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Acquiring and assessing 21st century skills through game development: a case study with an escape game template.

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Abstract. In this study, we observe how a video game creation activity with an escape game template can enhance the acquisition of 21st century skills among high school students. In Game Development-Based Learning (GDBL), the use of customisable template eases the technical cost of entry, provides a structure to guide and motivate students as well as provides learning traces for the teachers. Through the modification of the template, students can engage in tasks directly related to 21st century skills while personalising the game. We present a study on 221 high school students with 10 voluntary teachers in France, analysing the students' engagement, and the complexity of skills assessment in this context.

Keywords: Game-Development-Based Learning, Template, Skills, Assessment

1 Introduction

In 2019, Andreas Schleicher, Director of the Education and Skills Directorate at the Organisation for Economic Co-operation and Development (OECD), commented: "*Education is no longer just about teaching students something; it is more about teaching them to develop a reliable compass and the navigation tools to find their own way in an increasingly complex, volatile and uncertain world*" [10]. To prepare the youth for the future, 21st century skills such as creativity and problem solving have been identified by Margarida Romero [13]. Game Development-Based Learning (GDBL) could be a solution to train those skills as many video game development tasks require the application of 21st century skills [3, 12]. However, video game development is a complex endeavor with many technical challenges, raising the cost of entry for students and teachers alike. Providing a template of a pre-coded game that already works may be an option to ease this cost of entry while maintaining the interest of the students for the activity. Through a case study, we evaluate whether video game creation with a template is a relevant approach to the acquisition of 21st century skills along with an observation of the complexity of skills assessment in this context. In this paper, we present our approach to template design for GDBL, the construction of the escape game template, and our study to evaluate our template with 221 students in 12 classrooms and 10 teachers in France. Finally, we discuss our findings and outline our future work.

2 Background

Voogt and Roblin [15] conducted a comparative analysis of international frameworks for 21st century skills to identify the most common skills shared among these frameworks: Collaboration, communication, ICT literacy and social skills. These skills cannot be taught the same way as curriculum knowledge, they require a constructivist approach where education is seen as the bridge between the individual and society, and students are invited to "learn by doing" as Dewey's theory suggests [4].

In GDBL, students learn by creating a videogame [1], either from scratch-[7,11] or with a video game templates [14]. When students create their own videogame, they encounter many technical challenges, and the time they spend learning programming may come at the expense of developing other skills [11]. Video game templates allow to ease the technical complexity and have been used for the acquisition of 21st century skills in, among others, the Magical project [3] and the No One Left Behind project.[12]. These experiences show pedagogical advantages of the use of such templates. The structuration around activities constrained by the template breaks down the creation of the game into a series of tasks providing students with specific goals, which guide students work and help them stay motivated [9], while providing clearer learning traces [8], helping the teachers' assessment of the learning outcomes. Indeed, in the context of GDBL, assessing a creative production such as a video game, and the learning outcome of the activity of video game creation are challenging for the teachers as they do not know which skills are used to execute which tasks in video game production. Moreover, while the game produced by students provide an indication of the skills mobilised, it is not sufficient to assess all the work that has been carried out. In fact, to complete a task in game development, a student goes through subtasks of various natures. According to Griffin's methodology [6], skills can be evaluated based on the subtasks that have been completed, using the learning traces collected through the digital environment [2, 5, 8]. For our study, we will compare the learning traces from three different sources: observation of the game, the teacher's assessment, and the student's self-assessment.

3 The design of an escape game template for GDBL

Our approach to design video game template for the acquisition of 21st century skills is to provide a functional game that students can modify, because the video game template objective is three-fold: (1) easing the technical challenges of video game creation through pre-coded features, (2) providing clear goals and tasks to guide the students' work and enhance their motivation, and (3) providing a structure and learning trace to facilitate the skills assessment for the teacher. To do so, we need a fine analyse of the work carried out by the students and skills applied during the activity. To delimit the analyse and prepare a first template, we focused on a game genre: the escape game. Escape games are well-known, easy to understand, split into puzzles, accessible to play, and provide a variety of tasks. We considered the usual production tasks of such games and split them into subtasks (see Table 1).

Table 1. Subtasks done by students to complete tasks in the video game template.

Tasks in video game template	Subtasks done by students
Custom character images (4 images)	Find images (preferably royalty free images) Upload image
Custom text (7 texts)	Write dialog
Custom variables (3 variables)	Change variable
Custom sounds (4 sounds)	Find sound (preferably royalty free sound) or record sound Upload sound
Custom other elements	Give credits

To connect the subtasks to the skills, we first had to adapt them to the French curriculum as our study is conducted in France: Understand and express themselves orally and in writing (Communication), Use digital tools to share and communicate (ICT literacy), Developing intellectual honesty (ICT literacy), Understand and respect common rules (Social skills), Organize individual and group work (Social skills). Creativity and Problem-solving remains the same in the French curriculum. To associate subtasks and skills, we designed a survey using a 5-point Likert scale to assess each potential association. We recruited a group of 12 experts, including teachers, educational engineers, and educational researchers, from the special digital working group mandated by the French Ministry of Education, to participate in the survey. As reported in Table 2, we kept the associations that achieved consensus among the experts (a mean value above 3.5, with a standard deviation below 1.5).

Table 2. Skills associated to subtasks with the mean value and standard deviation.

Skills	Subtask
Understand and express themselves orally and in writing	Write dialog (M: 4.8, SD: 0.37)
Develop creativity	Write dialog (M: 4;8, SD: 0.37) Recording / changing sound (M: 3.83, SD: 1.34) Modify variables (M: 3.58, SD: 1.38)
Solving problems	Find royalty free image (M: 3.8, SD: 0.79) Modify variable (M: 4.5, SD:0.80)
Use digital tools to share and communicate	Write dialog (M: 3.91, SD: 1.03) Upload sound in game (M: 3.58, SD: 1.49) Recording / changing sound (M: 4.08, SD: 0.9)
Developing intellectual honesty	Writing (M: 3.58, SD: 1.11) Find royalty free image (M: 4.75, SD: 0.43) Find royalty free sound (M: 4.75, SD: 0.43) Give image and sound credit (M: 4.75, SD: 0.43)
Understand and respect common rules	Find royalty free image (M: 3.66, SD: 1.24) Upload image in game (M: 3.6, SD: 1.46)
Organize individual and group work	Find royalty free image (M: 4.25, SD: 1.46)

Finally, we created the resource necessary for a class session of 1 to 2 hours led by teachers without game development knowledge. We developed the escape game template in Construct3 an online game engine with a visual programming interface. The template is a 2D game of the escape game genre, a subgenre of the *point'n clic* games. The camera shows the game world from a 3rd person top isometric point-of-view (Figure 1). The player's goal is to unlock the last door with a key found by solving 3 clue-based puzzles. First, the player must find the phone number of a character named Bj by talking to a resident of the village. Then, they have to call Bj to obtain a radio frequency. Finally, they discover an excerpt of the Mario video game music by listening to the radio. "Mario" is the code they must use to escape the village. Students can personalise every clue, text, and character. The aim is therefore to modify the game while keeping it functional. Teachers can draw on several sources for assessment: observation of the session, the games created. To facilitate the evaluation of the text written by the students, all texts are exported in a CSV file.



Fig. 1. Template of the escape game developed on Construct3 game engine.

4 Method

The study took place over 4 months (November 2022 - February 2023) in 12 different classes from 10 different schools in France, involving 221 high school students (14 to 16 years old) and 10 voluntary teachers. Chloé Vigneau (first author of this paper) was present in the classroom to observe and ensure that the protocol was followed:

1. At least two weeks prior, the template, a tutorial on how to play the game and modify the template, and a link to a royalty-free images and sounds library, are provided to the teacher. Teachers are free to give these resources to their students or not.
2. At the start, each student receives a numbered USB that contains the template. The number is an identifier to associate a student with the game they have created in accordance with GDPR regulations¹. The students play the game for 10 minutes,

¹ GDPR defines the rights of individuals to their private data in Europe.

then they spend about 45-60 minutes searching for images and sounds on the internet, writing text, and customising the template.

3. At the end of the session, the students are asked to save their own game on the USB key and complete a survey, which serves as an initial learning trace. Teachers are asked to complete another survey, which serves as a second learning trace.
4. A few days after the experience, we play the games collected on the USB keys and analyze them to list the tasks that have been done in the game (boolean questions on text, sound, sound and variable changes). This data is the third learning trace.

5 Results

For this analysis, we define a game as functional when a player can play without any blocking bugs and we define a game as playable when it has no blocking bugs and when it allows a player to successfully complete the puzzle using the provided clues. With the template, 88% of the students were able to create a functional game, while 70% were able to create a playable game. In the game, they completed 0 to 4 tasks, with a mean at 1.9 tasks. Only 6 of the 186 games presented 0 task completed. The students self-reported in average 0 to 10 max subtasks, with a mean of 5.3 subtasks. Next, we compare the three learning traces to evaluate how they converge on skills applied during the activity.

5.1 Skills assessment from teachers' point of view

In the survey, teachers assessed whether the skills have been trained using the following scale: not worked at all, insufficiently worked, sufficiently worked in relation to expectations, worked and developed. According to them, creativity, the use of digital tools, and problem-solving were always sufficiently worked (Figure 2). While most of them found that Expression, Organisation and Respect rules were sufficiently worked the others found it insufficiently worked.

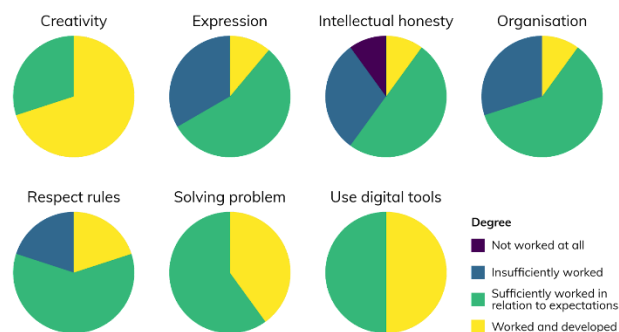


Fig. 2. Skills assessed by teachers.

5.2 Subtasks performed according to students

In the survey, students indicated the level of completion for each task using the following scale: not at all, a little, a lot, all done. The tasks related to pictures and writing are declared as the most completed (Figure 3). They also indicated whether each subtask was new to them or not. New tasks were defined as those they had never done before. Three subtasks are considered new by most students: finding images (>80%), writing (>80%), and finding sounds (>70%).

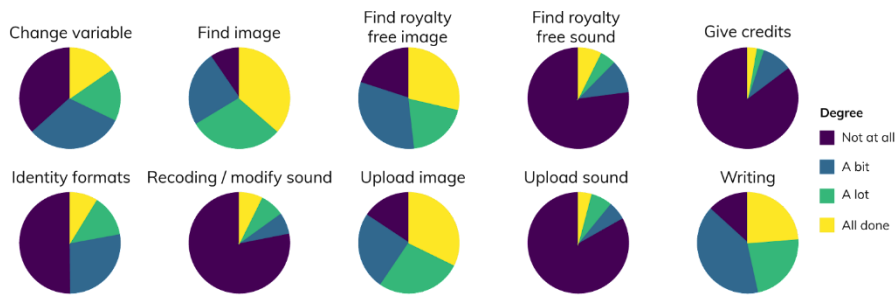


Fig. 3. Tasks performed according to students by degree in percent.

The two most frequently performed subtasks, finding images and writing, are new tasks for most students. The other subtasks declared as new, such as identifying format (60%), recording or modifying sound (60%), and giving credit (55%), were rarely done.

5.3 Tasks completed versus self-reported subtasks by students

We analysed the 186 games to verify whether any text, image, sound, variables, or other elements had been modified. A task is considered as done when at least one element has been personalised. Images were the most customised (91% of the games), followed by text (66%), variables (23%), and finally sounds (10%). We compare the result with the tasks students reported as completed by taking into account the mean of the subtasks reported at least as “a little” done. Students reported as completed more writing and programming subtasks than we can observe in games. On the other hand, they reported doing less work on image-related subtasks than what is observable in the games.

5.4 Skills performed by students

To determine the skills performed by the students while working on subtasks, we consider the subtasks declared as completed by the students. This approach avoids an assessment solely based on the result of the game created, as it may not be representative of all the work done in preparatory subtasks such as finding images. To score each skill, we calculate the average of all the subtasks related to the skill in our model that the student indicated as at least “a little” completed (Figure 4). Organisation, respect of

rules, problem-solving, and expression being the most performed according to our model and students self-reporting on subtasks. We discuss below this discrepancy with the teacher’s analysis.

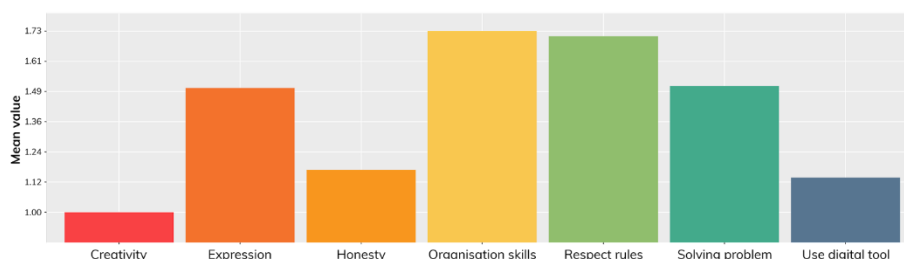


Fig. 4. Skills trained according to the subtasks declared as done by students.

5.5 Students self-reported satisfaction and tasks performed

According to the students' survey, 69% of the participants did not feel that they had created a game, while 58% expressed pride in their accomplishments. The average number of subtasks completed in relation to the sense of pride in the results shows that students who are proud of their achievements completed an average of 5.54 subtasks and 1.46 new subtasks. Those who were not proud completed 4.48 subtasks and 1.05 new subtasks. So, those who were proud of the result completed more subtasks overall and more subtasks that were new to them.

6 Discussions and limitations

To analyse how learning happen and can be assessed in “learning by doing” activity, we compared the teachers’ point of view, self-reported auto evaluation of the student and what has been done in the games. We noticed two main discrepancies.

First, subtasks self-reported by students and the tasks completed in the game were not equivalent. For example, 91% of the students had personalised the images in the game, but only 85% of students declared having done so. We analyse that students minimize the work done on tasks they already know such as image modification and overestimate their work on new tasks such as sound customization and programming. An explanation may be that new tasks, requiring more learning, may have been tried, even some preparatory subtasks done, but without being completed in the template.

Second, the teachers’ assessment of skills practiced and the skills mobilized by the subtasks declared as completed by the students converge on their evaluation of Organisation, Respect rules, Problem solving and Expression being practiced. However, all the teachers reported that Creativity and The use of digital tools were at least sufficiently worked while students reported few subtasks done related to those two skills. Plus, some teachers reported that Respect Rules, Organisation and Expression were insufficiently trained. We hypothesise that our model might not capture enough subtasks related to those skills and that providing the model to the teachers might help them

to assess less obvious subtasks, tasks and skills. This last point emphasises the complexity of assessing such skills in this context and the importance of having a clear skills framework for this activity.

Finally, our template only provided learning trace on the text written, and a more comprehensive learning trace would be necessary to help teachers assess with more details the work carried out by their students.

7 Conclusion

Through this study on 221 high school students, we evaluated the use of an escape game template to train 21st century skills in a very short class session. The template was successful in providing a structure for the workshop, allowing 88% students to finish their project in a very short timeframe, and 70% of them with an entire playable game. We can confirm that the video game template is an effective method for motivating students to practice known subtasks and learn new subtasks. 96% percent of students who submitted their games have completed at least one task in the template, which is a very good result on students' engagement. A majority of students (58%) felt proud about the result. Moreover, we observed that they completed both known and new subtasks, showing that the video game template can be used in two ways: for the discovery and learning of new tasks and for the practice of tasks that are already known.

Compared to creating a video game "from scratch," using a template reduces the technical barriers to entry, provides a guide for game creation, motivates students, and facilitates progress tracking of their learning. However, even with three sources of learning traces, assessing the skills applied during the workshop is still challenging. We discovered two discrepancies by comparing the three sources. As a result, if our model splitting tasks into subtasks and linking subtasks to skills seems to capture well the tasks related to problem-solving, it was less precise on other skills showing the need for a finer grid. Our future work will reassess this model and deepen its level of details as well as reevaluate the connection found in discrepancy in this study. Providing an automated analyses of the tasks completed in the template would be a more comprehensive learning trace to help teachers figure out what students did during the activity.

Solidifying the model between tasks, subtasks and skills is an important step to provide teachers with clear instructions on assessment and extract finer learning traces. As a next step, we will develop an easy to configure template so teachers can select in an interface which tasks they want their students to practice, and the template will adapt itself to the configuration. Indeed, we argue that, if teachers are more involved in the preparation of the video game template, they will have a better understanding of the tasks and subtasks required to complete the game and gain a better understanding of all the benefits of this Game Development-Based Learning activity. This configurable template, with a comprehensive learning trace of the tasks done, should help teachers prepare GDBL workshop on 21st century skills for their students and help them better assess their students' progress.

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