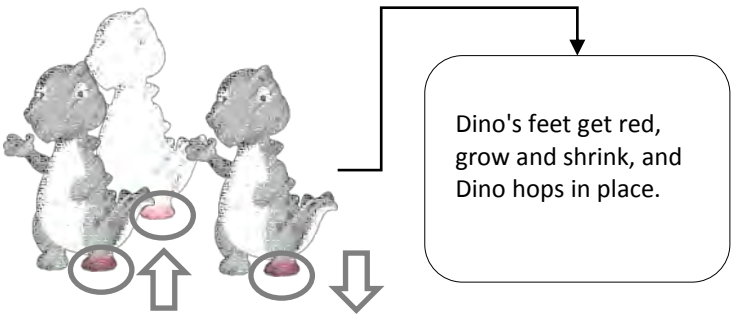
The game starts depending on the accessory selections on the game start screen and begins to process game play mechanics and dynamics (provided below). Attires can be selected single ones or in combination form (like a shoe – t-shirt combination). There are nine combinations in total. Once this level is completed with the right accessory selection, the player sees that part (one-third) of the scouting certificate is formed in the form of a jigsaw image. Then the other level is loaded.

Game Playing Algorithm

1. No sooner the player moves character (Dino) automatically forward than the game begins.
2. Under player control the character can move left, right or jump.
3. There are bonus and negative items and obstacles in the game, and they are produced randomly when playing games.
4. The player is expected to collect bonus items (such as apples, oranges, strawberries and bananas) and to avoid from collecting negative items (cola, biscuits, candy and chocolate) and hitting obstacles (tree log and rock fragments) with moving the character.
5. Five bonus collected increase energy and three negative items reduce energy (displayed in the energy bar). Bonus items are then stored separately in memory for feedback.
6. Each bonus increases the score, while each negative item reduces the score (displayed in the score bar).
7. Feedback is clearly given in the game flow chart for this level (see game flowchart).

In-Game Animations

- *Animation 1 (When no accessory selection is made or only t-shirt or coat or tracksuit is selected):* Character Dino's feet ache because no shoe selection and an in-game animation like the following takes place.



- *Animation 2 (When only shoes are selected only):* The slow-motion animation showing that Dino falls and its shoes come out of his foot is shown (as if tripped up).
- *Animation 3 (When only the boots are selected):* Dino's feet ache due to boots. This animation is like animation 1 but no hopping in place and the boots are transparent as if x-rayed.
- *Animation 4 (Combination 8: When sneakers and coats are selected):* Dino sweats from the coat which it wore. Dino gets too hot and sweats in the coat, it is seen as if looking through an X-ray like animation 3.
- *Animation 5 (Combination 9: When* sneakers and tracksuits are selected): Dino sweats from the tracksuit which it wore. Dino gets too hot and sweats in the coat, it is seen as if looking through an X-ray like animation 4.

In-game performance goal: Preschoolers are expected to choose the right attires for the run (How to wear them is learned with animations –tying laces or pulling up/down zipper etc.). The preschooler is expected to notice the problems s/he encounters, and understand why these problems occur during game play. Preschoolers learn from the consequences of their choices.