Student Opinions on the Use of High-Tech Mobile Devices in the Design of Digital Games for Learning

Eva Jeanette [a,1,*], Brooks Ovchinnikova[b,2], Heri Nurdiyanto[c,3]

aHalmstad University, Kristian IVs väg 3, 301 18 Halmstad, Sweden
bAalborg University, Kroghstræde 3, 9220 Aalborg, Denmark
cSTMIK Dharma Wacana, Metro, Indonesia
[1] Eva.jeanette@hh.se *; [2] brooks.Ovchinnikova@hum.aau.dk; [3]Heri Nurdiyanto@dharmawacana.ac.id
* corresponding author

ARTICLE INFO

ABSTRACT

Schools have adopted digital technologies as a strategy for learning and teaching activities because it offers opportunities for scaffolding. This strategy has been implemented in conjunction with creative activities. In addition, activities based on digital games, known as digital game-based learning (DGBL), and various mobile technologies, have been piloted in schools over the past few years to develop innovative learning. This research investigates how children's collaborative interactions develop while participating in activities requiring them to solve problems utilizing intelligent and mobile technology. Our research combines theoretical viewpoints on joint participation, affordances, and a sense of community in the context of collaborative interactions. This is done with a contextual perspective on learning as its starting point. The following are some of the questions posed in this research: (1) How do children's digital game design activities drive and support collaborative interactions while they are engaged in problem-solving activities? Furthermore, (2) How do children's ideas for designing digital games manifest themselves during activities involving the design of games that involve innovative mobile technology? The study is based on a case where a creative workshop was held with 22 Swedish third-grade children aged 9 to 10 years old who participated in game design activities in a pedagogical lab. When the children worked together to solve the problem of designing and producing a joint digital game idea using mobile technology, a sense of community emerged due to their efforts. The study's results were analyzed using a thematic approach, which revealed that the children used different orientations in their collaborative interactions. Based on this, we argue that it is crucial to be aware of the pedagogical context when preparing for educational activities that involve innovative mobile technology. This is because the pedagogical context is the aspect of the design that creates meaningful collaborative interactions, and it is only then that innovative mobile technology becomes smart. These findings have significant ramifications for the methodological field of incorporating cutting-edge mobile technology into various types of educational settings.

I. Introduction

There is a robust discourse in the field of intelligent technology stating that mobile technologies, tablets, and other so-called smart devices have become essential parts of children's everyday lives. In recent years, innovative technology has emerged in the educational domain as a tool to make learning more efficient Enabling children to learn using innovative technology is at the center of research and practice. However, when it comes to learning, these technological devices become smart only if grounded in a solid pedagogical foundation; they need to be used smartly to become

competent. There seems to be a need to clarify further how children can learn using innovative technology in meaningful ways in educational settings[1].

Research shows that the application of mobile learning and the use of game-based instructional strategies promotes students' learning and engagement. The concept of game-based learning is thus enabled to offer several possibilities for supporting learning outcomes when using educational or commercial games. Claim that good gaming or gamification models and learning strategies could be a crucial factor affecting students' learning achievement[2]. Relates gaming and gamified- cation to game-based learning, which they argue is grounded in four game-based approaches: using educational games, using entertainment games, learning by making games, and using game elements in non-game settings (gamification). While educational games have clearly defined didactic goals and objectives, entertainment games can have relevant subject-related content. For the game approach, the learner develops knowledge about making content using technology. Gamification becomes a non-game activity to make it more attractive and motivating. Designing games is suggested to provide greater engagement and learning than playing games. There is also a potential for using game creation as a pedagogical strategy in classroom activities. In this regard, collaboration has been identified as essential when interacting with intelligent technology in creating digital games. Creating games is not a new idea in teaching activities, but, according to Kafai, fewer people have sought to turn the tables: by making games for learning instead of playing games for learning[3]. However, the effects of game-based learning in making games are still largely unexamined.

Designing games can be complex, as game-based tasks must be adapted to children's knowledge and skills. Schmidt underlines that when children perceive activities as complex, their interest and concentration decrease, potentially influencing their performance and engagement. On the other hand, digital game-making activities offered children opportunities to practice collaborative work in groups and enhance a sense of community. Thus, research indicates that creating digital games can be considered a vehicle for collaborative problem-solving, where acts of making and creating can reveal the complexity of tasks and interactions in which children can make sense of the world. This means that the understanding of creation is not only about the creation of things but also about interpretation and meaning-making. This perspective is particularly relevant when considering collaborative problem-solving processes using digital game creation, as it fosters skills in making and creating and those related to working with others and empathizing with them. Despite these recent developments, a broader un- understanding of how game-based learning activities, mainly focusing on game creation with intelligent mobile technology, can provide a viable learning tool is still lacking[4]. A clear conclusion from this literature is that this gap in research refers to the importance of transcending digital game creation aspects inherent in the activity to encourage different ways of being productive and, thereby, enable children to probe different orientations towards problem-solving and experimentation[5].

This paper investigates how school children's collaborative interactions unfold while engaged in problem-solving activities using intelligent and mobile technology to address this research gap. Research shows that when children are involved in game-making activities, they develop problem-solving skills. This is because they are forced to explore different strategies and possible solutions, confront problems, and organize their actions. Who found that children improved their problem-solving performance with a game-based learning approach compared to traditional instruction. Children experience increased confidence in their problem-solving and project planning abilities by creating space for making' activities[6].

Our contribution to this approach is to analyze how Swedish school children (9–10 years of age) work collaboratively with problem-solving through game-based design activities. Furthermore, to emphasize the importance of understanding how school children can explore collaboratively while creating learning situations and how such processes can be facilitated. This contributes to clarifying a pedagogical foundation for children's learning with intelligent mobile technology that can be operationalized in educational settings. Supporting this aim, the following research questions are posed in the study: (1) In what ways do children's digital game design activities drive and support collaborative interactions while engaged in problem-solving activities? Moreover, (2) How do children's digital game design ideas manifest during game design activities involving innovative mobile technology? On this note, we wish to contribute to the field by exploring the possible mediating roles of intelligent mobile technologies used in an educational setting[7].

Intelligent mobile technology in the form of tablets and innovative- phones is a widely available tool for most people, no matter their age. This kind of technology has been identified as multi-functional, contributing to its attractiveness as a tool for learning. In their book chapter, Kearney, Burden, and Schuck identify that learning with innovative learning technology is effective through its holistic characteristics, which can empower the learners too, e.g., practice agency[8]. In particular, collaboration is essential when interacting with intelligent mobile technology. Chang and Hwang recently conducted a systematic literature review of published journal articles between 2007 and 2016 on mobile technology-supported game-based learning. Their review aimed to highlight the research domain and identify trends in mobile game-based learning. They conclude that this is an important research field and that "future studies could focus more on how to develop mobile game-based learning strategies and models which are more diverse, educational, and appropriate for all ages after examining the learning strategies adopted in the existing digital game-based learning and mobile learning studies. Furthermore, they claim that "good gaming or gamification models and learning strategies could be the crucial factor affecting students' learning achievement.[9]

Pedagogical activities, including iPads or tablets and various apps, can serve as examples of learning with intelligent mobile technology. Research shows that applying innovative mobile technology and game-based instructional strategies promotes students' motivation and learning. Furthermore, research shows that combining tangible objects with mobile apps to access new content can assist children in capturing details of what they find interesting to explore. The authors show how using innovative technology in the form of pervasive games encouraged children to conduct in-depth investigations of the physical environment[10]. In the present study, we included intelligent mobile technology and creative material through the 'making' of a stop-motion video via a smart app. This was envisioned to impact the children's engagement. Another way to engage the children was using collaboration. Researchers have pointed out that collaboration and promoting interactions among students while developing game designs help improve their learning performance. Even though today's children have access to and can use different kinds of innovative mobile technologies to practice collaboration, further research is needed to nurture it while involved in game-based learning activities. In this regard, creating games as a pedagogical problem-solving strategy shows promising learning results. Previous studies have elucidated how children learn through the activity of production[11].

In the present study, we have framed a game-making activity to push collaborative problem-solving among school children by creating an environment that allows them to explore intelligent mobile technology. Similarly, they have pointed out creative activities have positive learning potential when children make podcasts. Identified the significance of context in promoting children's participation in digital technology design and making. On that note, I found that the design space affects the creative process. As a crucial aspect of this, Cumbo, Eriksson, and Iversen underline the importance of combining a chilled activity and respectful adult guidance with leading to new insights[12].

All in all, this shows how the context of a collaborative problem-solving design task can influence children's participation and engagement while using intelligent mobile technology. "children's genuine participation in digital technology design does not happen in isolation/.../ it happens as part of the complex web of life". Thus, the complexity of children's social actions, experiences, and interactions need to be considered to create conditions for meaningful activity and in the subsequent analysis of it[13].

The abovementioned issue goes hand in hand with the complex task of designing a game, including innovative mobile technology, as it has to be adapted to all participating children's knowledge and skills. Suggest that such an activity should be split into different phases so that the activity forms a meaningful continuity for children. While studies propose that such an approach should be split into different days or weeks, we have chosen to apply this kind of segmentation of the game design activity taking place over half a day. In doing so, children will step through different phases while designing digital game ideas, including analysis of game goals, ideating solutions, and conceptualizing this ideation[14]. This is what is considered a prolonged problem-oriented design activity. While underlining that children learn about designing through practical and joyful hands-on experiences, developing game designs using intelligent mobile technology includes the creation and cognitive skills, such as problem-solving and social skills. This paper considers the combination of a design process's foundational creative, cognitive, and social aspects. States that

abstract teaching matters become tangible through different materiality. When creating games, children can interpret abstract aspects into tangible and collaborative dynamics in environments that allow them to explore subject matters through meaningful creations[15]. There- fore, a digital game design activity and the tasks involved have to carefully consider children's ways of expressing themselves, for example, by providing them with a variety of suitable tools. In this regard, I created generative toolkits to support children's game design activities through brainstorming and storyboarding techniques. Who suggested using props to get children started on an activity and using different media to encourage imaginative outcomes? This means that children's performance in collaborative problem-oriented design tasks and their engagement in design become essential values. The following section will elaborate on this paper's theoretical framework, introducing analytical concepts that will guide the data analysis to answer the research questions[16].

II. Method

We have conducted a qualitative study, which included a case where a workshop on game design activities with intelligent mobile technology was applied in a pedagogical laboratory setting, which was located at a university. The intelligent mobile technology consisted of iPads with the Stop Motion Studio software app installed, which the groups of children used to illustrate their game designs. The workshop case involved 22 Swedish third-grade children between 9–10 years of age, and it was designed to promote collaborative problem solving through intelligent mobile technology. To capture the children's collaborative interactions, we used video recordings as the primary method for data collection. Below, the method and material, data collection, and analytical approach are further described

The workshop was introduced and briefly described prior to the workshop in a written document sent to the principal of the school, the class teacher, and the participating children's parents. Before arriving at the workshop location within the university premises, the children were divided into six groups by their class teacher, with 3–4 participants. In the introduction of the workshop, the whole class, their class teacher, and a teacher assistant were gathered in the same room where a university teacher and the researchers welcomed the children and their teachers. Initially, the content and purpose of the problem-solving workshop were described and explained to the children. Their task was to create a prototype of a digital game design idea, which should be presented to their classmates through a stop-motion film. The workshop was divided into three phases: an introductory phase, an idea generation phase, and a prototype presentation phase. During the workshop, the children's class teacher, alongside the teacher assistant, also participated in the workshop activity but kept themselves in the background. In addition, four university assistants were available for the children when they needed help and supplied them with water and fruit. This setup allowed the researchers to observe the activities and take notes during the entire duration of the workshop.

In the first introductory phase, the university teacher introduced the workshop to the children and explained the content and procedures of the three workshop phases. Throughout the workshop, she also helped the children by keeping track of the time of each phase. Besides giving the introduction, the university teacher and the researchers discussed with the children about their prior experience and use of digital games and their knowledge of different game elements (for example, rules, structure, and plots). In this way, the researchers could see that all children sat together in one room in this first phase.

The problem given to the groups to solve was to collaboratively develop and agree on a game design idea linked to a specific game world that the researchers predetermined. At the end of the introductory phase, each group was handed an empty storyboard sheet to fill in jointly. The storyboard included four sections: (1) a game iPad per group to use and share between the group members. The iPads had the Stop Motion Studio software installed, which the groups of children used to produce a short film or a "pitch" capturing their game-design idea, i.e., their prototype (final phase of the workshop). In addition, the groups were provided with creative materials, such as clay, paint, LEGO, pencils, and markers. Each workstation was equipped with a fixed camera facing the center of the table, which recorded the activities taking place around the table. In this second phase, each group was introduced to their particular and predetermined game design context (the jungle, the ocean, the desert, the city, the forest, the space), which formed the framework for starting to ideate. The storyboard, handed out to the groups during the first phase, needed to be finished before

they continued to the ideation, where they used the innovative mobile technology and creative material. Here, the ideas for their specific game theme plots world/theme (predetermined); (2) characters; (3) plot; and (4) props.

At the start of the second phase of the workshop, the Idea generation phase, each group was assigned to their own work- station, which was set up in two different rooms (three groups in each room). The workstations were all equipped with one, and characters were discussed and negotiated by the children in parallel with the construction of props for the stop-motion film. During this phase, the children worked closely in their assigned working groups, first by filling out the storyboard and agreeing on the plot for the game, the characters, and props. After this, they created different items and props for their game design. Here, the children also moved around a lot within and between the two rooms, getting materials and looking at the other groups' creations. The group collaboration varied slightly, but all had a strong result orientation.

At the start of phase three, Prototype presentation, the children started to produce their stop-motion films. At the same time, they were deciding on the final plot of the game design. During this phase, the children started to negotiate more about the plot, what props to use, and different choices that had to be made about the stop motion production, for example, about how many props they could create within the given time frame. In one case, a group of three boys finished quite early with their production, and after reviewing their results and realizing that they had quite a lot of time left, they decided to add some more elements to their film. Here, the iPad (i.e., the intelligent mobile technology) had a clear central role in the workshop, since it produced the stop motion film and found other effects, such as music. In addition, the iPad served as an engaging and motivating resource for the children in their collaborative problem-solving work. This phase ended with the groups presenting their final productions to each other, explaining their games' plots while running their stop-motion films. After the three workshop phases, the workshop was finalized with a joint lunch, where the phases of the workshop and the inclusion of intelligent mobile technology were informally discussed and reflected upon.

The empirical data included video recordings from the six workstations (a total of 11 h), the groups' final presentations, and observation notes by the two authors. The video recordings were primarily used to capture the children's collaborative interactions, and, as an added value, we could study the recordings multiple times afterward. Teachers and guardians were informed about the study in writing, and all guardians agreed to let their children participate by signing informed consent forms. This consent form included guardians' approval of using video and photos for scientific purposes. In addition, children were informed at the workshop that they could withdraw from participation at any time if they felt uncomfortable. In line with ethical guidelines, all names of the participants and the school are anonymized.

The collected data were analyzed through a thematic approach; Both authors reviewed the transcripts to identify categories and themes in verbal and non-verbal actions and interactions between the children and the digital game-based design activities. Aligned with the analytical, the empirical data was transcribed and reviewed by both authors (phase 1) to generate initial codes (phase 2) and organize these codes into initial themes (phase 3). Next, both authors carefully checked the themes (phase 4), which initiated more distinct definitions of the themes (phase 5). Finally, selected excerpts were again analyzed about the research questions (phase 6). This analytical procedure resulted in three themes: (1) Different orientations in collaborative interactions; (2) Affordances fostering collaborative interactions; and (3) Affordances hindering collaborative interactions. These themes are further elaborated in the below results section.

III. Results

Some of the recurring patterns in the material that emerged in the thematic analysis can be linked to the children's different ways of relating to each other, and t It has to do with how they oriented themselves, usually either by being task-oriented or oriented towards others, so-called other-oriented. These patterns of different orientations were closely connected to how the collaborative interactions unfolded during the workshop and how the children jointly used innovative mobile technology to manifest their ideas about the plot of their standard game-based design. As such, they were revealed to be crucial elements of the collaboration process, something to be kept in mind

when designing educational activities, including intelligent mobile technology and group work amongst school children[17].

The pattern of task orientation was most commonly uttered by the children's joint ambitions to finalize the task within the given time frame. In their collaborative interactions, they acted rather goal-driven in that they negotiated details in their joint content of the game and numerous aspects regarding the production of the stop-motion films[18]. The negotiations often proved essential in progressing with the task: while negotiating different aspects, they simultaneously defined details concerning the task, which kept the development moving forward. As mentioned, the negotiations were primarily goal-driven in the workshop's initial phase. Towards the end of the workshop, the negotiations turned more critical, where the time aspect became an issue to consider. In excerpt 1, one of the groups (consisting of two boys and two girls) has the jungle as the theme for their game design. They have jointly devised a plot for their game which revolves around two tigers chasing two monkeys (player one and player 2), and are now developing the background material for their particular game design. In the example, boy2 seems hesitant about making more than one tiger aware of the time frame. In their collaborative interaction, a negotiating dialogue emerges between the children that have to do with finalizing the joint idea about the game's design but without challenging the given time frame. Productions to keep the groupwork moving forward (as shown in excerpt one below). This strong sense of task orientation was evident in all six groups, and all groups finished their productions in time, which supports this claim[19].

Moreover, negotiation took place during all phases of the workshop, and the nature of the negotiations also changed during the workshop and as the work progressed. The groups negotiated to mean about the game design, about the game itself and how to present it, about Excerpt 1.

Girl 2: -The only thing strange about just having one (tiger), because there are two monkeys and it can only chase after one at a time and in that case. . .

Boy 2: -But we only have one (tiger)

Girl 2: -Now, but then that sort of can only be one monkey as well; otherwise, it will be bizarre because it cannot chase both

Boy 1: -Can't we make a jaguar?

Boy 2: -Yes, but it will chase both and, but, then you can see who is taken by it and they win.

Girl 2: -A, but it will be a bit strange because it will say "victory."

in the end and.

Boy 2: -Yes, but we should not do the whole game

Girl 2: -No, but a part of it

Boy 1: - Can't we make a jaguar too?

Girl 2: -But it will not take long to do two tigers.

Boy 2: -Not two more!

Girl 2: -One more!

Girl 1: -I can make one more. Can I do one more then?

Boy 1: -But then I have not done anything in clay.

Boy 2: -But now we are thinking too big!

Boy 1: -No, we are not! It is easy. Can't we make a jaguar?

Boy 2: -No, we will not add another animal! Girl 2: -One more tiger.

Boy 2: -Yes, that is enough.

Girl 2: -Otherwise, it will be strange, for that.

Boy 2: -If we have too many animals, we will not be able to make it in time.

In excerpt 1, the children's negotiations regarding their standard game design details are evident. Girl 1 is determined to stay true to their initial game-design idea with two tigers and two monkeys, while boy 2 is more concerned about meeting the time aspect and suggests cutting one of the tigers out of the plot. Girl 2 continues by accounting for possible consequences of such a decision, affecting the entire game design. They make a joint decision about how to move forward (to produce one more tiger) through negotiating arguments. This example of joint participation in the collaborative interactions mirrors how the children's ideas manifested during the workshop activities through innovative mobile technology and what was possible to achieve given the technology's time frame and affordance[20]s.

In excerpt 2, another group (consisting of four boys) has 'space' as their particular game theme. They have conducted a rather plain design for their game plot: a spaceship moves through space, trying to avoid bumping into meteors and other obstacles. They have just finished producing their stop motion film and are satisfied with doing well within the given time frame. They are glancing at the two other groups in the same room; both groups are busy working.

Excerpt 2.

Boy 1: -We were fast!

Boy 2: -Yeah, the others are not done yet.

Boy 1: -Do you think ours is too short? Boy 2: -No.

Boy 3: - I do not know.

Boy 4: -It is pretty short, and we do not have so much stuff.

Boy 3: -Yes, a bit short perhaps.

Boy 4: -We could have had another.

Boy 1: -Should we add some more then?

Boy 3: -I think so.

Boy 2: -We have time, so.

In this example, the group who finalized their stop-motion film quickly, quite long before the time was up, reflects upon their work on the given task, and the other groups are still working. As they watch their film, they start to express a slight nervousness that their production perhaps is not good enough, expressed by boy 4 in terms of "It is kinda short, and we do not have so much stuff." The group has been too focused on the time frame, which almost compromised their game design idea. However, since they had much time left, they decided to do additional work on the stop-motion film and their game design, resulting in a more qualitative final production. During this collaboration stage, they start experimenting with different features available in the stop motion app (such as music) and add some of them to their stop motion film. This example shows the dedication and the task orientation that the children displayed during the workshop.

The pattern of other-orientation is mainly characterized by how the participants acted toward each other, especially in the first and second phases of the workshop, with general sensitivity to each other's views and ideas for their joint task of creating a stop motion film of their game design. Especially in the initial phase, encouragement was shown between the children when someone expressed an idea that would fit the game design and develop it further. Towards the end of the workshop, however, in the final phase, the children usually were more reluctant to new ideas that could delay the work process. Throughout the workshop, the children discussed and valued each other's ideas about what was possible to do given the affordable mobile innovative technology (stop motion app on the iPad) and workshop structure. This pattern of other-orientation was evident in all six groups[21].

In excerpt 3, one of the groups (three girls and one boy) are working with the desert as their theme. They have not established a straightforward story for their game design yet, but they have started to create a scenic reproduction of a desert with a large sheet of yellow paper on which they have painted some palm trees, an oasis, and some huts. During this work, they discussed different objects usually related to a desert.

Excerpt 3.

Girl 1: How about if we use these huts, like for instance these huts, like an obstacle you [as a player of the game] have to or if there are some dangerous animals in the puddles so you cannot go in there, for then they will take you.

Girl 2: Like sharks or crocodiles.

Girl 1: Yes, like dangerous animals, you must jump over here.

Boy 1: You can climb this liana up the palm tree.

Girl 2: Or you can hide in the huts.

Boy 1: and throw coconuts

Girl 3: We need to make some coconuts

In this example, girl 1: s idea of creating different obstacles in the game is received with enthusiasm and support from the others in the group; they are other-oriented in their approach towards her and her idea, and consequently, her initial idea sparks and generates new ideas from the others. This example shows that the other orientation often supported creativity and the development of ideas within the groups and facilitated the progression and completion of the task. In addition, a sense of community emerged in the groups while discussing each other's ideas concerning the task and what was possible to do with the intelligent mobile technology.

Another example of how the pattern of other-orientation was manifested in the material was by the appointment of leadership within the groups. As in all group work, the participants took on themselves (or imposed on others) different roles in the groups, and the most prominent role was the lead role. In all groups, one or two participants were appointed as leaders by the rest of the group members or by their own choice and led the joint work forward. This was most prominent during the initial stages of the first phase of the workshop and the duration of the final phase of the workshop. In the initial phase, the emergence of a leader or leader within the group(s) was necessary for the work to get started and not get stuck in the ideation. Here, the group leader usually filled out the paper sheet with the given theme for the groups, which served as a template for the formation of game designs. In the workshop's final phase, the leader's role was more characterized by keeping track of time and deciding what choices to make to keep progress. To sum up, both patterns of orientations show that the children's collaborative interactions were designated towards how to solve the task/problem given, considering the innovative mobile technology and its affordances[22].

The analysis of the second theme uncovered the properties of the iPad and the stop-motion app, the 'making' aspects of producing a stop-motion film; in particular, these affordances related to how the children, in a solitary and collaborative manner, were linking and framing resources targeting a fixing of the final stop-motion film. However, another pattern in the empirical data was related to how the children channeled their interest relative to being knowledgeable game players. The patterns are elaborated in the following section.

In general, the contextual setup of the workshop activity and the innovative mobile technology provided group cohesion and space for collaboration. The children gathered around the workshop table at the workstations, mostly standing up and sharing ideas. They talked about how these ideas could be materialized and divided the work of making the different parts of the stop-motion prototype. They were concerned not to talk too much but to proceed effectively with their game design prototype. While doing this, they also advised each other about different techniques and ways of making the characters and props for the stop-motion prototype to fit with their overall game design idea. After discussing and dividing their work, they continued in solitary modes by producing game props. This was followed by gathering around the workstation table, showing each other their creations, and discussing how the different individually created props and details could come together in the stop-motion video. This process continued interactively until the stop-motion video was finished. The main concern in the discussions was to check that the details they created were apt for the overall game design idea. This concern led to the children putting much effort into what material they used, how colors and shapes could convey a trustworthy message, and how the solution space was organized.

This example shows how the children were linking and framing game design ideas and props to finally being able to fix an original stop-motion prototype. The overall question for the children concerned in what ways the meaning of their prototype could become fixed. By 'fixed,' we refer to how the different properties of the prototype were held together to represent a specific idea, i.e., how the props afforded the children's idea. In other words, for the props to afford the ideas in authentic ways, they had to have a specific fix. This resulted in that it mattered for the children which material and technique they used and how those could help fix the meaning they wanted to convey. Accordingly, the 'making' process of the stop-motion prototype and its affordances (the props and characters) provided a distinct way for the children to organize and shape the stop-motion prototype and their collaborative interactions. In this way, the fixing provided a physical property that could be organized and shaped via the children's links, framings, and discussions, representing the children's particular take on the prototype and their collaborative interactions.

Another example concerning linking and framing to fix an original stop-motion prototype was the children's concern about conveying an aesthetically well-composed game design. They put much effort into balancing different perceptual properties such as color, texture, motion, and sound. In other words, the children wanted to achieve a desirable outcome. Here, the matter of having opportunities to make choices played a role. This was shown through the ways the children explored different choices of sound and music to accompany the overall game design idea. The Stop Motion Studio app offered different sound and music tracks, which the children playfully and humorously tried to get the best fit for their stop-motion prototype. This trying-out undertaking permitted the children to become particular about the style of the message they wanted to convey. The option of choices became a significant aspect of the design process as it empowered the children to realize their imagined solutions, which they wished to be original.

The second pattern concerned how children channeled their interest in digital games from their knowledge of being experienced game players. Illustrating this was the different game design characteristics implemented in the stop-motion prototype, e.g., audio-visual feedback, different challenge levels, social play, and rewards. For example, the group that had 'the city' as a game theme placed coins on the streets in the city for the player to collect and, if successful, become rewarded. Another example is the group that had 'the jungle' as a game theme, where they used a level-based and multi-player game design. The level design was designed to increase in difficulty, and when successful the player became rewarded with more player- lives. The multi-player aspect included competition between the players; when failing, the player received audio-visual feedback, where the sound was fading while a visual sign showed "Game over, sorry, Player 2".

Based on the two above-described recurring patterns, the second theme uncovers how innovative mobile technology promoted the game design process and how it instigated it. The way the Stop Motion app offered a variety of design choices helped the children to compose a balanced stop-motion prototype that represented a production they felt pride in. The third analytical theme demonstrates how two groups experienced challenges that hindered the collaboration and the 'making' process. In particular, this was expressed through conditional contradictions and controversies. While all groups started with the ideation by framing and detailing the potential content of the initial game designs, one of the groups was hindered by this and got stuck in the process. After guidance from the assisting teachers, it became clear that their approach to the ideation was to start using the technology. In this way, they could explore how different ideas and solutions worked in a 'smart' way, i.e., a kind of rapid prototyping, which helped them to end up with a content solution. This example shows how a critical situation triggered the group to apply another approach to start the game design process, which could be considered a productive contradiction.

Another example illustrates how some group members in different groups got stuck in details, which created tensions between the group members' ideas. In one of the groups, a boy enjoyed making monkeys as characters in their game plot and wanted to make more of them. However, the two assigned group leaders argued that making more monkeys was not a good idea as it would take time away from the rest of the planned production work. The argument ended with the boy helping out with making other props for their game plot. This has practical implications for intelligent mobile technology insofar as carefully considering how, when, and in what form bridging a collaborative activity and personal factors enables productive interactions.

The third theme demonstrated how contradictions could instigate a change in courses of action and how con- controversies can shape situations where collaborative interactions become challenged. Using a creativity workshop case performed with school children, this article explores how children's collaborative interactions unfold while engaged in problem-solving activities using intelligent and mobile technology. Recurring patterns of the children's collaborative interactions identified in the material show that they deployed different orientations of other orientations and task-orientation during the workshop. The task orientation among the children was connected to their (or an) eagerness to perform the task within the given time frame. In this way, the children approached the task according to an educational institutional context, acting on what they understood was expected, i.e., to finish the task in time. The other orientation was closely connected to the children's sensitivity to the other group members, as well as an insight into the importance of social interaction and scaffolding for the progression of collaborative group work. In line with Lave and Wenger, the children were concerned with supporting each other to become active participants collectively and productively. Even though the collaborative and social aspects keep up the balance in the group, it is the task completion that becomes the primary target for the groups. This can be seen when, for example, disagreements do not reach a conflict situation in the group or when negotiation processes due to disagreements do not continue for too long, but disagreements between people can be a resource for developing new ideas.

On the contrary, we argue that completion became the group's most important. However, ideas and disagreements also contributed to children's awareness of the implications of their thoughts and choices. They explicated them and created joint groundings for their efforts through which they could challenge ideas and understandings of the problems they approached. This is to say that divergent ideas can be beneficial if they lead to further elaboration and negotiation.

Given the combination of other-orientation and task-orientation in the collaborative interactions among the children, there was a need for group leaders to take charge within the group constellations. This combination of orientations also resulted in the unfolding of disagreements and negotiations taking place during the problem-solving. These elements impacted how children's ideas eventually manifested during the workshop activities. Negotiations were used by the group to drive elaboration of ideas, but only up to a certain point. Due to the time issue of finishing the task, the group leader often pragmatically dealt with the group member's opinions from a different viewpoint. In such situations, it was clear that to solve the design problem; the group used innovative mobile technology and creative material to make their viewpoints transparent. Here, the children could build on each other's creations through which they reached a decision, but not necessarily a consensus.

We emphasized that creating a stop-motion video representing the group's game idea was not linear or straightforward but required intense negotiation. This, in turn, increased motivation as some of the group members realized that achieving this goal depended on themselves and their peers. This seemed to influence how they provided emotional and instructive support to each other. This kind of collaborative motivation also seemed to increase the individuals' desire to be timely on the task. In addition, and in line with Lave and Wenger's idea that successful learning is a result of increased central participation in a collective and productive activity, a sense of community emerged when the children worked on solving the problem of designing and producing a joint digital game idea using intelligent mobile technology.

The study applied a contextual approach, highlighting the importance of the physical environment (the workstation and its attributes) and the unique opportunities and limitations it created when including intelligent mobile technology. This includes recognizing the reciprocal relationship between context and 'smart'-based activities to drive and support collaborative interaction. This is aligned with previous research. We claim that these issues are vital to consider when it comes to the use of intelligent mobile technology in educational settings. The present study pinpointed how the pedagogical framework contributed to meaningful interactions, including a topic where the children had prior experiences and a space that afforded open-ended and focused learning opportunities. In this regard, we stress that a pedagogical framework with intelligent mobile technology should acknowledge the structure of social practice rather than only putting forward a pedagogical structure as a source of learning.

Lave and Wenger underline that participation in learning activities is not necessarily directly dependent on pedagogical goals, even when they appear to be a central factor (like classroom

activities). Instead, they argue that learning should be holistically understood, including its multiplicity of interactions and relations. Hence, based on our findings, we argue that affording children's interests and an open-ended pedagogical structure allowed for contradictions and controversies among the children's viewpoints. Here, the guidance by the research assistants contributed to respectful conversations. This, in turn, gave space for meaningfulness where different viewpoints and agreements became constitutive of collaborative interactions. By using the terms of Lave and Wenger, this to say that to be part of collaborative interactions, including intelligent mobile technology, "does not take place in a static context." Considering all this, in what ways were the different affordances appropriate, i.e., 'apt'?

This study showed that the affordances of linking, framing, and interest were apt for children's physical exploration to drive their use of intelligent mobile technology. The 'driving' was apparent when they tried different ways of representing their game idea to fix their stop-motion prototype, which included several discussions and negotiations. Furthermore, it was visible as the topic (game design) appealed to the children's interests and experiences. On the other hand, intelligent mobile technology embraced the affordance of choice, which became a driver of collaborative interactions in situations where the children should, for example, choose what kind of sound and music should accompany their game plot. We point out that these affordances have distinct meaning-potentials contributing to meaningful collaborative interactions.

Further, the study showed how physical and innovative attributes supported or drove collaborative interactions. This was where discussions, disagreements, and negotiations materialized, and new meanings emerged. When considering collaborative problem-solving processes and their implications for fostering skills in making and creating, it is essential to acknowledge interpretation and meaning making as part of understanding creation and fostering social skills. In the present study, we have pointed out that children's prior knowledge and skills are essential when using game-based tasks. This contributed to the fact that children could overcome hindrances when they considered a task too complex.

The present study includes limitations related to being context-bound and the absence of a baseline study or control group. Further studies, including larger samples and initiated with a baseline study on children's problem-solving tendencies, aptitudes, interests, etc., are needed to determine causality relations as well as to generalize the study results regarding school children's collaborative interactions in problem-solving activities while developing digital game designs using intelligent mobile technology. In particular, the absence of a control group did not permit us to univocally understand the influence of intelligent mobile technology compared to other collaborative design approaches. This would have strengthened the rigor of the study. Nevertheless, this paper provides a rich account of collaborative interaction instances, which provides a clear overview of the study. The results also demonstrate that even though they cannot be generalized, the findings clarify the complex relationship related to children's collaborative interactions when they engage in problem-solving activities using intelligent mobile technology. The present study's outcomes become more robust by including other forms of evidence from different research types.

IV. Conclusion

This article investigated how school children's collaborative interactions developed while engaged in problem-solving activities using intelligent and mobile technology to develop digital game-based designs. The activity pushed the children towards two kinds of collaborative orientation; (1) task orientation and (2) other orientation. Task orientation emerged when children's ambitions were directed towards finishing the game design (or solving the problem) within the given time frame. Thus, their collaborative interactions were goal-driven, where the goal of the children's negotiations was to keep the work moving forward as straightforwardly as possible. Other orientations animated by the children's acting toward each other show sensitivity toward the others' views and ideas. The activity also demonstrated how the children's collaborative interactions were challenged and hindered them in solving the problem at hand for a while. However, these challenges opened up for the children to elaborate on and negotiate the situation, which changed the situation from being challenging to becoming productive.

The children's ideas were manifested through linking and framing during the digital game design activity to convey an aesthetically well-composed stop-motion prototype. It was essential to have

opportunities to make choices, e.g., by exploring sound and music to accompany their overall game design idea. This explorative and experimenting with choices allowed the children to become particular about the style of the message they wanted to convey. The children's game design ideas were manifested through their interests and experiences playing digital games. This was explicated when the children presented their stop-motion prototype.

The main contribution of this study relates to the activity's workshop design, including different phases and a combination of innovative mobile technology and creative material as a foundation for applying game-making in educational contexts to support collaboration and energize problem-solving. In particular, this has implications for developing mobile game-based learning strategies where children's interests and experiences are essential when fostering their learning through collaborative problem-oriented tasks. Another contribution of this work relates to the limited research about making games as a way to apply game-based learning. The results showed how this form of learning creates a source of togetherness, which, in turn, creates awareness of a common purpose and the extended collaborative experience of working towards a collective goal. This has implications for new ways of designing for learning that include viable tools to nurture innovative learning experiences, which contribute to a broader understanding of game-based learning activities. We suggest that outcomes from this study have important implications for the methodological field of including innovative mobile technology in education.

References

[1]   A. Qazi *et al.*, "Adaption of distance learning to continue the academic year amid COVID-19 lockdown," *Child. Youth Serv. Rev.*, vol. 126, Jul. 2021, doi: 10.1016/j.childyouth.2021.106038.

[2]   B. Olszewski and H. Crompton, "Educational technology conditions to support the development of digital age skills," *Comput. Educ.*, vol. 150, Jun. 2020, doi: 10.1016/j.compedu.2020.103849.

[3]   K. Scheiter, B. Brucker, and S. Ainsworth, "'Now move like that fish': Can enactment help learners come to understand dynamic motion presented in photographs and videos?," *Comput. Educ.*, vol. 155, Oct. 2020, doi: 10.1016/j.compedu.2020.103934.

[4]   Y. Singh and P. K. Suri, "An empirical analysis of mobile learning app usage experience," *Technol. Soc.*, vol. 68, Feb. 2022, doi: 10.1016/j.techsoc.2022.101929.

[5]   G. Chen, C. K. Lo, and L. Hu, "Sustaining online academic discussions: Identifying the characteristics of messages that receive responses," *Comput. Educ.*, vol. 156, Oct. 2020, doi: 10.1016/j.compedu.2020.103938.

[6]   C. H. Chen and C. C. Tsai, "In-service teachers' conceptions of mobile technology-integrated instruction: Tendency towards student-centered learning," *Comput. Educ.*, vol. 170, Sep. 2021, doi: 10.1016/j.compedu.2021.104224.

[7]   H. Crompton and D. Burke, "Mobile learning and pedagogical opportunities: A configurative systematic review of PreK-12 research using the SAMR framework," *Comput. Educ.*, vol. 156, Oct. 2020, doi: 10.1016/j.compedu.2020.103945.

[8]   Y. Shi *et al.*, "An assessment of the reliability and validity of the Chinese version of the Reporting of Clinical Adverse Events Scale for nursing interns: A cross-cultural adaptation of scales and online investigation," *Nurse Educ. Pract.*, vol. 57, Nov. 2021, doi: 10.1016/j.nepr.2021.103244.

[9]   Y. P. Yuan, G. Wei-Han Tan, K. B. Ooi, and W. L. Lim, "Can COVID-19 pandemic influence experience response in mobile learning?," *Telemat. Informatics*, vol. 64, Nov. 2021, doi: 10.1016/j.tele.2021.101676.

[10]   J. M. Twenge, T. E. Joiner, M. L. Rogers, and G. N. Martin, "Increases in Depressive Symptoms, Suicide-Related Outcomes, and Suicide Rates Among U.S. Adolescents After 2010 and Links to Increased New Media Screen Time," *Clin. Psychol. Sci.*, vol. 6, no. 1, pp. 3–17, Jan. 2018, doi: 10.1177/2167702617723376.

[11]   Maciej Serda, "Synteza i aktywność biologiczna nowych analogów tiosemikarbazonowych chelatorów żelaza," *Uniw. śląski*, pp. 343–354, 2013, doi: 10.2/JQUERY.MIN.JS.

[12]   Y. L. Chen and C. C. Hsu, "Self-regulated mobile game-based English learning in a virtual reality environment," *Comput. Educ.*, vol. 154, Sep. 2020, doi: 10.1016/j.compedu.2020.103910.

[13] X. Zhan, D. Sun, Y. Wen, Y. Yang, and Y. Zhan, "Investigating Students' Engagement in Mobile Technology-Supported Science Learning Through Video-Based Classroom Observation," *J. Sci. Educ. Technol.*, Aug. 2022, doi: 10.1007/S10956-022-09970-3.

[14] M. M. Diacopoulos and H. Crompton, "A systematic review of mobile learning in social studies," *Comput. Educ.*, vol. 154, p. 103911, Sep. 2020, doi: 10.1016/J.COMPEDU.2020.103911.

[15] E.-M. Mohr, K. Rheidt, and N. Arslan, "Cityscape and Places of Memory in Assos," *Cityscapes Monum. West. Asia Minor*, pp. 9–20, May 2019, doi: 10.2307/J.CTVH1DMGK.7.

[16] A. H. Svellingen, K. Røykenes, A. Forstrønen, J. Assmus, and G. Brattebø, "Examining predictive factors of nursing students' self-confidence in multiple simulation sessions: A randomized controlled study," *Nurse Educ. Pract.*, vol. 57, Nov. 2021, doi: 10.1016/j.nepr.2021.103231.

[17] S. Ghavifekr and W. A. W. Rosdy, "Teaching and learning with technology: Effectiveness of ICT integration in schools," *Int. J. Res. Educ. Sci.*, vol. 1, no. 2, pp. 175–191, 2015, doi: 10.21890/IJRES.23596.

[18] M. Bagherzadeh, H. Jafari, J. Y. Charati, and V. Shafipour, "The effect of an empowerment program on the moral sensitivity and caring behaviors of emergency nurses in Iran," *Nurse Educ. Pract.*, vol. 57, Nov. 2021, doi: 10.1016/j.nepr.2021.103243.

[19] R. Wahila, L. Mwape, K. Lyambai, and M. Kabinga-Makukula, "Use of Social Media to Support Nursing Students' Learning in Zambia," *Creat. Educ.*, vol. 09, no. 08, pp. 1237–1251, 2018, doi: 10.4236/CE.2018.98092.

[20] M. J. Bourne, S. C. Smeltzer, and M. M. Kelly, "Healthcare inequities among adults with developmental disability: An integrative review with implications for nursing education," *Nurse Educ. Pract.*, vol. 57, Nov. 2021, doi: 10.1016/j.nepr.2021.103225.

[21] M. Ahmadi, F. Estebsari, S. Poormansouri, S. Jahani, and L. Sedighie, "Perceived professional competence in spiritual care and predictive role of spiritual intelligence in Iranian nursing students," *Nurse Educ. Pract.*, vol. 57, Nov. 2021, doi: 10.1016/j.nepr.2021.103227.

[22] L. Nowell, D. White, K. Benzies, and P. Rosenau, "Factors that impact implementation of mentorship programs in nursing academia: A sequential-explanatory mixed methods study," *J. Nurs. Educ. Pract.*, vol. 7, no. 10, p. 1, Apr. 2017, doi: 10.5430/JNEP.V7N10P1.