Constructionism Meets Design Thinking: Reflection-in-action during digital game design

Reflective practices during Design Thinking projects

Integrating Constructionist Approaches with Design Thinking to foster Reflective Thinking

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In this paper we discuss the reflective practices that Vocational High School students expressed while designing digital games following the Design Thinking Methodology. These games, as outcomes of Design Thinking projects, addressed issues from daily or professional life. The study was implemented within the framework of the European research project Exten(D.T.)2 (https://extendt2.eu/), which focuses on the integration of new technologies in Design Thinking educational activities to develop 21st-century skills. The results of the study showed that Design Thinking methodology significantly encouraged students to pose reflective questions and make intuitive reflective summaries while the feedback activities stimulated their critical thinking and reflection.

Keywords and Phrases: reflection, Design Thinking, digital game design, feedback

INTRODUCTION

One of the main goals of the constructivist approach to education is to produce reflective thinkers (Başol & Gencel, 2013). In a rapidly evolving world, reflection is considered to be a critical asset for students, allowing them to better resolve complex situations, considering multiple solutions to a single problem (Fullana, et. al., 2016). However, reflection is not an inherent trait. Engagement in activities that engage students in reflection is important for them to develop a reflective mindset. The educational intervention presented in this article was implemented as part of a broader research project, which explores the integration of Design Thinking with emerging technologies in order to foster student's 21st century skills. This study explores the types of reflective practices Vocational High school students deploy when they engage in Design Thinking activities to create digital games addressing real-life issues. It focuses on two research questions:

RQ1: What types of reflective practices emerge when students engage in learning activities based on Design Thinking methodology?

RQ2: What is the role of feedback activities in developing reflective thinking?

1 REFLECTION

Reflection has been described as the process by which an individual evaluates an existing situation based on experiences, deriving new and original conclusions, and applying them to improve understanding and problem-solving (Salido & Dasari, 2019). As a central element in constructivist approaches (Başol & Gencel, 2013), reflection fosters inquiry and critical evaluation, allowing the reconstruction of experiences (Toraman et. al, 2020) through "*active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the conclusion to which it tends*" (Dewey, 1933). A significant number of studies highlight the importance of reflection during learning activities, indicating that it supports students to establish connections between new and prior knowledge (Tsingos et al., 2014), foster critical thinking skills (Colley et. al., 2012), enhance self-awareness regarding the learning process, and cultivate a sense of ownership and responsibility for learning (Bond, Evans, & Ellis, 2011).

In the literature, various reflective practices have been explored, including reflective writing like online journaling (e.g., Barney & Mackinlay, 2010), diaries (Bruno & Dell'Aversana, 2017), as well as group-based discussions (e.g. Olson et. al., 2016) and video based reflection (Tripp & Rich, 2012), focusing though mainly on higher education. Even in these contexts many of these practices are often perceived by students as a "challenge" (Jindal-Snape & Holmes, 2009), "tedious" (O'Reilly & Milner, 2015), and "exhausting" (Mortari, 2012). Thus, there is a need for approaches to reflective learning that encourage deeper engagement with the process.

2 REFLECTION-IN ACTION DURING DESIGN THINKING ACTIVITIES

Tripp & Rich (2012) also describe that reflection involves defining problems, creating actionable plans, and implementing them. By these definitions is evident that reflection is closely related to design approaches in learning (Bekker et al, 2015). According to Schön (2017), during design activities individuals reflect-on action, after the work has been completed, and in action, during the process. Reflection-in-action facilitates an ongoing process of observing a situation, analyzing its dynamics, attuning to potential deviations, and subsequently responding with innovative or alternative approaches. In the context of design, Schön describes reflection-in-action as a 'conversation', with the design context, a dynamic interplay between tacit knowledge and action (Schön, 1992). While less studied than reflection-on-action, many of the difficulties associated with reflective thinking relate to reflection-in-action. Students often rush to solutions without fully immersing themselves in the design process, resulting in superficial work and limited understanding of the underlying knowledge (Luo & Baaki, 2019). They may also engage in poorly monitored, linear design processes with minimal reflection, limiting learning opportunities (Crismond & Adams, 2012).

To address these issues, we aimed to provide to the students with opportunities to express their reflective practices in purposeful structured contexts. In our approach, we used the Design Thinking methodology to design learning activities where students create artifacts meaningful to others, focusing on empathy, problem identification, idea generation, prototyping and continuous improvement through user testing and feedback (Carroll, 2015). Design Thinking relates to constructionism since one of its key elements is the design of rapid prototypes that can be shared. This is a core concept in constructionist learning, where children learn by creating meaningful artefacts (Papert, 1980). Taking one step forward DT decenters what is meaningful by emphasizing empathy before developing any initial ideas and focusing on a final solution that is for others (Girvan et. al., 2023). In this context emphasis is given on sharing artefacts “under construction” providing this way a purposeful context for students to reflect-in-action (Schön, 2017) aiming to refine their designs according to others’ feedback. Feedback, as a central element of the methodology, stimulates reflection (Stable, 2017), offering opportunities to observe, compare, and improve the work (Chang et., al., 2012). However, in current Design Thinking models, feedback practices remain tacit (see for example the Double Diamond Design Thinking model by the Design

Council, https://www.designcouncil.org.uk/our-resources/the-double-diamond/), often resulting in feedback being implemented superficially (Crismond & Adams, 2012). In our approach we put emphasis on feedback activities during design, integrating them in a distinct structured phase of a Design Thinking activity called "Sharing and Feedback". In doing so, we aim to enable students to use these processes to stimulate their reflective practices in a purposeful and meaningful for them context.

3 METHODOLOGY

To explore students' reflective thinking during a Design Thinking project, we adopted the Design-Based Research (DBR) (Bakker, 2018). In DBR, the main objective is to gain a deep understanding of the processes that unfold within specific contexts, leading to the development of new theoretical insights and contributions to educational practice (Cobb et al., 2003). Rather than seeking statistical generalization from large samples, DBR focuses on theory-building by identifying propensities and processes. Findings are thus presented as specific instances of broader theories, models, or concepts, supporting a form of generalization aimed at theoretical refinement (Bakker, 2018).We designed and implemented an educational intervention based on Design Thinking methodology, during which students used an online authoring system to create digital games about real-world issues of their choice. The educational intervention took place at a Vocational High School of Athens and lasted a total of 12 teaching hours. The research was approved by the Research Ethics and Deontology Committee (https://www.elke.uoa.gr/content/epitropi-ithikis-kai-deontologias-tou-ELKE-EKPA) of the National and Kapodistrian University of Athens (NKUA), as well as by the Research Committee of the Department of Educational Studies of NKUA. Additionally, before the start of the activities, the researcher collected a consent form signed by a parent or guardian and an assent form signed by each student.

The activities were conducted in the school's computer lab, involving 14 students aged 15-22, comprising 2 girls and 12 boys, who worked in 4 groups of 3-4 members each. The groups were formed based on mixed school performance and student preferences, consisting of 3-4 students per group, each using one computer. One teacher and one researcher played a multifaceted role by intervening when necessary, monitoring progress, facilitating discussions and observing the dynamics and outcomes of each group. For the implementation of the Design Thinking project, the children used two digital tools, NQuire (https://learn.nquire.org.uk/) for creating digital questionnaires and the educational software ChoiCo (Choices with Consequences) (https://extendt2.com/widgets/choico/) for designing their games.

3.1 ChoiCo

ChoiCo (Choices with Consequences) (https://extendt2.com/widgets/choico/) is a free, open-source software that allows users to either play or design digital games where the gameplay flow is determined by the player's choices. The environment consists of the Game Mode, where users can play a ChoiCo game (Figure 1), and the Design Mode (Figures 2 and 3), where users can modify existing games or create new ones from scratch. As players of a ChoiCo game, students make choices that have either positive or negative numeric values on a set of predefined fields. The player's goal is to make as many choices as possible before one of these fields exceeds a predefined minimum or maximum value.

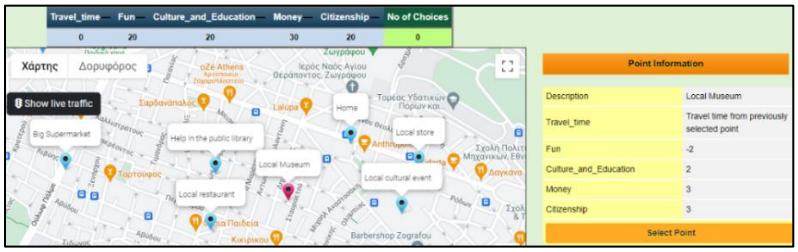

Figure 1: The Play mode in ChoiCo environment.

As designers, students can either modify an existing game or create a new one by adding or removing choices from the game's map or background (Figure 2a), adding or removing fields in the game (Figure 2b), defining the consequences of each choice in a database (Figure 2b), and programming flow and termination rules using a visual block-based programming language (Grizioti & Kynigos, 2021) (Figure 2c).

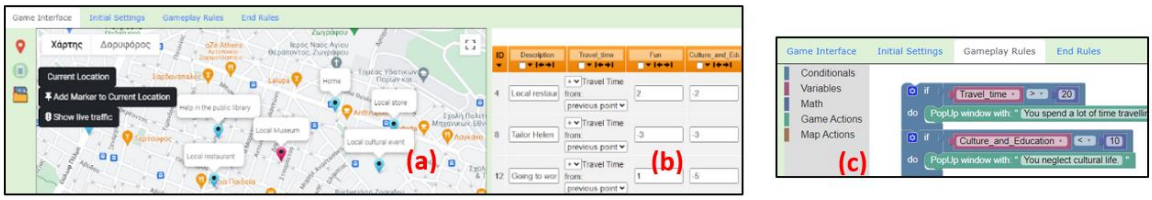

Figure 2: The Design mode in ChoiCo environment

3.2 Flow of activities

We structured the activity based on the Exten(D.T.)^2 Design Thinking model, developed in the context of the Exten(D.T.)^2 project. During Phase 1 "Empathize and Understand", students played a ChoiCo game designed by the teacher to familiarize them with the rationale of ChoiCo games. In Phase 2 "Define and Ideate", groups brainstormed their game concepts and used NQuire to create questionnaires to gather user preferences and needs. After completing and answering the surveys, students analyzed the results to collaboratively outline their game's choices and elements. They used ChoiCo's design function to create initial prototypes, testing feasibility. In Phase 3 "Rapid Prototyping and Iteration", students refined and improved their initial prototypes through iterative design. In Phase 4 " Share and Feedback", groups rotated seats to play each other's games and provided constructive feedback for improvements. Finally, in Phase 5 "Respond and Deliver", groups reviewed feedback, made final adjustments, and created presentations for their games. All groups presented their games and answered questions from the class.

3.3 Data collection & analysis

We collected audio and screen recording data and conducted student and teacher interviews. We analyzed the data following the thematic analysis method (Xu & Zammit, 2020). The process involved transcribing the data, identifying incidents where students expressed reflective thinking, assigning explanatory codes to these incidents (e.g., "reflective questioning"), and grouping the codes into thematic categories (e.g., "reflective practices"). The reflective practices that emerged from the data analysis were reflective questioning and reflective summaries . Regarding the role of feedback in the development of reflection, results showed that its role was essential in stimulating critical thinking and reflection.

4 FINDINGS

4.1 Reflection

Vocational High Schools are significantly overlooked, and the educational programs implemented there often fail to align with the needs of the modern workplace (Güngör, 2020; Shrestha, 2016). As a result, these schools struggle to provide both general knowledge and technical and professional skills to their students (Skywark et al., 2022), resulting in decreased participation of students in the learning process. As the teacher mentioned during the interview his main motivation for implementing a DT project with his classroom was to 'engage these students in their learning and make them see how to work in a structured way. As he explains:

> ''These kids come to school to take the degree, they never think about what they do here, they are never truly engaged they do not care. The process was beneficial because it made them think methodically, step by step. Thus, they could also follow their progress, think on it, process their mistakes and make improvements, going deeper in the issue'.

Indeed, during the project, students expressed reflection practices, including reflective questions or summaries of their work.

4.1.1 Reflective Questioning

Students engaged in reflective thinking during the development of the game, aiming to make it as realistic as possible to engage its players seriously. This process led them to form numerous reflective questions, encouraging them to reason about their decisions. For example, questions like "Is there a car that is actually environmentally friendly?" and "Are you happy when you attend history lessons?" initiated interesting discussions about the issues their games addressed. In the following episode we present a dialogue indicative of students' posing reflective questions during the development of a game that addresses the issue of school absence. Student 1 and 2 (S1, S2) are discussing about the values, consequences of the choice 'Park'.

Excerpt 1

S2: Put the park (he means as a choice in the game)
S1: Do you ever go to that park?
S2: Yes, some go.
S3: Put 5 for joy.
S2: But you get absences and then your mom bothers you, not 5.
S1: What joy do you get?
S3: When you sit there, you're not in class.
S2: And then when you get absences, don't you have a problem?
S1: Ok…3…

As shown in the above dialogue students question and evaluate their ideas and reflect on various consequences the choice can have. They discuss both immediate pleasures and long-term consequences, such as the joy of relaxing in the park versus the problem of school absences. It is important to note that students are more engaged in the discussion probably because the game involves familiar settings and experiences (the park, schoolyard, interactions with peers). Drawing on personal experiences makes their reflections grounded and meaningful. Similarly, they engage in similar discussions when it comes to the values of the school subjects the player of their game can attend.

Excerpt 2

S1: In math, you are supposed to pay attention, not socialize, so 0. You gain a lot of knowledge.

S2: What do you want to put, 5?

S3: Maybe math isn't all about knowledge.

S2: There are other theoretical subjects too.

S1: If you don't know history, you can live. If you don't know math, you can't.

21: Actually, now that I think about it, in history, you gain the most knowledge... if you know what has happened, you can predict what will happen in the future. (everyone cheers)

4.1.2 Reflective summaries

In the context of DT projects, it is easy to get overwhelmed or lose focus. In these terms reflection often serves the need to stay focused on the final goal, tracking at the same time the progress of the work and adjusting it to current demands and constraints. In cases where students got lost or faced a situation where they needed to make decisions, they communicated summaries of their work, like in Excerpt 3.

Excerpt 3

S5: Ok lets' see, if we do the first idea it would be step by step….first step the factory and the player is the customer that wants to make her/his own bike, meaning he/she chooses the motor and other parts, and then he/she will run it to races…the second step is the race. If we do it otherwise the last step of the first option will be the first…meaning the player starts on the road. The motor breaks and then he has to go to the mechanic…. So, step two is the first step in this scenario…

S6: I think the one that most of them would like would be the first…Could we not do both? To do the factory the races and then the mechanic….

S5: It is too much; we do not have so much experience…so the simpler we do it the more possible that we make it in the end

In the above episode summarizing their two options, made it easy for both students to make a selection. It is notable that S6' reflection is driven by others' preferences for what the outline for their game should be. S5 on the other hand bases her opinion on practical issues that have to do with the final purpose and the constraints of the activity: having to prepare a demo for demonstration to others by the end of the available time, being at the same time inexperienced with ChoiCo.

4.2 Feedback and Reflection

4.2.1 Critical thinking

The feedback activity also provided the context where students realized the need to evaluate critically the comments received. Students acknowledged that feedback was beneficial to their work. During the interview, S1 points out:

> 'Basically, we ended up using the negative comments. It's good to know that when something is useful, you follow it, but if it isn't, you leave it behind."

Indeed, during the feedback session students often asked their peers to reason about the feedback they gave them in order to be able to evaluate whether it is useful or not. For example, when another group needed the opinion of the rest of the class regarding which car brands to include in their game about DIY vehicles and many of them answered BMW, student S6 insists that they reason about their suggestion., before she finally rejects it.

Excerpt 4

S6: Guys, a quick question, BMW or AUDI?

Many from the class: BMW!

S6: But why?

S11: You asked and we answer…

S6: But why?

S11: You just asked us to choose one of them…

S6: Yes but you do not help us like this, why you choose BMW…

S10: Because they are beautiful!

S5: Ah ok, this not so important in our game though…

In the next episode the researcher reads the feedback suggesting that the option for the park be removed from the game regarding school absence.

Excerpt 5

Researcher: Here someone says delete the park choice.

S4: Yes, we did not do that…

Researcher : But why? Did you ask?

S2: Yes, we decided to keep it…

Researcher: Why? What does it offer to the game?

S2: Our game is supposed to make people think about school absence. A child who comes to school might go to the park... so it's a reality...

4.2.2 From feedback to reflection and vice versa

During the design thinking project, feedback and reflection were closely related. On one hand feedback provided the context where students could identify weaknesses of their work through external perspectives. Understanding these perspectives, evaluating them critically and finally integrating them in the work required careful reflection on their relevance and value. For example, in the next episode an external user who plays the DIY vehicle game expresses some concerns.

Excerpt 6

S14: I do not understand, is there any right combination of parts I have to do to win?

S7: No…hmmm you are right, the aim is not clear. We want the player to be able to build a car by purchasing parts from wherever they want. For example, they might want a car with a Ducati engine but an Italian design. They build the car from scratch and then test it on the road.

S14: Oh ok…so this is why you have speed…However, if they want to test it on the road, they can't just look at speed; they need to consider driving safety as well. Factors such as tires, suspension, and chassis rigidity play a crucial role.

S5: Ok…create a new field for this…

In the above episode, the group realizes that the player's aim is not clear to the player. The player's live feedback and questions provided the context for reflective discussion during which student S14 describes in detail their rationale. Describing in detail the rationale. At the same time the player reflects on the group's idea resulting in suggestion that led to the addition of the field safety in the game.

The fact that feedback session provided the context for reflective discussions was acknowledged by the teacher as a great advantage of implementing such activities in the classroom. Referring to the project of the group that designed the

game on school absence, the teacher pointed out that 'using feedback activities is a way to encourage reflection'. As he explained:

> 'These students had as a choice the park in the game. Adding the choice in the game may be realistic but some did not find it appropriate. If this prototype was shared with students of the whole school then imagine how interesting discussions would have occurred on which students choose to go there at which hours and why. In addition, when they discussed about the consequences of the choice, they had a positive value in joy but a negative in learning, meaning they though in depth about the situation they tried to simulate.'

On the other hand, acknowledged the value of receiving feedback from an external user and they often asked for it themselves. For example, in the next episode students try to define the consequences of the player attending the subjects - choices in their game. When they realize that they have different views student S2 admits that a survey to gather others' views on the issue may provide a more valid conclusion.

Excerpt 7

S1: Joy, I believe that you benefit because you learn history.

S4: It depends on the teacher.

S1: So, do you enjoy attending history lessons?

S4: Sometimes…energy?

S1: It is tiring, you lose energy…

S4: Not attending the lesson… you get tired when you studying it….

S2: I think this needs a questionnaire….

Trying to define the consequences of each subject choice in the fields of fun, knowledge, money, social life, students do not hesitate to bring in the discussion a different perspective, asking one of the teachers of the school who happens to have come in the classroom.

Excerpt 8

S2: Physics…put 3 in Joy

S1: So, you are happy when we have physics?

S2: No but I am happier that having mathematics which is 2…

S4: I am not happy in neither of these cases…

S1: Let's ask the professor…Mis, mis, do you think we are happy when we have a lesson with you?

Physics teacher: I do not know…you are to say…

S2: Ok let's do it otherwise…Are you happy when we have a lesson?

Physics teacher: Yes I am.

S2: Ok if you are happy I am happy, put 3

Even though the rationale by which the students change the value he proposed from 2 to 3 is not exactly clear, it is interesting that he engaged in the discussion regarding an element of the with someone involved in the situation the game addresses, suggesting that students develop intuitive ways of receiving feedback and empathizing with others when tasked to create something for someone else to use.

5 DISCUSSION AND CONCLUDING REMARKS

Our study explored the types of reflective practices students deploy in the context of Design Thinking activities (RQ1) and explored the role of feedback in developing students' reflective thinking (RQ2). While in other studies reflection is

considered a burden for students (Jindal-Snape & Holmes, 2009; O'Reilly & Milner, 2015; Mortari, 2012), in this study, reflection occurred intuitively in an altruistic constructionism context (Girvan et. al., 2023). Students expressed reflective thinking through posing reflective questions or making reflective summaries of their work (RQ1). In the first case students applied "reflection in-action" (Schön, 2017) since while designing the game they would reflect on design elements, such as the values of the game choices. Reflection in-action mainly emerged during the "Rapid Prototyping" phase and it was facilitated by the authoring digital environment they used to design their games. Traditionally, this phase is challenging and time-consuming to implement in conventional Design Thinking activities. In ChoiCo students could easily and quicky make modifications to their artifacts and switch roles from designers to players in a direct way so they could directly reflect in every change they made while designing. This immediate access to previous versions provided a rich context for in-action reflection, enabling students to make informed design decisions without losing engagement. In the second case students also applied "reflection on-action" (Schön, 2017), since they would summarize their work to evaluate it or explain it to someone else. Reflection on-action mainly emerged during the "Share and feedback" phase where students had to communicate their designs and their design rationale to external users. Overall, the Design Thinking methodology facilitated the emergence of both reflection in-action and reflection on-action during the phases of rapid prototyping and feedback accordingly, providing the students a structured context where they had to express their reflective practices. During the activity, feedback provided a purposeful context for critical thinking, stimulating reflection, while on the other hand reflective thinking at the same time encouraged feedback-seeking (RQ2). Research consistently highlights the importance of feedback in learning processes, showing that effective feedback can significantly enhance student performance and achievement (Butler & Winne, 1995). However, peer feedback has been mainly studied in general educational setting, so further research is needed to explore more in detail feedback ad reflection interdependencies in the context of constructionist approaches.

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