

Deliverable Report



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Deliverable 6.1

Report on Pilot Professional Development activities

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1 Abbreviations

| | |
|------------|--|
| ChoiCo | Choices with Consequences |
| DT | Design Thinking |
| ELE | Electronic Learning Environment |
| ET | Emerging technology |
| Exten(DT)2 | Extended squared |
| IG | Instructional goal |
| M | Month |
| MaLT2 | Machine Lab Turtleworlds 2 |
| NKUA | National and Kapodistrian University of Athens |
| PD | Professional Development |
| SDG | Sustainable Development Goal |
| SorBET | Sorting Based on Educational Technology |
| UGent | Ghent University |
| WP | Work Package |

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3 Summary

Deliverable 6.1 concerns activities performed in Work Package 6: “Professional Development” led by UGent and more specifically in Task 6.1 “Design of Professional Development Activities” during months 3 to 12 of the project (M3-M12) and the piloting implementation of Task 6.2 “Three-cycle implementation of Professional Development activities” during the period M6-M12. For Task 6.1, in both NKUA and UGent, a professional development (PD) module for providing pre- and in-service teachers the necessary tools for developing and organising a Design Thinking (DT) project involving digital tools was designed and developed. Both developed modules consisted of a constructionist methodology for teachers to design DT digital based interventions for secondary education, and supporting material such as templates, instructions for using the technologies and for the design of DT projects and examples of DT projects, showing pre- and in-service teachers what was expected. Differences between the modules in both institutes were related to the specific background of the students and available resources such as instructional facilities and human resources. During the development of the PD modules in M3-M6, evaluation tools for the PD learning materials were created in WP7 and customised to the implementation settings in NKUA and UGent.

The PD modules were piloted in existing courses in UGent and NKUA that were compulsory for some groups of pre-and in-service teachers. During the implementation, students received instructions on DT as an innovative methodology to address wicked problems in schools and learned how to enhance DT teaching projects with the digital tools ChoiCo, MaLT2 and SorBET (NKUA) and ChoiCo (UGent). They used the developed supporting material to co-create, in small student groups, digital learning resources for a specific group of learners, following the DT methodology. During the implementation, the evaluation tools co-created together with WP7, were used to gather data for identifying factors (barriers, opportunities, risks, accessibility issues) influencing the integration of emerging technologies in DT methodology by teachers.

4 Introduction

Deliverable 6.1. is the first of three deliverables of Work Package (WP)6 “Professional development”. This WP concerns the iterative design, development and implementation of (PD) activities for pre- and in-service teachers in order to use the Exten(DT)2 materials, technologies and approaches in their classroom. Most materials and technologies that were used during the PD activities were designed and developed in WP3 and WP4, based on valuable insights extracted from the literature review performed in WP2. Some specific supporting material, such as templates for the DT process used during the implementation, was developed in WP6. Data obtained from WP6 are analysed in WP7 to give feedback and input to WP3 and WP4. Figure 1 shows the interdependence of WP6 and other WPs in the project.

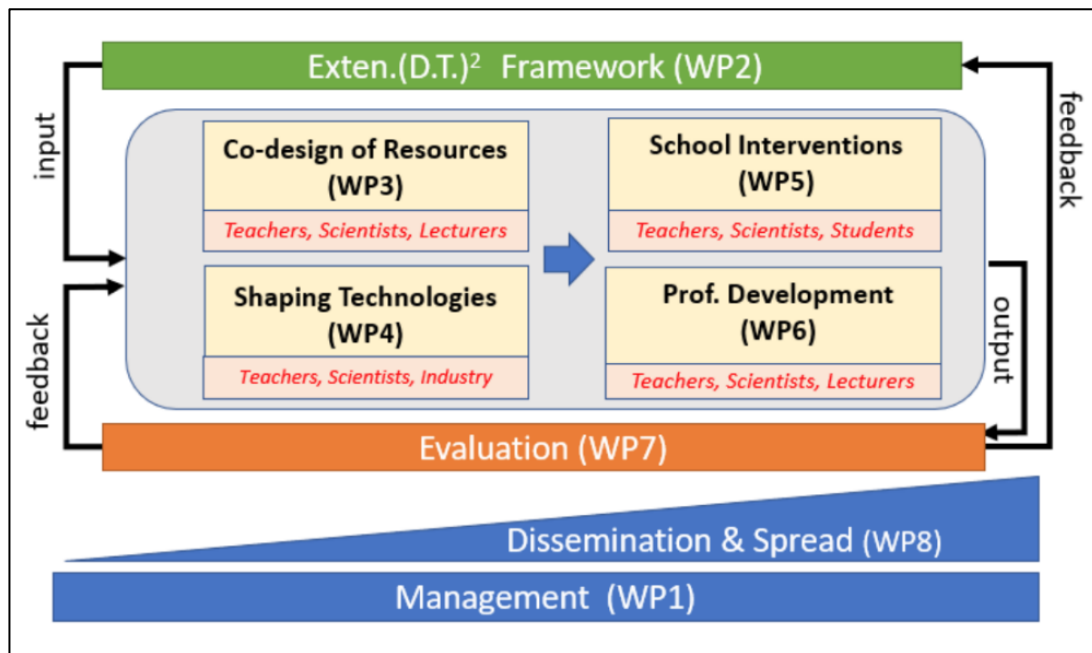


Figure 1: Interdependence between WP6 and other work packages in the Exten(DT)2 project

The present deliverable reports on Task 6.1 and Task 6.2 during the first year of the project. Task 6.1 concerns the design and development of a learning module that provides pre- and in-service teachers the necessary tools for developing and organising a design thinking project involving digital tools. The development of the PD modules within Extend(DT)2 was in Year 1 based on the expertise of project partners UGent and NKUA, who already had experience with the DT methodology and/or the technologies and insights from the literature review (WP2). The PD modules in both institutes were designed and developed taking into account the

specific circumstances and expertise present in each institute and their countries. The design and development will be described separately.

Task 6.2. concerns the three-cycle implementation of the developed PD activities. In Year 1, an exploratory pilot study was performed by implementing the developed PD modules in existing courses in teacher education programmes of UGent and NKUA. The aim was to explore whether the developed PD modules were effective and to explore students' experiences with the modules. The implementation provided data to WP7 (evaluation) identifying factors (barriers, opportunities, risks, accessibility issues) influencing the integration of emerging technologies in DT methodology by teachers. For a discussion of the data gathering and their analysis, we refer to Deliverable 7.1.

5. Design, development and implementation of the PD modules

This section concerns the design, development and implementation of PD modules in UGent and NKUA, used for piloting. As the digital dashboard to monitor the progress of the students (WP4) was still under construction during this period, the modules focused on the DT methodology and the technologies (ChoiCo, SorBET, MaLT2).

The PD activities, created in Extend(DT)2 aim at developing a learning module that allow pre- and in-service teachers to design, develop, coach and evaluate Extend(DT)2 projects, i.e., digitally enhanced projects in which students and pupils use the DT methodology to address wicked problems. For the students, the digital component consists of using one or more of the technologies ChoiCo, SorBET, MaLT2 and nQuire while executing the project. For the teachers, the digital component consists of teaching their students how to use the above-mentioned technologies, but also working with the digital dashboard to monitor the students' progress that is developed in WP4. The PD modules, developed in WP6, hence have to address pedagogical and digital competencies of teachers as well as their mutual integration. The modules therefore must include the following:

- methodology (incl. supporting material) for designing and developing a DT project,
- methodology for coaching and evaluating digitally enhanced DT projects. This methodology will be fully developed in Year 2, based on the results of WP5 (school interventions) during Year 1 (Deliverable 5.2),
- supporting material for learning to use and integrate the technologies ChoiCo, SorBET, MaLT2, nQuire in the DT project. For this, material and tools developed from WP3 will be used, and
- supporting material for learning to use the digital dashboard. At the time of this report, this is not relevant as the dashboard is still under construction in WP4.

5.1 Designing and developing the PD module at UGent

At UGent the ADDIE model was followed for designing and developing the PD module. ADDIE is a methodology for instructional design, involving different phases: an analysis phase, a design phase, a develop phase in which materials are developed, an implementation phase and evaluation phase (Branch, 2009). The different components of the learning process that we took under consideration while using the ADDIE model to construct the PD module, are summarised in Table 1, and can also be represented by the Curricular Spiderweb, shown in Figure 2 (Akker, J. van den 2003).

Table 1. Components of the learning process to take into account when designing learning material (Akker, J. van den 2003).

| | |
|-------------------------|---|
| Rationale | Why are they learning? |
| Aims and objective | Towards which goals are they learning? |
| Content | What are they learning? |
| Learning activities | How are they learning? |
| Materials and resources | With what are they learning? |
| Teacher role | How is the teacher facilitating their learning? |
| Grouping | With whom are they learning? |
| Location | Where are they learning? |
| Timing? | When are they learning? |
| Assessment | How to assess their learning progress? |

The ‘rationale’ component, mentioned in Table 1 and Figure 2, is the major orientation point; the other components are linked to that rationale and should also be consistent with each other. In the case of Extend(DT)2, the rationale of the DT projects is the development of 21st century skills in order to develop citizens that can fully thrive in the modern world. The aims and objectives are, in formal education systems, often decided on macro- or meso-level (e.g., in national curricula, attainment targets, etc.), the other components are situated on micro-level in the classroom, and are hence decided by the teacher. The PD module, developed in WP6, should enable teachers to determine the content of each component when designing an Extend(DT)2 project for their class.

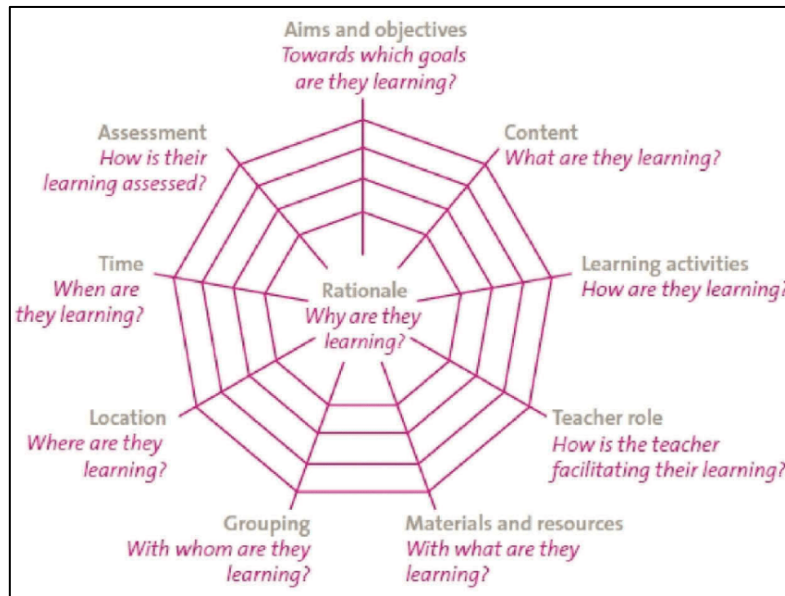


Figure 2: The curricular spiderweb (Van den Akker, 2003)

The ADDIE approach, used at Ghent University, is shown in Figure 3. The different phases in the model were elaborated by the researchers at UGent in order to develop the PD module used in the pilot phase. During the development of the module using the ADDIE model for instructional design, the researchers on a regular basis asked feedback on the structure and content of each component in the model from teachers and assistants within UGent, who are involved in the teacher education programme.

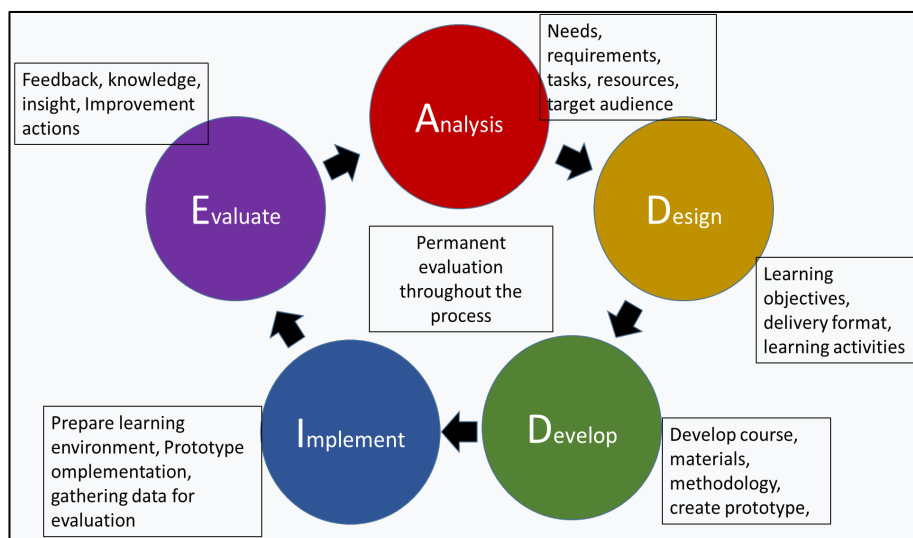


Figure 3: The ADDIE model for instructional design

5.1.1 Context

At UGent, the Extend(DT) professional development module was implemented in the courses 'Vakdidactiek wetenschappen' and 'Vakdidactiek engineering and technology'. These courses are mandatory for pre-and in-service teachers who are enrolled in the *Educational Master in Sciences and Technology* programme. The focus of the courses is on general aspects of STEM-teaching, design and development of interdisciplinary projects and 21st century skills. The course involves 24 lessons of 75 minutes, scheduled as every fourteen days 2 lessons/week on Wednesday evening. The Extend(DT)2 module was implemented in lessons 19-22 at the end of the academic year.

In the courses mentioned, the students are considered as designers of their own lessons, who actively adapt their activities to their specific context. As an Extend(DT)2 project covers different facets (content, design thinking, technologies), the Extend(DT)2 PD module should address all of these. In what follows, we will describe the different steps, followed during design of the PD module.

5.1.2 ADDIE model: Analysis phase

In the analysis phase, we first defined the **general goal**, i.e., the content, skills, attitudes we wanted our students to possess when finishing the PD module.

For the PD activity at UGent, this general goal was:

- *Pre-service teachers are able to develop, in co-creation, a learning activity in which a specific group of students in secondary education develops a ChoiCo game around Sustainable Development Goals (SDG's), using the design thinking methodology*

Because this goal was too general to develop learning activities, we defined so-called **instructional goals (IG)**. These IG state what students have to learn during the PD module, in order to reach the general goal. When defining these IG, we took into account the fact that - as the PD module was piloted at the end of the academic year, the pre-service teachers in the class already had pre-knowledge and skills on developing a project for secondary schools, and had experience with writing lessons preparations. However, they lacked specific knowledge and skills on DT and ChoiCo, these were the so-called **performance gaps**. These gaps had to be filled by the PD module in this work. The instructional goals for our students, goals they will reach following our instruction, and filling the performance gap, were then the following:

- IG1: Pre-service teachers understand the different stages of design thinking
- IG2: Pre-service teachers develop a digital version of the ChoiCo game using the design thinking methodology
- IG3: Pre-service teachers write an activity plan for a Choico game-project for a specific group of students in secondary education
- IG4: Pre-service teachers show 21st century skills such as communication, collaborative critical thinking, creativity and problem solving skills

After the goals were defined, we analysed the **targeted audience**.

The student group of pre-service teachers at UGent has specific characteristics, due to composition, age, number of students and background of students. When developing the PD module, these characteristics had to be taken into account. In Table 2, we show the **learner analysis** of the students, taking the PD module at UGent.

Table 2: Learner analysis for the professional development activity at UGent

| | |
|--------------------------------------|---|
| Students group | The students are a group of 64 pre-service teachers in science, mathematics, engineering and technology. |
| General characteristics | The age range of the students is from 21 to 65. Most of them have a master degree in a STEM discipline and are now following a shortened teacher education program. Some students are however still in a regular bachelor or an educational master program. The background of the students is very diverse: all STEM disciplines are present, some of the students have working experience in their discipline, some are working as an in-service-teacher, and others have no work experience at all. Some students have a family they have to take care of. Some have already taken almost all courses in the teacher education program, others (the bachelor students) have only taken a few. |
| Number of students | Officially there are 64 students enrolled, but in practice there are always 5-10 students absent (either because they are ill, stopped with the program, or other personal reasons). |
| Location of the students | The students are living in different places in Flanders, Belgium; most them live nearby the campus (in the city of Ghent), others live in other cities or villages and have to come by car or public transport. |
| Experience level on computer science | The experience level on computer sciences is very diverse, ranging from experts (graduated master in computer science) to almost |

| | |
|---|---|
| | none (students that graduated already a long time ago, and had work experience in which computers were hardly involved). |
| Experience level on design thinking | All students are involved in developing an interdisciplinary STEM project within a SDG in which the DT methodology was more or less followed, but the different stages were not explicitly elaborated. |
| Experience on developing learning materials | All students have already developed learning materials, they followed courses about developing powerful learning environment. |
| Student attitude | Students have a large workload and are reluctant towards developing another project. Not all of them like working in an interdisciplinary group or are eager to program a digital game. Because the activity takes place in the evening, some of them will be tired after a day's work. |

The next thing we did was analysis of the required and the available **resources**. There are different types of resources that have to be considered.

- *Content resources*: these contain content that is valuable for the project, varying from illustrations and examples over references (internet-links, references to articles, etc.) that can be used as back-up material for already known content or references to new content. In the case of the PD module, the required and available content can be summarised as follows:

| required | available |
|--|--|
| <ul style="list-style-type: none"> ● Content on design thinking ● Video and manual on ChoiCo ● Template for brainstorm session ● Template for developing ChoiCo game ● Content on SDG ● Content on ADDIE process ● Activity plan template | <ul style="list-style-type: none"> ● Video on the internet ● Video (WP3), English manual available (WP3), has to be translated in Dutch ● To be produced ● To be produced ● Internet link ● Link to course handbook https://www.standaardboekhandel.be/p/krachtige-leeromgevingen-9789401461269 All students had taken this course. ● Available (WP3) |

- *Technology resources:* what (digital and not-digital) technology is needed for the project (computer, a 3D printer, flip charts, white boards, sticky notes, pencils, etc.)

| Required technology |
|--|
| <ul style="list-style-type: none"> ● laptops, at least one / group during the sessions ● small white boards, pencils in different colours, sticky notes ● access to the internet at home and in the classroom ● beamer for presenting the produced games to other groups |

- *Instructional facilities:* number of classrooms available, time is available for the project, what communication platform is used for giving/coaching instruction or for delivering (digital) deliverables or prototypes?

| Available facilities for instruction |
|--|
| <ul style="list-style-type: none"> ● e-learning Learning Environment (ELE) is available for all students. This will be used for communication on the PD module: information on the module itself, student’s tasks, links to available content resources. The ELE will be used to upload the students’ deliverables. ● One large room for the on campus activity (140 places, movable chairs and tables) where students can work in groups of 4-7 students. The room is available during the hours of the lectures, but also the hour before, so the room can be organised in advance. ● Two classes of 2 ½ hours in which the students are present. Because the PD module had to be slided in-between the usual course content, the classes were scheduled at the end of the academic year, with Easter holidays in between. This time is very limited and is not long enough to elaborate every instructional goal. Because students are already familiar with writing lesson preparations, the researchers decided to focus on IG’s 1,2 and 4. Students will have to prepare before they come to the lesson, so they have already some basic knowledge on design thinking and ChoiCo. |

- *Human resources:* the number of teachers and trainers that are needed to develop, implement and evaluate the learning activity, during the live/remote instruction stages, but also for developing materials, and giving intermediate feedback.

| Human resources needed |
|---|
| <ul style="list-style-type: none"> ● Lecturer/scientist for giving the instructions ● Lecturer to put the resources (videos, links, templates) on the platform ● Scientist to translate and adapt non-Dutch supporting and evaluation material to the specific UGent context ● Scientist to develop the PD template ● Two coaches for coaching during class sessions of the PD activity ● Two-four teaching assistants for observing during intervention |

After setting the goals and analysing the targeted audience and the available resources, we decided on the way the teachers of the PD module would **communicate and interact** with the students. The choices here were made considering the costs (time), advantages and disadvantages of the possible delivery systems. (e.g., when we planned to use a video, we would have to develop one or look for a good video on the internet). In Table 3, we show the delivery system template used for the PD activity at UGent.

Table 3: Delivery system template for the PD module at UGent

| | |
|---|--|
| <p>Possible delivery options</p> <ul style="list-style-type: none"> ● video ● classroom setting ● online PD session ● blended | <ul style="list-style-type: none"> - DT and on ChoiCo: for DT and ChoiCo, videos are already available (WP3). We decided that our students knew enough English to work with these videos. Because of time limits, we decided that the students had to watch the videos before the start of the lecture. - Designing and developing a ChoiCo game, using DT methodology: this will be done in a classroom setting. As mentioned, the students have a high workload, and not all are enthusiastic to do another task. We expect that encouraging them to work and communicate in groups in a classroom setting, will increase their engagement, as they already know each other. We also expected that an online brainstorm would not work for all students, as not all of them have good digital skills and the chance of their attention being diverted is larger when they are at home. |
|---|--|

| | |
|---|--|
| Estimated time of every delivery option | <ul style="list-style-type: none"> ● Video on DT: 15 min ● Video on ChoiCo: 15 min ● Classroom session 1: 2 ½ hours ● Classroom session 2: 2 ½ hours |
|---|--|

5.1.3 ADDIE model: Design phase:

In the design phase, we set up the pathway for achieving the instructional goals, defined in the analysis phase. We started by rephrasing the learning goals into smaller **learning objectives** that can be reached with specific actions. For every learning objective, we then identified the **learning tasks** (= teaching methods, activities) that were required to reach each objective and see the desired behaviour in the students (= performance objectives). We also defined the order in which the learning tasks had to be presented to the students.

IG 1: Pre-service teachers identify the different stages of DT

| Task | Performance Objective |
|--|--|
| Students receive instructions on DT, with a description of the different phases and what they mean (video) | Students show that they understand and are able to apply the design thinking methodology |

IG2: Pre-service teachers develop a digital version of the ChoiCo game using the DT methodology

| Task | Performance Objective |
|--|--|
| Students receive instructions on ChoiCo, what it is, how it can be used in a learning context, and what content and skills are needed for developing this game (video) | Students identify and acknowledge the possibilities of ChoiCo for learning |
| Students develop a draft paper version of a ChoiCo game, using a template (classroom setting) | Students use the template and fill it in for the different stages of the design thinking process |

| | |
|---|--|
| Students learn the content and skills needed to use the ChoiCo technology (classroom) | Students can modify and/or create the programming aspects of a ChoiCo game |
| Students develop a digital version of their ChoiCo game (classroom) | Students use the paper draft version of their ChoiCo project to create a working digital ChoiCo game |

IG3: Pre-service teachers write an activity plan for a ChoiCo game-project for a specific group of students in secondary education

Because of time restrictions, and because the students already have experience with writing lesson preparations, it was decided that this IG would only be addressed in a superficial way by presenting the activity plan as an example of a lesson preparation for a DT project.

IG4: Pre-service teachers show 21st century skills such as communication, collaborative critical thinking, creativity and problem solving skills

| Task | Performance objective |
|--|---|
| Students develop the game in small groups, in which they have to work together (brainstorm, discussion on SDG, etc.) | Students communicate with respect when they are designing and creating the game |
| Students create a ChoiCo game | Students show creativity, critical thinking and problem solving skills |
| Students present their work to their peers | Students are able to communicate the results of their activity to their peers |

5.1.4 ADDIE model: Develop phase

In this phase, the learning resources (media and instructions) were identified and developed to guide the students through the PD activity. The video instructions on DT and ChoiCo were available and were used as such (DT training video; How to design your ChoiCo game; Playing and modding a ChoiCo game. These resources can be found on the project website <https://extendt2.eu/technologies/>. The tutorial on ChoiCo was translated in Dutch, and delivered in paper form to the students during the classroom sessions. https://drive.google.com/drive/folders/1Sq_f0k_bPcq2eRKcA7FyoLCPUCvG51z6. Templates for the design thinking workshop (see implementation) were developed and uploaded on the

digital platform Miro (<https://miro.com/app/board/uXjVMbw0K78=/>). The templates were also available as a paper version during the classroom setting.

For evaluation of the acquired skills of the students, a range of evaluation tools was developed in WP7. These documents include informed consent, observation protocols, pre-intermediate and post surveys (Qualtrics) and a student interview protocol. These documents had to be translated in Dutch and adapted to the specific situation at UGent. They were supported by tutorials for the instructors that were also developed in WP7. All evaluation tools (original English version and adapted Dutch version) are available on: https://drive.google.com/drive/folders/1SxETx41_a_sAMI7bDyQ8dhmEfMgMvi5D

5.1.5 ADDIE model: Implementation phase

In this phase, the spaces (physical and virtual) where the activities took place were prepared, and the developed pilot project was implemented. This phase will be discussed in Section 5.2. *Pilot implementation of the PD activity at UGent*, together with part the evaluation phase.

5.1.6 ADDIE model: Evaluation

In the evaluation phase, the designed learning resources are evaluated, to see if they reach the goals. As mentioned in Section 5.1, during the development of the module using the ADDIE model for instructional design, the researchers had already asked feedback on the structure and content of each component in the ADDIE model from teachers and assistants within UGent, who are involved in the teacher education programme. The evaluation results of resources, structure and methodology of the PD module will be discussed briefly in Section 5.2, and more extensively in Deliverable 7.1.

5.2 Pilot implementation of the PD activity at UGent

According to the literature on DT education, workshops or bootcamps can be widely seen as a way to teach DT (Royalt et al., 2015). This derives from the fact that a workshop environment gives students an opportunity to learn by doing it, as a constructivist approach (Scheer et al., 2012). With this regard, in order to teach DT to pre- and/or in-service teachers who follow the courses ‘*Vakdidactiek wetenschappen*’ (H002175A) and ‘*Vakdidactiek engineering and technology*’ (H002221A) at UGent, the pilot PD study was conducted as a workshop, and will in what follows be referred to as ‘The Design Thinking Workshop’.

To create a constructivist learning environment for the students, the DT workshop included certain stages of the Double Diamond model such as Discover, Define, Develop, Deliver (The Design Council, 2023) and templates were prepared to guide students through these stages (see Section 5.1.4 ADDIE model: develop phase). The workshop was divided into two sessions;

the first one consisted of the Discover and Define stages, and the second session was about the Develop and Deliver stages.

Following the flipped classroom approach, students were asked to watch some tutorials on ChoiCo and Design Thinking methodology and read the manual on how to design a game with ChoiCo. The links to the tutorials were offered to the students through the ELE of the University, these links were put on the ELE three days before session 1 of the workshop. In this way, the theoretical part was studied by students beforehand and the practical part was held on campus. At the same time, the students were informed on the goals of the workshop and asked for their informed consent to participate in the evaluation.

The day of the first session, the link to the pre-survey questionnaire was put on the ELE, with a request for the students to fill it in. At the start of the first session (which started in the evening), every student present in the room was given a paper version of the informed consent document and asked to read and sign it. Then the students formed groups of 4-7 students. The lecturers did not intervene in this group formation. Due to the wide variety in students' backgrounds, the formed groups were multidisciplinary and all had at least one person with programming skills.

The first session took place in the classroom and the templates were shown to the students in Miro (<https://miro.com/app/board/uXjVMbw0K78=/>) as well as given to each group in print. In Figure 4, a photo is shown of the class setting during this first session.



Figure 4: Overview of the class during the first session of the pilot implementation

The session started with an introduction (Figure 5) where students were informed about the aim of the project and the workshop. Students were told that the workshop was to enable them to follow a DT process and design a ChoiCo game to learn about DT.

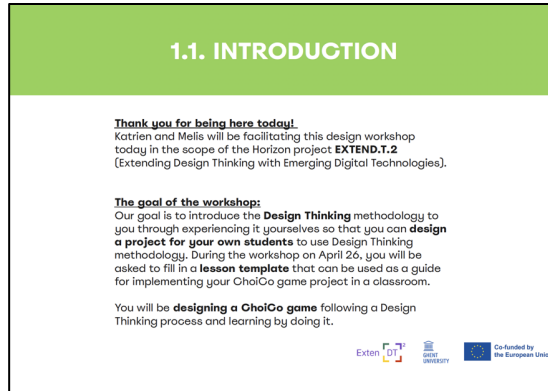


Figure 5: Introduction slide that explains the aim of the study

Then, the workshop agenda (Figure 6) and ground rules (Figure 7) were explained to create a structure.



Figure 6: Workshop agenda

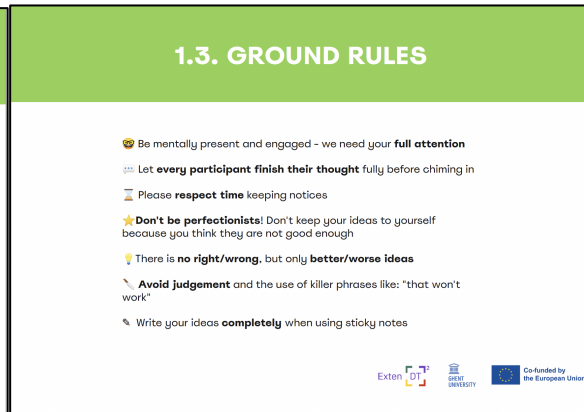


Figure 7: Ground rules of the DT workshop

The first activity that aimed to act as an icebreaker was the warm-up where each group was asked to find a group name and draw a logo for their group. Figure 8 shows some logos, drawn by different groups during this activity.

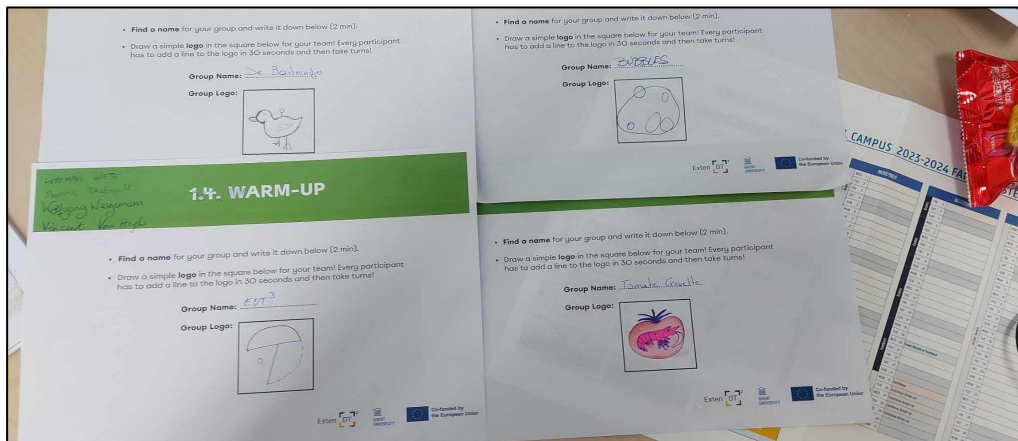


Figure 8: Logos, drawn by students' groups during ice-breaker activity

After that, the Discover stage started with a problem-framing activity (Figure 9). The students were given 17 SDGs and were asked to select one SDG-related problem to focus on in their ChoiCo game design since DT is about wicked problems (Rittel & Webber, 1973) and these goals relate to these sorts of problems. SDGs n° 1, 2, 11, 12, 13 and 15 each were chosen by 1 student group, whereas SDG n° 14 was chosen by three groups.



Figure 9. Problem framing as the first activity of the Discover stage

After selecting the problem(s) they would focus on, the students were asked to fill in an empathy map by considering who will be playing the ChoiCo game they design, in other words, who the user is. In this phase, the students had to interact with each other. Most student groups choose to create a ChoiCo game for secondary grade. One group preferred to create a game for primary school children, because they had children in this age group. In Figure 10, some empathy maps are shown.



Figure 10: Empathy maps, filled in by students during the second activity of the Discover stage

The last stage of the Discover stage was brainstorming where the student groups were given the task to come up with several ChoiCo game ideas. Some student groups used sticky notes for brainstorming, whereas others used a white board. In Figure 11, pictures show some results of this stage.

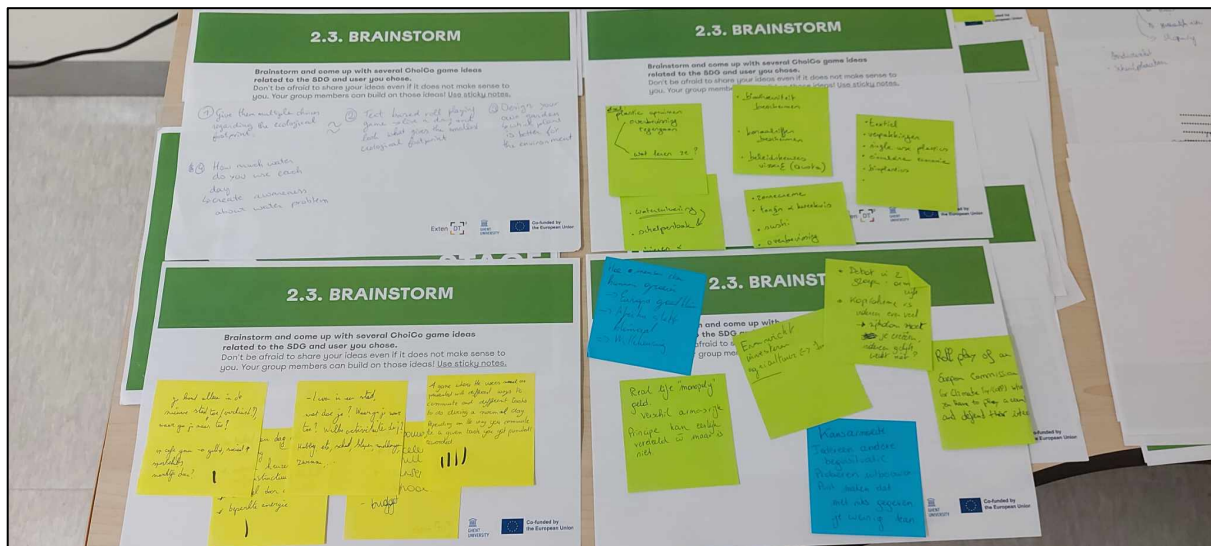
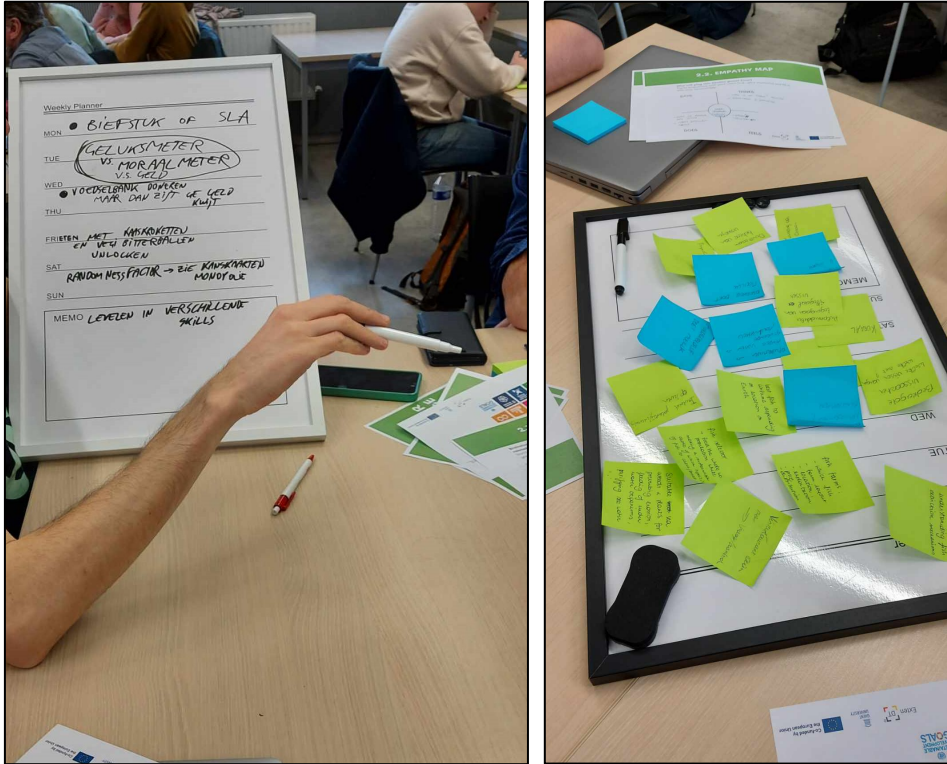


Figure 11: Brainstorming as the third activity of the Discover stage

As a continuation of this activity, in the Define stage (Figure 12), the students were supposed to vote within their groups for the best idea and define the aim of the ChoiCo game they would be designing in the second session of the workshop. It was observed that the students during the brainstorm session very quickly selected 1 idea they wanted to work out, and then stopped brainstorming. This idea was then formulated as the problem definition. Only one group formulated several ideas, before selecting the problem they wanted to work out.

After finishing the problem definition, students were asked to fill in the intermediate survey. After the session, this question was repeated, by means of an announcement on the ELE.

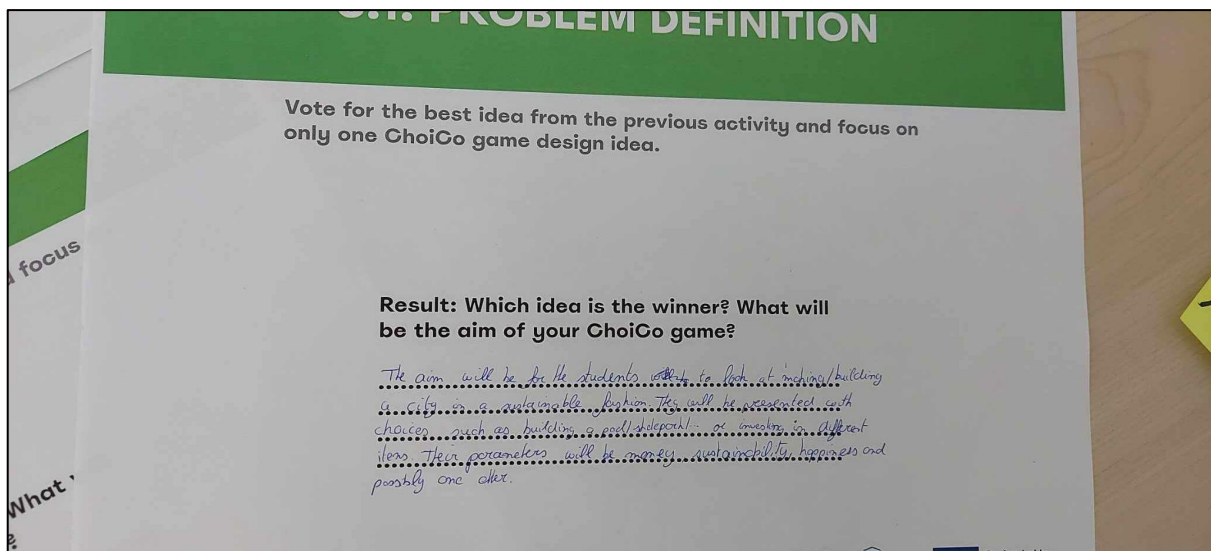


Figure 12. Problem definition activity for the Define stage

The second session of the workshop took place in the same classroom, but this time the session was held in a phygital (physical + digital) way by filling in the templates online on the Miro board. The purpose of the session was that the student groups elaborated their problem in a digital ChoiCo game during the timeframe of the lesson. In order to make sure that students would not be doing other irrelevant work on their computers, they were asked to use only one laptop per group. Another rationale behind this decision was to let group members work together rather than getting lost in their personal laptops.

When the groups were formed again, there were students that were absent during the first session. These students were assigned to one of the already formed groups and had to work in this group during the Develop and Deliver stage, and to elaborate on the problem of that group that was defined in the first session. The “new” students were assigned to the smallest teams. In some teams, group members were absent during the second session of the workshop.

Idea generation was chosen as an activity for the Develop stage and students were asked to fill in the templates on the Miro board. Figure 13 shows an empty template.

4.1. IDEA GENERATION - choices

What are the choices players can make and what are their consequences?
Fill in the chart below according to the game idea you chose last time.

| | field 1 | field 2 | field 3 | field 4 |
|----------|---------|---------|---------|---------|
| choice 1 | + or - | | | |
| choice 2 | | | | |
| choice 3 | | | | |
| choice 4 | | | | |

4.2. IDEA GENERATION - background

Find a background image for your game!
You can check the website freepik.com

PASTE THE IMAGE HERE.

4.3. IDEA GENERATION - instructions

Describe the game instructions below.
This text will appear when players start playing this game.

4.4. IDEA GENERATION - initial settings

Determine the initial settings and put the values in the gray boxes below.
What will be the initial values for your fields? When someone just starts playing the game what will they see here?

| field 1 | field 2 | field 3 | field 4 |
|---------|---------|---------|---------|
| | | | |

Example:

Frame 17: Design mode

- On game start
- Initialize
- Game Actions
- Map Actions
- Set Field **money** to **€3**
- Set Field **conv 4000** to **€3**
- Set Field **€2000** to **€3**
- Set Field **€2000** to **€3**
- Set Field **€2000** to **€3**
- Set Field **€2000** to **€3**

Frame 18: Play mode

Figure 13: Idea generation as part of the Develop stage, template as given to the students

Figure 14 shows a template, filled in by one of the groups during the session. Idea generation was about the choices the users will have in the ChoiCo game, the background of the game, instructions on how to play that ChoiCo game, and initial settings.

4.1. IDEA GENERATION - choices

What are the choices players can make and what are their consequences? Fill in the chart below according to the game idea you chose last time.

| | field 1 morality | field 2 personal gain | field 3 money | field 4 time spent |
|-----------------------|------------------|-----------------------|---------------|--------------------|
| choice 1 eat fastfood | -5 | +10 | -7 | -5 |
| choice 2 go exercise | 0 | +10 | -1 | -7 |
| choice 3 do charity | +10 | 0 | -3 | -7 |
| choice 4 maintain | +2 | +3 | -1 | -50 |
| choice 5 work | -2 | -1 | +10 | -20 |

4.2. IDEA GENERATION - background

Find a background image for your game! You can check the website [freepik.com](https://www.freepik.com)

4.3. IDEA GENERATION - instructions

Describe the game instructions below. This text will appear when players start playing this game.

Welcome to the triangle of life.

Your goal is to maximize the balance between money, personal gain and morality, with a limited time.

While solving world hunger without having "game over" every choice you make has consequences.

4.4. IDEA GENERATION - initial settings

Determine the initial settings and put the values in the gray boxes below. What will be the initial values for your fields? When someone just starts playing the game what will they see here?

| field 1 morality | field 2 personal gain | field 3 money | field 4 time spent |
|------------------|-----------------------|---------------|--------------------|
| 0 | 0 | 10 | 1000 |

Figure 14: Idea generation as part of the Develop stage, filled in template

After filling in these templates on Miro, in the Deliver stage (Figure 15), the students were guided to the ChoiCo platform to create a digital prototype of the game they had in mind. Figure 15 demonstrates the instructions and information given to the students in their game-design process with ChoiCo. Some examples were also provided on the Miro platform to make the game-design process easier for students so that they would not have to go back to the ChoiCo manual or tutorials. The students finished their ChoiCo game and uploaded it on the ELE. In total 8 ChoiCo games were produced.

In Figures 16-18 some screenshots of the developed prototypes are shown. Because of time limitations, there was no time for peer evaluation or to improve the prototypes. At the end of the second workshop session, one representative from each group presented their game ideas to the whole class. After finishing the presentations, the students were asked to fill in the post survey.

5.1. PROTOTYPING (DIGITAL)

Go to the 'design mode' in the ChoiGo platform (<http://ext1.ppp.uoa.gr/choigo/>) and create your game according to the information you provided in the Develop stage.

5.2. PROTOTYPING - background

Click on this icon to change the background image and upload one from your computer.

5.3. PROTOTYPING - choices

1. Click on this icon to create choices and then click somewhere on the background image.
2. The choice you created will appear here. Give it a name.
3. Write the name of the fields you defined earlier.
4. Click on this to add more fields.

5.4. PROTOTYPING - instructions

Click on this icon to write down the instructions for the players about how to play the game, aim of the game, etc.

5.5. PROTOTYPING - initial settings

Click on this icon to write down the instructions for the players about how to play the game, aim of the game, etc.

5.6. PROTOTYPING - gameplay rules

Do you want the players to see some pop-up messages after reaching a certain point? Define that in the 'game rules' tab.

Example:

5.7. PROTOTYPING - end rules

When does your game will end? Define it on the 'end rules' tab.

Example:

Figure 15. Prototyping as part of the Deliver stage- example acting as supporting material for the students



Figure 16: Screenshot from the ChoiCo game “Pollution-Biodiversity”

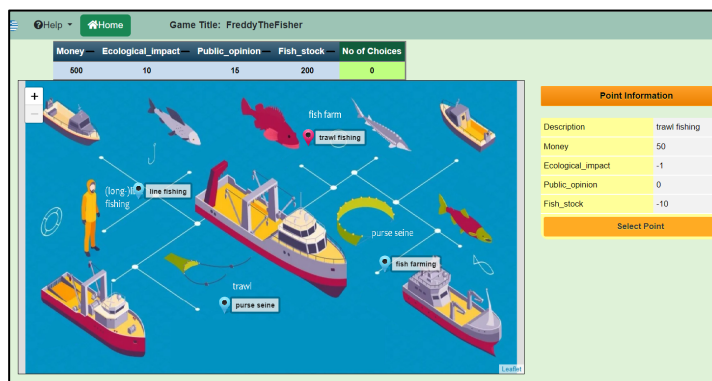


Figure 17: Screenshot from the ChoiCo game “Freddy the fisher”

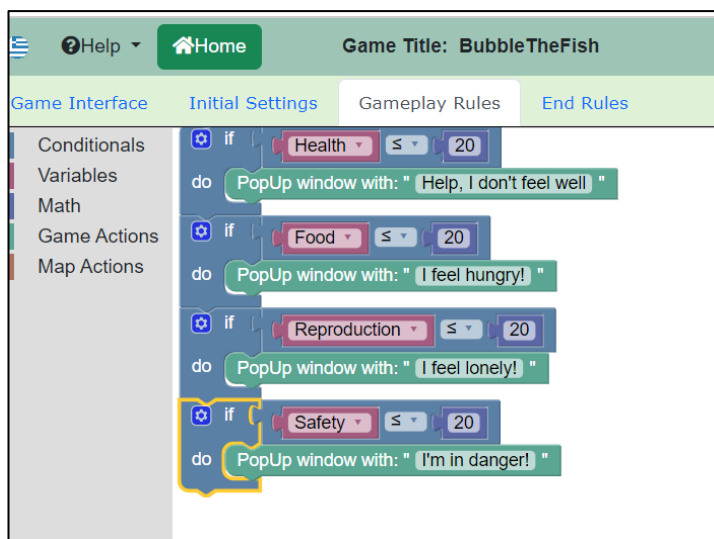


Figure 18: Screenshot from the ChoiCo game “Bubble the fish”

5.3 Evaluation of the pilot PD implementation at UGent

Evaluation of the implementation was done by means of pre-, interim- and post-surveys combined with observations, a reflective diary of the instructors and a focus group interview. The participants in the PD module were pre- and in-service teachers, with teaching experience ranging between zero and a maximum of two years. Their background was either engineering or sciences and most of them were comfortable using technology. There was, however, also a minority of students who felt very uncomfortable with the latter. In what follows, some selected results of the evaluation are briefly discussed. Detailed evaluation forms and can be found as part of Deliverable 7.1.

1. Time and timing of the implementation

In Year 1, the PD activity was implemented at the end of the academic year during two regular lessons of two courses in the teacher training programme. This was necessary because the PD material had to be developed, and because the PD module had to be inserted in courses that were already planned, leaving little flexibility and not enough time for the students to develop good ChoiCo projects, and to insert peer-feedback in the module. The activity plan, developed in WP5 was presented to the teachers as an example of a lesson preparation for a DT project, but the allocated time was not enough for the activity plans to be fully completed by the students. For the next implementation, we will start earlier in the academic year, and provide at least three lessons for the PD module with intermediate peer feedback of students to the prototype of other groups.

2. Methodology

Students value DT as an innovative methodology for addressing wicked problems. They appreciate the clear instructions, the multidisciplinary context, and the hands-on approach. They are however not convinced that DT can easily be applied in a classroom setting, because of the time intensiveness of the approach. There are also doubts about the application of DT in subject courses such as physics or mathematics. A solution might be to use another technology such as SorBET or MaLT2 for these students, or to create examples that are subject specific. Although students were told about the goals of the activity during the first workshop, it appeared that several of them did not know what these goals were. In the next intervention, more time will be reserved to explain to the students why the PD module is inserted in their teacher training.

3. Supporting material

The students in general appreciated the supporting materials that were presented to them. They suggested, however, to shorten the instruction videos and to add Dutch

subtitles. From an organisational point of view, the links to the video tutorials on ChoiCo and DT must be presented to the students earlier. The instructors noticed that some students did not look at these tutorials before the session, because they were too busy with preparing lectures for their internship or had other obligations. Next year this material should be presented to the students at least two weeks before the session. In order to encourage the students to watch this supporting material in advance, we will create interactive videos by applying tools such as Eddpuzzle when developing educational content resources, so the students' interaction can be monitored.

4. Student participation

As known from the analysis phase during design and development of the module, the student population is very diverse, some students have families or are working during their teacher education program. This means that some do not always make it to the lessons. We noticed that some of the students were absent during the first workshop but did show up for the second workshop. We assigned these students to an already existing group. Unfortunately, because they had missed the first stages of the DT process, they did not really participate in the latter stages. Possible solutions that will be considered are recording absences, organising other appropriate times for these students, or working out an online PD activity so that these students can do the workshop at home.

5. Evaluation

The documents for evaluation (pre-survey) were presented to the students on the same day as the first workshop. As a result, some students filled it in during the first stages of the workshop, reducing their participation and attention. Next time, the pre-survey should be delivered earlier. At the end of the first and the second workshop, the students were asked to fill in the intermediate and post surveys. As it was already late, most students left the room, with the promise to do this at home. Next year, we will factor in some time during the workshop itself.

5.4 Designing and developing the PD module at NKUA

5.4.1 Context

The “*Educational Design of Digital Material and Scenarios*” is a compulsory course for 1st Year Masters students of the 2-year MSc interdepartmental Program “Digital Transformation and Educational Practice” in the Department of Educational Studies of National and Kapodistrian University of Athens (NKUA). The course focuses on the main approaches and methodologies for using digital technologies in educational and learning design. The aim is for students to

learn about the main computer-based learning theories, to learn how to design educational resources with digital tools and how to apply the DT methodology in the classroom. The PD implementation was part of the course and lasted five weeks, meaning five lectures, one per week in the period from 21 March 2023 until 4 April 2023.

5.4.2 Analysis

For the PD activity at NKUA, the different phases of the design and development process will not be described in detail. The development of the supporting materials used at NKUA has already been described in Deliverable 3.1. Here we will give an overview of the different components (see Figure 2: Curricular spiderweb).

In the context of the course, the **goals** of the implemented PD module, were at two levels:

1. Students on the course should be able to implement the DT methodology in a small design project that involves the co-creation of a digital product for educational purposes e.g., an educational game or an application.
2. Students on the course should learn how to teach DT to high school and elementary students and how to organise and monitor DT projects in the classroom.

An **analysis of the learners** revealed that the students in the MA course at NKUA are a group of 15 pre- and in-service teachers, with various backgrounds, ranging from a teacher in primary education, to teachers with backgrounds in engineering, languages and classical philosophy. Some students have a background of secondary education. Some have teaching experience, others do not.

The PD module at NKUA comprises five lectures, each lecture addressing one of the stages of the DT process. As students were not familiar with the concept of DT, the lecturers had to provide some theoretical background about design. They also had to provide information on the technologies ChoiCo, SorBET and MaLT2, and develop tools for every stage of the DT process. The **content resources** that were used for guiding the students throughout the PD module were manuals for ChoiCo, MaLT2 and SorBET, video tutorials for playing and modifying games with ChoiCo, a template for Designing a ChoiCo game and an Activity Plan template. **Technology resources** were laptops and an online space for teams to cooperate. **Instructional facilities** were a classroom during the PD sessions, the ELE and access to the internet. The five PD sessions were given in a face-to-face setting.

5.4.3 Design

After the analysis, performance objectives and corresponding **relevant learning activities** were defined and designed. The designed learning activities were assignments students had to fulfil. The PD module followed the DT methodology, and consisted of four phases: Discover,

Define, Develop and Deliver. For the different phases of the PD module, the assignments were:

- *Discover phase:* participants decide on their project theme and explore practices and technologies they can use to **discover** various aspects of the problem and their users' needs.
- *Define phase:* participants explore practices and technologies they can use to **define** the criteria of their DT project.
- *Develop phase:* participants explore practices and technologies they can use to **develop the educational resource (e.g., educational game)** for their students.
- *Deliver phase:* participants explore practices and technologies they can use to **deliver/present** to the public what they co-created.

5.4.4 Develop

The learning resources (media and instructions) that were identified and developed to guide the students through the PD activity were developed (see also Deliverable 3.1). These included technology supporting materials <https://extendt2.eu/technologies/>, an activity plan template (https://extendt2.files.wordpress.com/2023/03/extendt2_deliverable-5.1-report-on-the-activity-plans-for-school-interventions_final.pdf), a presentation on design thinking and an online workspace for student teams to collaborate. Examples of tools and processes that could be used during the different phases of the PD module, e.g., Padlet, Google forms, Miro, etc., were collected. A range of evaluation tools were developed in WP7. These documents include informed consent, observation protocols, pre- intermediate and post surveys (Qualtrics) and a student interview protocol. They were supported by tutorials for the instructors that were also developed in WP7.

5.4.5 Implementation

The lecturers prepared the classroom, and created the online workspace for each student team in which students could collaborate (share files, discuss their projects). This space also had four forum threads, one for each design thinking phase of the PD module i.e., Discover, Define, Develop, Deliver. A detailed description of the implementation phase can be found in Section 4.5. *Implementation of the PD module at NKUA.*

5.4.6 Evaluation

Data for evaluation was collected from interviews, students' discussions in the course forums, students' artefacts, pre- interim- and post-surveys, observations and reflections from

lecturers. The evaluation of resources, structure and methodology of the PD module is discussed in Section 5.6, and a detailed description will be reported in Deliverable 7.1.

5.5 Pilot implementation of the PD module at NKUA

The PD module was part of the “*Educational Design of Digital Material and Scenarios*”, a compulsory course for 1st Year Masters students of the 2-Year MSc inter-departmental Program “Digital Transformation and Educational Practice”. In this context, the MA students became involved with DT at two levels:

1. By implementing the DT methodology in a small design project that involves the co-creation of a digital product for educational purposes e.g., an educational game or an application.
2. By learning how to teach DT to high school and elementary students and how to organise and monitor DT projects in the classroom.

The co-creation of an educational product was part of the course and lasted five weeks, i.e., five lectures, one per week. Before the start of the project, necessary information about the purpose of the project was communicated to the students, and informed consent was obtained. At the start of the first workshop, the course lecturers divided the students into groups according to two criteria:

1. Multidisciplinarity: It is recommended that students in each group come from different scientific backgrounds, so the first criterion was for each team to have students with diverse expertise (e.g., a computer scientist)
2. Gender: Mixed gendered teams, where possible

Based on this, students worked in four groups and grouping was decided according to the criteria of multidisciplinary and gender as above. After group formation, the participants were asked to complete a pre-course survey, forming data for the evaluation (WP7).

Since all students were pre- or in-service teachers, each team had to identify a challenge or an issue in their school to work on. The only limitations given by the course lecturers were:

1. The case should be relevant to the production of a digital artefact for educational purposes, and
2. The teams should use the ChoiCo platform/SorBET/MaLT2 for the development of the final product.

As supporting material, the students were given an example that showed them how their project had to be described:

DT Project Title: Ecological Footprint

Brief Description of the DT project: This case concerns the design and development of an educational game or gamified application with which kids will explore and learn about their ecological footprint.

Case Problem: According to studies the ecological footprint is affected severely by the choices we make in our diet. Many people including young children are unaware of what the ecological footprint is, due to the lack of information.

Case Impact: The game aims to inform people about their ecological footprint through a fun and interactive activity. In the game, the player has to make daily choices relevant to their diet and see how they affect their ecological footprint, Money, comfort and other parameters. The game ecological impact of the available products was based on real data, studies and formulas concerning the product packaging, the production methods, the country of origin etc. Therefore, apart from realizing their ecological footprint, the players will also have the opportunity to learn how this footprint is calculated and affected.

Figure 19: Example of the description of an educational product, to be developed during the PD session at NKUA

After filling in the pre-course survey students received a PowerPoint introduction on the DT methodology and on the existing technologies. Various examples of tools and processes that could be used during the **Discover phase** to explore various aspects of a problem and users’ needs (e.g., how to create and share questionnaires, create with google forms, etc.) were shared with the students. Then they were given the assignment to decide on their project theme and explore the practices and technologies (MalT2, ChoiCo, SorBET) they could use. In this phase pre-service and in-service teachers exchanged ideas about digital tools and resources that could be used for their DT project. As teachers with different backgrounds and expertise were working together, this broadened the number of perspectives and possibilities used to discover different aspects of the selected problem. At the end of the workshop, students were asked to fill in a short reflective survey about their experience of this first session.

During the second workshop, an analogous lesson structure was followed: now the students were given the processes and the tools for the **Define phase** and had to explore practices and technologies they could use to **define content, structure, target audience and resources** for their project. During this phase, students decided on the wicked issue their game/artefact would refer to, the target audience, the technology they would use and the main idea and concepts that their artefact would embed. They also made some preliminary decisions on the role of the player (e.g., the player takes on the role of a citizen in a city), the aim of the player (to balance health and fun), and the main elements of their games (fields and choices if it was a ChoiCo game; and categories and examples of objects if it was a SorBET game). At the end of the workshop, students again filled in the reflective survey.

In the third workshop, processes and tools for the **Develop phase** were presented to the students. These explored practices and technologies they could use to **develop the**

educational resource (e.g., educational game) for their students in their DT project. In this phase, participants were involved in developing and exchanging rapid prototypes (digital games) using the project’s technologies. Table 4 summarises, for each group, the subject of the DT project, the final educational product, the number of prototypes that were exchanged during the Develop phase, and the final digital constructions that were created during the complete process.

Table 4: Overview of DT issue, number of prototypes and final digital constructions for the PD implementation at NKUA

| Group | DT issue | Final product | Number of prototypes | Final digital constructions |
|---------|---|---------------|----------------------|--------------------------------|
| Group 1 | Gender stereotypes | SorBET game | 2 | 1 SorBET game 1 pitch Video |
| Group 2 | Student motivation in museum visits | SorBET game | 4 | 1 SorBET game 1 pitch Video |
| Group 3 | Problems disabled students face at school | ChoiCo game | 4 | 1 ChoiCo game 1 pitch Video |
| Group 4 | Cultural diversity and racism in schools | SorBET game | 4 | 1 SorBET game 1 pitch Video |

A reflective survey was taken to ask for their experiences.

In the fourth workshop, the students used the tools and processes they were presented for the **Deliver** phase. During this session, they explored the practices and technologies they could use to **deliver/present** to the public what they co-created during the sessions. All groups developed a pitch video, explaining their project.

During the fifth and last workshop students used their pitch videos to present the final products of their DT project to their fellow students.

5.6 Evaluation on the pilot PD implementation at NKUA

Evaluation of the PD implementation occurred by means of interviews, students' discussions in the course forums, students' artefacts, pre- interim- and post-surveys, observations and reflections of lecturers. The participants in the study were pre- and in-service teachers, with various backgrounds, ranging from a teacher in primary education, to those with a background in engineering, languages and classical philosophy. Some students have a background of secondary education. Some participants have teaching experience, others do not. From the data, it appeared that feedback was related to four themes: time, teachers' involvement, DT methodology and the use of technology. Some important issues that were mentioned are described below.

1. Students referred to time as a factor that significantly affected their experience. During the sessions, students did not manage to complete what they had initially designed in a satisfactory way, leading to feelings of disappointment and frustration. They also had questions about the feasibility of implementing digitally enhanced DT projects in educational settings at a school, as it takes time to learn about the tools and technologies (e.g., how to create a video). Possible solutions are simplifying the method by using fewer phases, or just part of the methodology to save time.
2. Participants were positive about the multidisciplinary of the groups, the grouping criteria provided rich opportunities for discussion and exchange of different views.
3. Non-STEM teachers had difficulties not only to find a strong relationship between the methodology and their practice but also between the digital tools and non-STEM subjects. it can be noted that not only the various types of material, but also the examples of DT projects designed by NKUA, had a focus on STEM-related domains such as programming, engineering and mathematics. This resulted in preservice teachers linking the methodology to these domains. Developing non-STEM examples in the PD module would help to solve this issue.,
4. Integration of the real-world context along with the integration of the empathy concept - where students deal with real problems and try to find solutions according to needs of others - were discussed as elements that give added educational value to the DT methodology. The real-world context influenced motivation. The fact that DT includes a distinct phase on empathising allows students to explore the DT issue both theoretically and practically, leading to a better understanding of the problem. Additionally, MA students found the methodology suitable to help students learn through productive failure, something contradictory , by the way students are used to working in the context of formal education. Thus, according to their feedback, this would be a challenge for them.

5. Participants did not find the technologies ChoiCo and SorBET challenging and thought that the tools would not be difficult for children in schools to use in relation to other difficulties such as those described above. They emphasised that the constructionist nature of the digital tools was the most important factor that makes a DT project possible to implement as they can support the rapid prototyping phase. The technologies made it possible for students to easily implement and practise the “going back and begin again” process; typical for DT and considered to be the most challenging part.

6. Conclusions and challenges for future work

Two PD modules for the design and development of technology enhanced DT projects were designed, developed and piloted in higher education courses in teacher education programmes in Belgium and Greece. Preliminary results of the evaluation showed that, in general, students acknowledge the DT methodology as an innovative approach to address real-life wicked problems and for acquiring 21st century skills. They appreciate the environment that promotes divergent thinking and the added value of working in multidisciplinary teams, which leads to more enriched discussions and broader insights when empathising with the problem. The evaluation data, however, also revealed some challenges that have to be addressed before the next implementation.

One important issue is time. The present modules do not allow participants to fully run through the DT process when creating an educational artefact such as a ChoiCo or SorBET game, because of time limitations. They feel disappointed and frustrated because they could not fully develop their original design. Possible solutions are reserving more time for the PD module, or simplifying the method by using fewer phases, or just part of the methodology to save time. Also using a blended approach, in which content on design thinking or the technologies is offered by short interactive videos may be an option.

Another important aspect is the perception by participants of the relevance and applicability of digitally enhanced DT projects in the classroom. They perceive these projects as very time-consuming activities, because next to the DT activity itself, pupils also have to learn how to apply the digital tools and technologies. Limiting the number of tools that are used during one project could help to solve this. Students also doubt the usability or possibilities of DT and the digital tools within specific subjects such as languages, physics or mathematics. A possibility is that researchers develop examples of DT projects within these subjects in which the projects’ technologies are implemented and present them to the students.

It was observed that brainstorming can be challenging for people who have not acquired the DT mindset. Usually, the main obstacle is that participants do not want to make a mistake,

say something wrong or be judged during group work. Methods have to be found to convince participants of the value of learning through productive failure, something which is contradicted, though, by the linear way students are used to working in the context of formal education.

The technologies are by most students not perceived as challenging, and are, because of their constructionist nature, ideal for rapid prototyping. However, students do appreciate the supporting manuals and videos, developed in WP3. In Year 2, as the technologies will be extended with extra features, the supporting materials will also have to be updated.

Although DT is about creating a situation in which there are no limitations on the thinking and creativity of the participants, the DT structured PD modules must be well organised, with well and clearly defined goals of the module as a whole, and of the different phases. Instructional, supporting and evaluation materials must be provided in good time, so students have time to explore and address them in-between their other activities. For situations in which students are not able to attend every phase of the PD module (online) solutions must be found to help these students catch up with any information they missed.

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