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CURIO 2.0: A Local Network Multiplayer Game Kit to Encourage Inquisitive Mindsets

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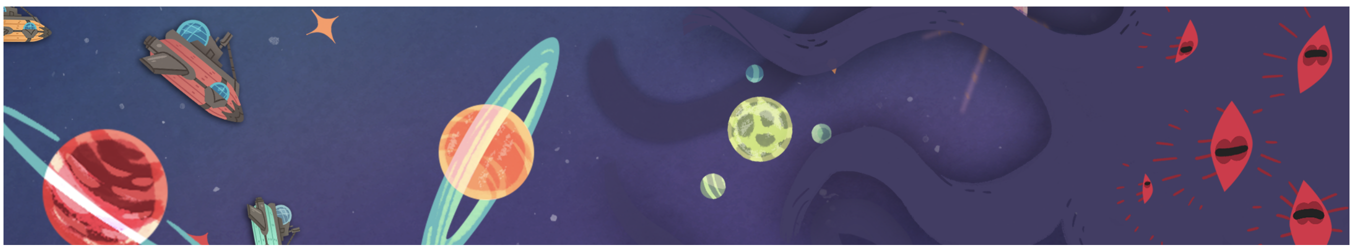

Figure 1: The Haze of Confusion besieges the CURIO galaxy.

ABSTRACT

Research has found that successful game-based learning (GBL) is dependent on several factors, e.g. students, parents, teachers and educational setting. Nevertheless, many existing GBL solutions primarily consider the student. Similarly, they focus on imparting and assessing content-specific knowledge rather than encouraging students to become intrinsically motivated learners. This paper presents CURIO, an educational game kit that involves teachers as 'game masters'. It encourages inquisitive mindsets in students and helps to structure discussions when introducing a new topic in class. It informs the teacher of students' pre-existing knowledge so that they can better shape upcoming classes to their needs. A pilot study with a class of 25 primary school students and their homeroom teacher evaluated a prototype of CURIO. The paper concludes with guidelines learned from creating and testing CURIO that can help with the development of tools for teachers using the same design philosophy.

*The first and second author contributed equally to this research.

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CCS CONCEPTS

• **Applied computing → Computer games**; *E-learning*; **Collaborative learning**.

KEYWORDS

game-based learning, GBL, videogames, serious games, games for education

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1 INTRODUCTION

Game-based learning (GBL) can be used in a variety of ways and for a variety of purposes. Although 'learning' is an explicit part of their branding, these games do not always need to convey subject matter information to contribute to educational processes. Instead, they can also try to change attitudes regarding certain subjects. This paper argues for a game-based learning approach that pursues activation and participation more so than conveying educational content. It invites students to examine a topic that might seem complicated or intimidating through a game-like interface. This experiential introduction can then make further studies into the subject feel less daunting, as the students have a more approachable and tangible point of departure from which to explore other educational materials.

While games can encourage students to become intrinsically motivated learners beyond only imparting and testing knowledge or training skills, this approach is currently not the most common for games used in classrooms. A survey of 700 US teachers showed that the primary reasons for using (digital) games in classrooms are to teach new material, to practice already learned material, and to reward or give a break to students [27]. The survey also shows that games used in classrooms tend to focus on a specific subject matter (e.g. literacy or math). This is understandable, as educational content is time-consuming and expensive to make, but it also limits the use of a single game. The resulting games are predictable and lack variation [19]. While more intricate, commercial games (e.g. Roller Coaster Tycoon [14, 24]) can provide educational experiences on a range of topics (e.g. economics and physics), they pose other challenges in incorporating them into the curriculum (e.g. time required for a satisfying game session or learning how to use the game) [14, 31].

In addition to integrating fixed, educational content [25], the emphasis is also often placed on the game and the student. While teachers may use gameplay as a starting point for discussion, devise quizzes around a game, or gather data from built-in assessment tools [27], the teacher is rarely involved in the play experience themselves. Changing this may, in part, help to increase the perceived usefulness of games as classroom tools, a lack of which forms a barrier in teachers adopting games in their practice [23].

A final concern with classroom games is that many present themselves as single-player experiences. While one positive aspect of games is to encourage collaboration and discussion, games in classrooms do not often appear to utilise this strength. On the other hand, games that do accommodate multiple players tend to be costly or rely on external infrastructure. Games like Minecraft [21] and Kahoot! [12] are notable examples. They can be altered depending on the content and accommodate multiple players. However, Minecraft requires creativity on the side of the teacher to integrate it meaningfully into the curriculum. Kahoot!, on the other hand, is focused primarily on retention of information and requires an internet connection to play.

CURIO is a multiplayer game kit that stimulates inquisitive mindsets in primary school students. It does so by encouraging students to ask questions about a new topic and therefore stimulate further investigation. This paper uses the term 'game kit' rather than 'game' to refer to the CURIO project. While CURIO presents itself as a game of space exploration for the whole class, its primary function lies in its use as a teaching 'tool' and its ability to be expanded upon and shaped by the teacher. CURIO involves the teacher in the active role of a 'game-master', who sets the content for and guides each game session as it takes place. CURIO is subject independent and may be utilised for any manner of topics. While CURIO can be fit into the curriculum as teachers see fit, its intended use is when introducing a new topic to the class. When used in this manner, the game kit serves as a playful introduction to the topic, helps to structure discussion, informs the teacher on the students' preexisting knowledge, and can provide input for upcoming classes. In doing so, CURIO aims to tackle some of the issues with existing GBL solutions.

The primary contribution of this paper is in describing the CURIO game kit. A prototype of the game kit was tested with an elementary school class in the Netherlands. The paper discusses the results from this pilot study and the insights gained from creating and using the CURIO game kit. It presents these insights in the form of guidelines for teachers wishing to integrate the game kit in their classrooms or others looking to create tools for teachers following a similar design philosophy.

2 THEORETICAL FOUNDATION AND RELATED WORK

Digital Game-Based Learning (GBL) has had a remarkable journey in the past couple of decades. From being a multi-billion dollar industry in the mid-90s to evaporating almost entirely in the early '00s [11], GBL has, alongside many other genres of 'serious games', grown to once again become an enthusiastically debated area of interest for both developers and researchers to thrive in.

From the perspective of many educators and proponents of game-based learning, games are viewed as a medium in which the current generation excels [2, 20]. Students are said to navigate game environments with ease and regularly employ methods of problem-solving, engage in advanced collaborative efforts, and communicate complex concepts to one another during their private gaming sessions at home [4, 5, 9]. Seeing students relish in and master activities that are seen as fundamentally analogous to what teachers work hard to interest them in is, of course, a catalyst for wanting to harness "the power of games" for educational purposes [13, 20, 26].

However, even though the discourse and interest surrounding GBL is continuously growing, the type of wide-spread implementation that has long been predicted and anticipated is yet to happen [6]. One reason for this might be that games, on their own, do not facilitate learning as effectively or as 'automatically' as one might hope.

For example, Turkle [30] and Linderoth [17, 18] have posited counter-arguments regarding the perceived inherent learning potential of games, assumed by researchers such as Gee [9] and Annetta [1]. The critique, ratified by other researchers as well (e.g., [7, 15], in essence, comes down to what a game teaches its player, and a distinction is usually made between learning 'game mastery' and learning transferable, subject matter-relevant knowledge. The issue that educational games often face is that they can only reliably account for the former. In contrast, the latter is both more difficult to evaluate in research and to ensure through game design and implementation. For example, game designer Raph Koster [16] has defined games as systems that teach but adds that they ultimately only teach the player to identify game patterns and to hone the skills necessary to perform well in the confines of those patterns. This, in essence, is the focal point for the continuously on-going debate regarding 'transfer' in serious games and game-based learning (e.g. [29]).

Previous research in serious games and educational games has emphasised the compromise between educational and engaging content, and there has been plenty of suggestions of how to reach optimal compromises between these two 'poles' through appropriate design decisions [7, 20, 32]. While this approach is reasonable for games that are not intended for use in formal educational contexts, this research shows that it is insufficient when stricter frameworks for a game's use are introduced. Regarding the game itself as the primary conduit for educational material and engaging content disregards the transformative potency of teachers and classroom settings. No matter how well the developer manages to achieve a balance of providing transferable learning and an engaging gameplay experience, the system surrounding the game will determine the impact the game will have in a formal educational environment.

These challenges inherent in digital game-based learning is the impetus for emphasising the importance of pedagogical context when working with digital game-based learning. Whereas games in-and-of-themselves might not live up to their hype as student-driven educational environments, games used deliberately in a pedagogical context might be able to have a positive impact on educational pursuits. No singular actor has the sole responsibility or authority to decide the ultimate impact and pedagogical value that an educational game holds [3]. Instead, successful game-based learning is the outcome of efficient and deliberate orchestration of a plethora of different activities, working processes, technologies, and active stakeholders. Developers, educators, and students all make essential contributions to the educational game system and depending on the specifics of the educational game project, the interplay between these actors will affect it and each other differently.

With all these challenges and possibilities inherent to GBL pursuits, CURIO positions itself as an educational tool that takes real-world implementation challenges and previous misconceptions about game-based learning into account in its design process. In short, CURIO aims to be a utility in the hands of instructors and teachers, giving them the chance of co-creating an engaging and inspiring environment in which their students can experience a variety of subjects in a novel and approachable way. Up until here, this paper has outlined some of the constraints and common pitfalls of existing game-based learning projects. Realising these is as crucial as understanding the positive values one wishes to pursue, and the CURIO game kit provides an example project that aims to address these problematic aspects specifically.

3 THE CURIO GAME KIT

In CURIO, students restore curiosity to a fictional galaxy besieged by the Haze of Confusion, the game's antagonist. The Haze sweeps across the galaxy, draining the planets' inhabitants of their enthusiasm for a particular topic. Students play individually but are sorted into three teams (blue, red and yellow). By visiting the planets and asking the inhabitants questions, the students help them regain interest in their topic. Eventually, students will face the Haze and answer multiple-choice questions in order to defeat it. Once the students save the galaxy from the Haze, they can spend points earned during play to decorate their spaceship.

A teacher prepares the scenario for each game session, which determines the topics for the individual planets (subtopics grouped under a broader main topic) and the questions posed by the Haze in the final confrontation. For teachers, CURIO serves as a tool that can engage students in a new topic, to assess existing knowledge, and to receive input for upcoming classes. While playing, the teacher acts as a 'game master' who controls the flow of the game.

3.1 Student Side

The game starts with an animation that shows the 'Haze of Confusion' spreading across a fictional galaxy from the left to the right side of the screen. The sequence introduces students to the threat they need to defeat, and then shows them in which team they will play. The introduction is followed by multiple game rounds, each of which is broken down into individual phases.

Phase 1: Vote for target location. Students see the map of the galaxy, which shows the three player ships and several planets with sub-topics connected to them. The exact layout of the map is randomised upon starting the session. In this phase, students individually vote for which planet they want to visit. Most of the map will be covered by a 'fog of war' at the start of the game, limiting the options of the students. As they visit planets, the neighbouring planets will be unlocked and become available for selection. In the first round, the player ships will appear on the far left side of the map around a space station. In subsequent game rounds, they will appear from the last selected planet, and any neighbouring planets are revealed.

Phase 2: Outcome of the vote. An indicator flashes across the planets that were available to choose, building anticipation before the result of the vote is revealed. The planet that was chosen by the majority of students becomes highlighted. In case of a tie, the planet is chosen randomly from the top choices. The three player ships teleport away from their current location and appear at the new location, where they land on the planet.

Phase 3: Ask questions. The game transitions from the map view to a view of the planet. Each planet has a different aesthetic and inhabitant, with a total of seven unique options. The planet appears de-saturated in colour, and the inhabitant is surrounded by the Haze of Confusion. The inhabitant welcomes the player in a lethargic manner. They suggest that the players ask them questions about the planet's sub-topic to spark their curiosity again. Students are then provided with an interface through which they can type in questions, with the goal of asking as many valuable questions relating to the sub-topic as possible within the time limit.

Phase 4: Question review. While the teacher evaluates the incoming questions, students are shown questions posed by the

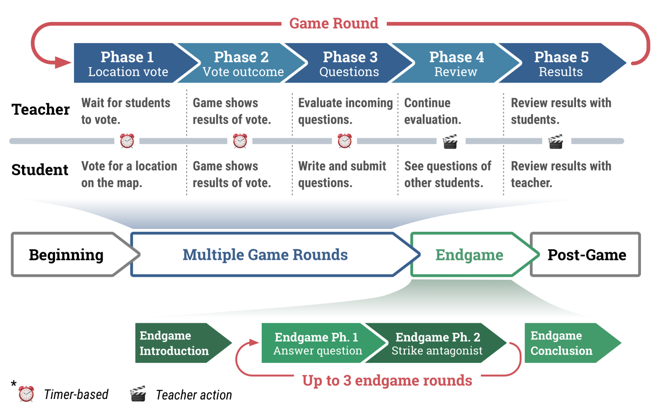

Figure 2: Diagram showing the game flow in phases for both students and teachers.

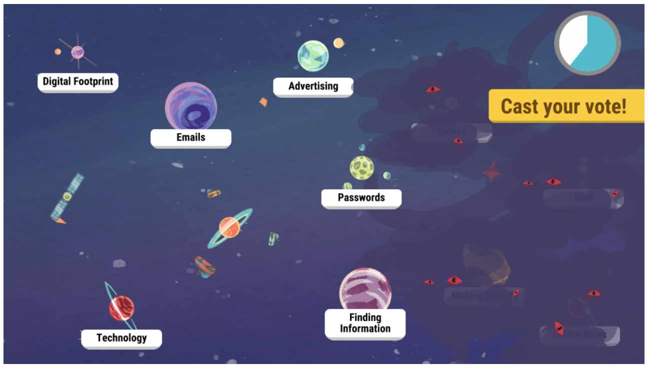

Figure 3: Main game screen of student-side application, showing the map where students can vote for their next destination (i.e. sub-topic).

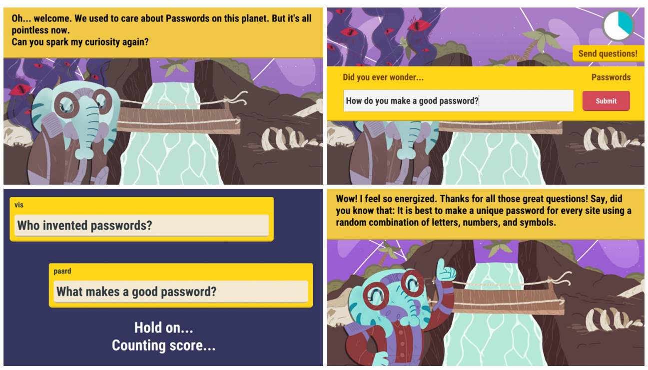

Figure 4: The game phases for students after landing on a planet. Arriving at the planet (TL), asking questions (TR), carousel of accepted questions while waiting for the teacher (BL), resolution and getting information on sub-topic (BR).

class that have already been accepted. Each question also shows the author.

Phase 5: Round results. Students see the planet view and the inhabitant once again. With their curiosity restored, the inhabitant will no longer be affected by the Haze of Confusion and the planet itself has been revitalised. The inhabitant thanks the students and shares some information with them based on the sub-topic. Depending on the cumulative amount of accepted questions from a particular team, the inhabitant is very happy (threshold met) or a little more neutral (threshold not met). The information the students receive is the same regardless.

The game continues in rounds following these phases until the endgame is triggered. This can happen in two ways. First, the students may vote to end the game in Phase 1. This requires them to uncover enough of the map to reveal the 'Endgame'-node, visualised by another space station. Second, the teacher may trigger the endgame at any point in Phase 1. The endgame is split into several phases as well.

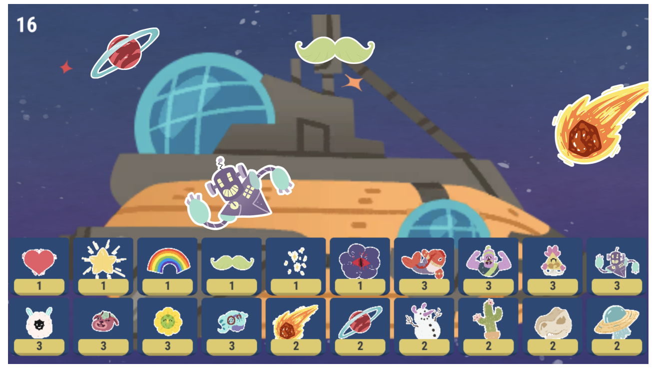

Figure 5: End of the game for students: decorating the ship with stickers

Endgame Introduction. The player ships travel to the final node on the map, and the game pans towards the right to reveal the Haze of Confusion. From here, the final confrontation begins.

Endgame Phase 1: Answer question. The students are posed a question by the Haze. The question will relate to one of the subtopics that they visited, and the correct answer is the bit of information that they learned from the inhabitant they helped. This aspect of CURIO aims to check whether students paid attention during the sessions and absorbed the information.

Endgame Phase 2: Strike antagonist. Depending on how the students answered the multiple-choice question, each team shoots a rocket at the Haze. If a majority of the students in a team answered correctly, the rocket is visually bigger.

The game will repeat phases 1 and 2 until the students answered three questions. In case less than three sub-topics were visited, the phases will only repeat for that amount. Once the students answer enough questions, the game moves on to the endgame conclusion.

Endgame Conclusion. An animation plays to show the player ships defeating the Haze successfully, bringing the game to a satisfying conclusion.

Post-Game Activity: Decorate ship. Students can earn points throughout the session. They earn these by asking valid questions and answering the multiple-choice questions correctly in the endgame. They can use these points in the final activity of the game. A large version of the spaceship appears on screen, which students can decorate with stickers using their points. All students decorate the ship together, meaning that they will see each other's stickers as they place them. This rounds off the game session with a simple reward for the students. The final picture of the ship can be saved out as a screen capture to have a memento of the game session.

3.2 Teacher Side

While students play the game, teachers act as the 'game master'. The teacher's involvement starts with preparing the scenario for a game session. The teacher can open their side of the CURIO application to manage classroom and scenario files.

Classroom file: Holds the names of all students in a class. Students log in using their name at the start of the game session. The

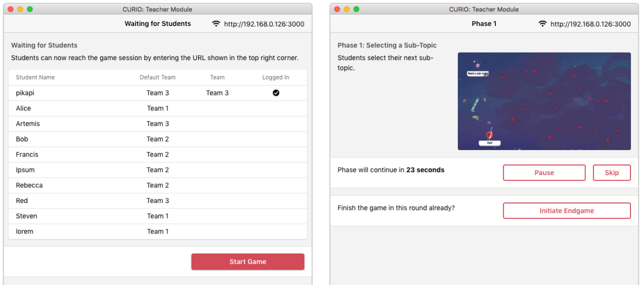

Figure 6: Screenshots showing the teacher interface.

teacher can, therefore, know who asked particular questions or how individual students answered the multiple-choice questions in the endgame.

Scenario file: Scenario files hold the information for a particular scenario. The teacher sets an overarching topic for a game scenario (e.g. 'The Internet', 'Physics', 'Algebra'). They then define several sub-topics (e.g. 'Online shopping', 'Passwords', 'Digital footprint'), with a minimum of one sub-topic. The teacher provides an exam question for each sub-topic, as well as the answer to that question. The students can encounter these questions in the confrontation with the Haze. They can also uncover the correct answer to the question if they visit the planet corresponding to the sub-topic during the session. Because of how the planet inhabitant conveys the information, it is ideal if the answer forms a standalone sentence. The teacher also provides between one and four wrong answers to the question.

The teacher selects a created classroom and scenario file from the interface. With both selected, they can then start a game session. When they do, they see a list of the names in the classroom file. From this point on, students can connect to the teacher's IP address using their own devices and log in to the game using a name in the classroom file. The teacher sees a student's status change in the list when they log in, as well as their team (red, blue, or yellow). Team sorting is random initially, with students being distributed across the three teams equally as they log in. The teacher can overwrite the sorting manually.

Once everyone has logged in, the teacher starts the game. From this point on, the teacher application follows the same phases as the student application. Some phases are timer-based and will advance automatically, while others will only do so when the teacher chooses to do so. The interface shows the phase the game is in, as well as a description of that phase. A screenshot from one of the running student applications is periodically sent to the teacher application (every 5 seconds) to inform the teacher of what students see at that moment. The following sections describe the phases that require specific input from the teacher. Any other phases are timer-based by default and will advance without interaction. Any phase can be advanced before the timer runs out or paused by the teacher.

Phase 1: Vote for target location. There is no specific interaction required from the teacher, but they can decide to initiate the endgame early in this phase. The application will ask for confirmation before triggering the end. Selecting this option will override the vote of the students for this round. Instead, the ships advance to the confrontation with the Haze in Phase 2.

Phase 3 and 4: Evaluate questions. Questions asked by the students will appear in the teacher application. The teacher can choose to accept or reject a question. For each accepted question, that student and their team will earn a point. The questions appear in batches. Once the teacher processes all available questions, questions submitted in the meantime appear next. This process repeats until no more questions are left. Phase 3 will advance automatically for the students after a set timer, while phase 4 will stay until the teacher has assessed all the questions and decides to move on to the next phase. Phase 4 is a suitable moment to pause the game session and discuss some of the questions submitted that round.

The phases repeat until the endgame is triggered, either by the students or by the teacher. The game requires no additional input from the teacher once the endgame begins. Students answer the multiple-choice questions and defeat the Haze, after which they decorate their ship. The teacher can decide when to end the game session by closing the teacher application.

CURIO saves the submitted (and accepted) questions for each session, including which student asked each question. This information can be useful in planning upcoming lessons or have further discussions and activities in class about the topic that the game session covered.

3.3 Technology

While the design of the CURIO game kit consists of two components (teacher and student side), the application runs as a single executable on the computer of the teacher (supporting Windows, Mac, and Linux). The executable, created using the Electron software framework [8], opens the teacher interface and starts a local server in the background. The server hosts a WebGL application, created using the Unity game engine [28], that students access by connecting to the IP address of the server (prominently displayed in the teacher interface) via any internet browser capable of displaying WebGL content. Teachers can also change their computer network name in such a way that the server is reachable by using a more memorable address, such as *"http://curiogame.local"*.

Students can use laptops, desktop computers, or (high-end) mobile devices to load the WebGL application, thus allowing for a variety of different devices and operating systems. Since the teacher hosts the WebGL application, student devices need to connect to the same local network as the teacher's computer. None of the machines require access to the Internet — once students access the WebGL application, their browser connects to the teacher interface via the local server for any communication about game states. As long as the teacher keeps their interface open, the game is accessible to students. By closing the teacher interface, the server is shut down as well, thus making the student side of the application unavailable.

The student side application can also run as a native Android or iOS application, which then requires installation on each device. In this case, students do not use a browser. Instead, they use the native application to connect to the server running on the teacher's computer. Students enter the IP address or computer name address of the teacher's computer into the native application to connect to the server. Otherwise, the game functions the same as the browser version.

All data in CURIO is created on the teacher's computer and accessed from there. The teacher application stores all scenarios and gameplay data into a local database in the application folder. Teachers can export created scenarios and class lists for backup purposes, or to share them with colleagues. Any identification of individual students is limited to the name that teachers give them within a class list. They could, for example, use the name of a student, or a nickname that students choose for themselves.

3.4 CURIO 1.0

We mention the version number of CURIO in the title of this paper to emphasise that its design has changed over time. The CURIO project incorporates a bottom-up approach. Focus groups were held with science teachers and other stakeholders to design a teaching toolkit aimed at fostering scientific curiosity, which encourages students to ask questions and explore possibilities. An earlier version of the design [10] focused on many of these design goals and the initial concept that resulted from the focus groups. The first design proposed a game kit that would put teachers into the role of both facilitators of gameplay as well as participants (similar to 'game masters' in pen and paper role-playing games). Students would populate a shared virtual 3D environment with vegetation by 'planting' thought-provoking questions about educational topics.

While development efforts typically go through multiple iterative changes, these changes tend to become smaller in scope as the development progresses. This progression happens because substantive modifications at a later point become more costly in terms of development work. In the case of CURIO 1.0, the first quarter of the overall development time focused on creating a comprehensive game design based on what the team believed they could achieve, both technologically and organisationally.

However, as time progressed, important development details kept changing. Eventually, CURIO is intended for use in Malta, where the public views game-based learning with scepticism. For example, a suggestion received at the first public presentation of the project was to forego mention of the word 'game'. Here, 'games' are considered to be closely related to gambling, based in part on the prolific local gamified gambling economy. As such, educational and game design considerations also had to contend with political realities that made the development progress more challenging.

At the same time, technological solutions in the classroom turned out to be limited and varied between schools. In the end, this meant to develop CURIO in a manner that would allow for a broader range of target platforms and with ranging connectivity options, while retaining the core of the game: to let students inhabit a shared virtual environment. To retain the spirit of the game, the existing design and planned aesthetic had to change to complete development in the remaining time. Especially given that students and teachers need to feel confident in the consistent functionality of a game-based learning kit, the redesign removed some of the costlier design choices of the original game in order to provide that consistency.

We mention this aspect not because it is unique to the CURIO development, but precisely because publicly funded game-based learning efforts are likely to encounter challenges that make it difficult to carry out the initially intended design. Public funding is typically granted based on a plan that lays out how the partners will spend the received resources. Reworking a large part of a project can seem to run counter to this agreement. However, we argue that it is of public interest to ensure that developers use their funding in a manner consistent with the spirit in which it was granted. Doing so should be preferable over carrying out a plan regardless of what discoveries might occur during the project. In the case of game development (and possibly development efforts in general), it means that making necessary changes might be the prudent thing to do, as long as it is possible to implement them with the remaining resources. At the same time, we consider it necessary to report such changes in academic literature. The development of serious games may otherwise appear to be the result of a series of iterative improvements in which no development work is ever lost.

Even the redesign presented in this paper is not guaranteed to succeed in its goal to provide teachers with a valuable teaching platform. Several evaluation studies, such as the pilot described in the next section, are required to assess whether CURIO can be considered a valuable tool for teachers. At the same time, maintaining the original design would have required a different target environment, or additional resources, neither of which was available at the time.

4 PILOT STUDY

One of the principles of game development is that the assumptions made in the design of a game need to be tested, not just at the end, but throughout the development process. Even when parts of the game are not yet fully functional, it is possible to test the core design for viability, and feedback can provide input for further development.

This section describes a pilot study conducted with elementary school students at a Dutch primary school. The goal of this study was to evaluate the functional stability of the game kit prototype, the reception of the game concept by students and their homeroom teacher, and the suitability of the game kit to stimulate educational discussions. The study took place as a single session with 25 students, one teacher, and two experimenters. It lasted for one hour, including roughly 30 minutes of active playtime.

Students used a functional version of the CURIO game kit, here referred to as the 'prototype'. The prototype was targeted primarily at testing functionality of playing in the classroom. Preparing a game session still required technical expertise at this point, as teachers did not yet have a graphical user interface to create game sessions. The prototype also did not yet include the ludic and narrative conclusion of a game session. Instead, the end of the game displayed a ranking of the three teams, adding an element of competition. The homeroom teacher was involved in a supporting role, rather than as an active participant. Instead, one of the experimenters acted as a teacher and hosted the session with support from the homeroom teacher.

Data collection happened in the form of observational notes, a lightly structured (group) interview, and a child-friendly game experience questionnaire (the "extended Short Feedback Questionnaire" or eSFQ) to support our evaluation efforts [22]. The eSFQ includes child-friendly presentations of Likert scale ratings and uses single-word labels that can be marked to indicate how a game is received. It uses two categories of labels, those that describe the game (e.g. "boring", "exciting") and those that remark on the experience of playing with others (e.g. "fair", "frustrating"). One question about playing the game previously was removed, as it did not apply in this context. The authors of the eSFQ have validated the questionnaire on students aged 10 to 14 years, which partially overlaps with the target group of the pilot.

4.1 Procedure

The experimenters met with the homeroom teacher to discuss the testing procedure before the session. The experimenters then tested the reliability of the wireless network and went through all steps of the game kit to ensure its functionality.

The homeroom teacher introduced the experimenters to the class. In addition to providing a supporting role, they could monitor the students' devices from their computer during the session. One of the experimenters fulfilled the role of the teacher, while the second took observational notes. The teaching experimenter explained the purpose of the test and highlighted that certain aspects of the application were still under development. They also told the students that their feedback could improve the game for others who might use the application in the future.

The homeroom teacher formed groups of students instead of each student participating with an individual device. This setup prevented potential troubleshooting on a large number of devices within a limited amount of testing time. Instead of using 25 devices, groups of 4-5 students shared a total of six Chromebooks. Rather than identifying each player by name, teams could choose animal names: fox, rabbit, frog, snake, fish, and hedgehog. A group was thus together considered, for example, player "fox". Due to a technical issue, these six groups were distributed unevenly over the three in-game teams, leading to unequal distributions in team sizes.

After the experimenter ensured that students did not have any remaining questions about the test procedure, they presented the topic of the game session: The Internet. The experimenters chose this topic in advance with the teacher as one that students were likely familiar with but had not considered in depth. Students played three rounds in which they chose for sub-topics that related to the session topic. The topics chosen by popular vote within the game kit were: (1) technology, (2) making friends online, and (3) online shopping.

A short discussion followed each game round, during which the experimenter highlighted some questions students had provided. The questions formed a starting point to assess what students already knew about the sub-topic and trigger further consideration. The experimenter paired such inquiries with new information that students might not yet be aware of. In each case, the discussion was kept short as the allotted time before the end of class was limited. In a normal teaching situation, teachers would likely be able to schedule their time differently and continue for longer, depending on what inquiries are formed by the students.

After the game session concluded, the experimenter asked students for their opinion on the game, focusing on feedback that could improve the game. This exchange was followed by handing out anonymous single-sheet questionnaire forms (the eSFQ mentioned above) to gather individual feedback. The homeroom teacher took over once students completed the forms, discussed some school-related matters and ended class. The experimenters then discussed the test session with the homeroom teacher and took notes of what the teacher thought about the game kit and its intentions.

4.2 Results

The active part of the user test session (that is, playing the game, excluding prior explanations) lasted roughly 30 minutes. All participating students filled-in the eSFQ (N=25). Students ranged from 8 to 10 in age (Mn=9.4, SD=0.6). The gender distribution was 16 female students (64%) and nine male students (36%).

Enjoyment (measured by filling in a thermometer depicting increasingly happy smileys) was on average rated 3.9 out of 5 (SD=0.9). When asked whether they would want to play the game again, 18 marked *Yes* (72%), five marked *Maybe* (20%), and two marked *No* (8%). Given that the prototype still lacked visual variety and a satisfying conclusion, we consider this a positive result.

The three Likert-scale questions yielded the following results (rated from 1 to 5, with 5 indicating highest agreement): *I wanted to continue playing to see more of the game* — Mn = 3.9, SD = 1.1, *I was curious about what would happen in the game* — Mn = 3.9, SD = 1.2, and *I was looking for explanations for what I encountered in the game* — Mn = 3.0, SD = 1.4.

Ratings of the first two statements suggest that students were engaged and focused on the task. The third statement received somewhat mixed ratings. It is possible to assume this is because, in itself, the game does not present events that students need to investigate. Instead, students need to to think about what could make a virtual character interested in a topic. We might hypothesise that the overall narrative of the game (a haze of confusion affecting a galaxy) is only a mild trigger for investigating a given sub-topic. However, given that the narrative is primarily a framing device for the involved sub-topics, we consider this an acceptable shortcoming as long as the game kit can serve as a platform for shaping discussions within the classroom.

In terms of labels that were marked, the three most frequently marked labels describing the game were *Fun* (80%), *Easy* (60%), and *Great* (40%), while the three least used labels were *Boring* (20%), *Difficult* (20%), and *Childish* (0%). When asked to mark labels regarding how it was to play the game with others, the three most picked labels were *Fun* (80%), *Satisfying* (64%), and *Cooperative* (60%), while the three least used labels were *Competitive* (8%), *Discouraging* (4%), and *Angry* (0%).

Based on observations from the test session, students were engaged in the game and invested in performing well. Students appeared to understand that performance was connected not only to asking many questions but also to the quality of such questions. This understanding showed through the team discussions that emerged and was also commented on by the teacher. It further became evident that 'something happening on-screen' was an important reminder for students to remain focused on the task. During phases in which the game kit simply informed them to wait for the teacher to catch up on evaluating questions, students became noticeably louder. Given that the teacher is occupied during this time, the game kit should provide support in the form of offering useful information to students.

In the group discussion, students noted various reasons for enjoying the game. They enjoyed coming up with questions and cared about how the experimenter received their questions. The chosen topic was one that all students knew of but had never given considerable thought. One student commented that asking questions made her think more deeply about the topic than she would have done usually and also realise she knew more about it than she had initially thought. While students generally enjoyed working in teams, there was at least one younger student who felt overshadowed by teammates hogging the device. Due to the technical mishap in uneven team distribution, some students perceived the competitive aspect as unfair. Overall, students did not mention competition as particularly positive, and it sooner had the potential of creating a negative situation for the 'losing' students.

The final discussion with the homeroom teacher highlighted the potential for the application, especially in modern teaching environments involving (mobile) computers. The teacher mentioned they would use a tool like CURIO in their teaching. In this particular school, the teaching method is shifting more towards a project-based approach, in which groups of students formulate a research question and examine it for some weeks. The teacher noted that CURIO would be a good fit at the start of such a project to help students come up with questions to explore. They also expressed a preference for having students control the game individually rather than in teams so that each student could think of questions at their own pace. Overall, the teacher expressed interest in being involved in future evaluations and was enthusiastic about CURIO's goals.

4.3 Changes to CURIO

The results of the pilot inspired several changes to the game kit. The number of sub-topics per game session was reduced to limit game length. Teachers also have more control over certain aspects (e.g. team composition and session length), and students have increased interactivity options at moments when the teacher evaluates student questions. A short brainstorm with the students resulted in the endgame and post-game activity, which provide a natural conclusion to the session. These additions tone down the competitive aspect, and students also receive individual rewards for their questions. Several additional minor changes are not discussed in detail, but can be described as adjustments to timing and visual feedback to clarify what students can do at a given moment in CURIO.

5 DISCUSSION

The pilot study with the CURIO prototype generated promising results. Response from the students was generally positive, and their feedback provided useful input at that stage of the prototype's development. The students were engaged and focused during the game session. In addition to this, CURIO facilitated discussion between the students and appeared to stimulate more profound thought on the presented topics. The teacher's feedback suggests that CURIO is a good fit for new educational approaches in the Netherlands that focus on experiential learning. The quality of the questions asked by the students increased over time, indicating that it is best to use the CURIO game kit for at least half an hour, if not longer. Repeated use of the kit may also contribute to students learning to ask more valid questions. The initial test suggests that CURIO can meet the primary goals it set at its inception. It has the potential to be a useful tool for teachers in structuring conversation around a new topic, to stimulate students in taking on an inquisitive mindset around a topic, and to give teachers a better understanding of the prior knowledge and assumptions of their students.

While these initial results are positive, further validation of a concept like CURIO is necessary to assess its usefulness to teachers and students alike. The final version of the game kit requires testing in different schools that follow a variety of teaching methods. Depending on the environment, CURIO may or may not fit well with the applied teaching method.

It is also essential to understand the CURIO game kit in the way it has been intended: as a tool that teachers can use to support their teaching efforts, using infrastructure that they have at their disposal. The pilot site was chosen, in part, due to its existing integration of technology in the classroom. This setup is what many schools aspire to, as is evident by 'one tablet/laptop per child' initiatives. This level of technological infrastructure, however, is far from the standard in all schools.

It was a welcome find that CURIO appears to fit well with the teaching methods employed at the pilot site. However, different schools and teachers may provide varying opinions on CURIO's usefulness to them. The CURIO game kit does not propose that technology in the classroom intrinsically improves the quality of education, but instead aims to provide valuable content for classrooms that utilise technology to support teachers and students. Teachers that categorically dismiss the use of game-based technology will find as little use for the game kit as those that expect it to provide educational value without their involvement.

5.1 Using CURIO in class

This section presents guidelines for using CURIO in the classroom, based on the results of the pilot study and the design intentions behind the application. Notably, these come with the caveat of putting interested educators in the position of testing out a new tool. Nevertheless, they should be considered as best available evidence for how CURIO can support teaching. Apart from aiding educators, these guidelines can support the development and research of other GBL projects intended for similar circumstances and environments.

I. Game Flow: Ideally, each game round in a CURIO session is followed by a discussion between the teacher and students. The teacher can refer to inquiries made to explain aspects of the related topic. Especially in large classes, it can make sense to address the most frequently occurring questions, as well as ask students to argue for what answers might be possible and why. CURIO makes it easy to extend or skip most of the individual phases in a game round as teachers see fit. Teachers are encouraged to make use of that functionality to support their teaching efforts.

II. Timing and Time Investment: The CURIO game kit is best suited for the introduction of new topics where teachers can expect to find some pieces of pre-existing knowledge among their students. Topics that are radically unfamiliar to students might lead to the formulation of fewer, too general questions. On the other hand, topics that are very specific or too well understood might lead to questions that are less likely to be actually on the mind of students. Sessions involving CURIO should not occur too frequently, as the process of formulating questions is mentally exhausting and should be followed by actually addressing some of the posed inquiries. Teachers should also take care to not rush through a session, but rather implement breaks as teaching and playing are interdependent activities when using CURIO. Teachers should schedule 1-2 hours for their first session with CURIO, and should make sure that students can anticipate the ending if a session ends before exploring the entirety of the game board.

III. Managing Expectations: CURIO should not be framed as a reward in itself, and should not be used as such by teachers. While it features elements that are intended to feel rewarding, it is an activity that demands time and concentration from both students and teachers. This demand makes it a poor choice for concluding an already intensive teaching day. Teachers will need to be open for the possibility of using games as a legitimate medium for education, and not solely as source of entertainment. This also means leaving enough time for the conclusion of the game where students get to collectively defeat the game's symbolic antagonist and decorate their ship as a reward.

IV. Preparation: While care has been taken to keep organisational tasks in the game as simple as possible, teachers are advised to prepare their session with CURIO in advance. A well-prepared scenario will allow teachers to have a better idea about what to discuss between the individual game rounds and ensure that the questions that students come up with are relevant to what is supposed to be covered by the curriculum. Class lists are also best created before a session takes place. For the very first session, teachers will also have to explain how students connect to the teacher's computer.

V. Openness to Questions: CURIO gives teachers full control over what they deem to be acceptable questions. During early focus groups, teachers remarked that the phrasing of 'rejecting' a question sounded harsh. While students are not directly informed about having their inquiries rejected, the blunt language for not accepting a question is by design. Teachers are invited to be rather generous about what is an acceptable question, as the process of coming up with questions is in itself demanding. Whether or not to discuss a question in class remains up to the discretion of the teacher. Rejection of inquiries is intended as a measure reserved for inappropriate behaviour rather than an evaluation of student performance.

6 CONCLUSION

While game-based learning tools are increasingly common in classrooms, they remain limited in their uses as of yet. Although educational games can activate students and encourage participation, they generally focus on imparting and testing content-specific knowledge. Secondly, while they offer teachers the ability to gather data on students' progress, they often exclude the teacher from the play experience.

CURIO is an educational game kit that aims to address these issues with existing GBL solutions. It involves teachers as active participants, helps to structure discussions around a new topic, may be used to gather data to shape upcoming classes, and encourages students to adopt an inquisitive mindset. It does so by leveraging existing technology in classrooms while allowing for a variety of technological solutions that do not require specific hardware or external infrastructures (e.g. an internet connection). Further evaluation is required to show whether CURIO can indeed assist students in tackling a new topic. Future efforts, for instance, may involve using CURIO at the start of a project and evaluating students' behaviour over an extended period.

Similarly, further examination will need to show whether CURIO is found useful by teachers of different backgrounds and educational settings (e.g. varying by school and country). Early results from the pilot study presented in this paper, however, are promising. They suggest that CURIO can indeed fulfil its intended function and serve as a valuable tool for teachers, as well as an engaging experience for students that fosters thought and reflection.

At this stage, we encourage others to test CURIO in their environment or to learn from its development in creating GBL solutions following a similar philosophy. In doing so, gaming in the classroom may not only facilitate the acquisition of knowledge but also foster inquisitive minds that are motivated to explore and question the world around them.

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