Dig-Equality FF - A playful approach for researching and fostering gender education in secondary schools

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***Abstract*—Despite continuous efforts to promote ICT related career paths, statistics still show a clear underrepresentation of women in both ICT professions and education. The Dig-Equality FF project develops a set of educational materials for young adolescents to address this issues early on. The following paper presents a part of this tool box: a gamified survey and reflection tool aiming to identify and tackle potential obstacles on the way to a gender balance in the field of ICT. This playful educational tool gathers data to analyse prevalent gender stereotypes regarding job sectors among young adolescents but also to spark discussion and reflect on related aspects. Thus, we aim to alleviate potential misconceptions and point out new perspectives.**

***Index Terms*—Educational Tool Design, Game-Based Learning, Playful Research, Women in Engineering**

I. Introduction

Women are still underrepresented in ICT worldwide [1]. One of the reasons for a low presence of women in technical professions are the lower enrolment numbers in corresponding technical studies and, subsequently, low numbers of related degrees. In 2017, the proportion of women in technical subjects at Austrian universities was only 26.7%. Colleges for technical-commercial disciplines were attended by 74% boys and around one quarter girls in the 2017/18 school year [2]. Possible reasons in the current discourse are "Influences from the family, insufficient professional information, missing female role models, the difficult situation for women in male-dominated professional fields, as well as the role of school, teaching and teaching staff" [3].

Attracting female students for ICT needs more than simple promotion of ICT fields. The reasons for many failed initiatives may also rest in the fact that young women do not see themselves in technical professions. Students frequently refer to ICT as a "male domain" and therefore consciously or unconsciously exclude themselves from ever taking part in it. The goal of the *Dig-Equality FF* project is to research, address and discuss gender-stereotypes and young individuals' viewpoints at an early age of 10–14 years in secondary schools. Through prompting the learners to reflect on gender stereotypes in ICT we further aim to spark the learners interest for this field which might have previously been repressed due to inherent gender stereotypes. As a means to support this goal, we develop a set of open educational materials based on an extensive, mixed-methods approach. The project aims to provide data on current views by e.g. qualitative analysis of student's drawings of stereotypical computer scientists but also points out future perspectives by providing a set of video interviews with male and female role models talking about their career path in ICT and answering students' previously gathered questions. The following paper presents another educational tool developed in the course of the project: PlanetXplorer, a gamified approach to integrate both an analysis of present viewpoints and means to point out future directions through reflection and group discussion.

II. PlanetXplorer

PlanetXplorer extends Dig-Equality's toolbox by providing a playful approach to elaborate and evaluate students' views on gender related issues in the field of ICT. Students command a space mission that explores a foreign planet and need to make several choices to help build a settlement. Embedded in this gamified educational tool are two separate goals: for one, during the early stage of the project, the tool aims to gather data on pre-existing stereotypes based on an integrated quantitative survey that records above mentioned choices. For another, PlanetXplorer will eventually be provided as an open source tool to help students' and teachers to reflect on and discuss gender-related topics in the field of ICT careers.

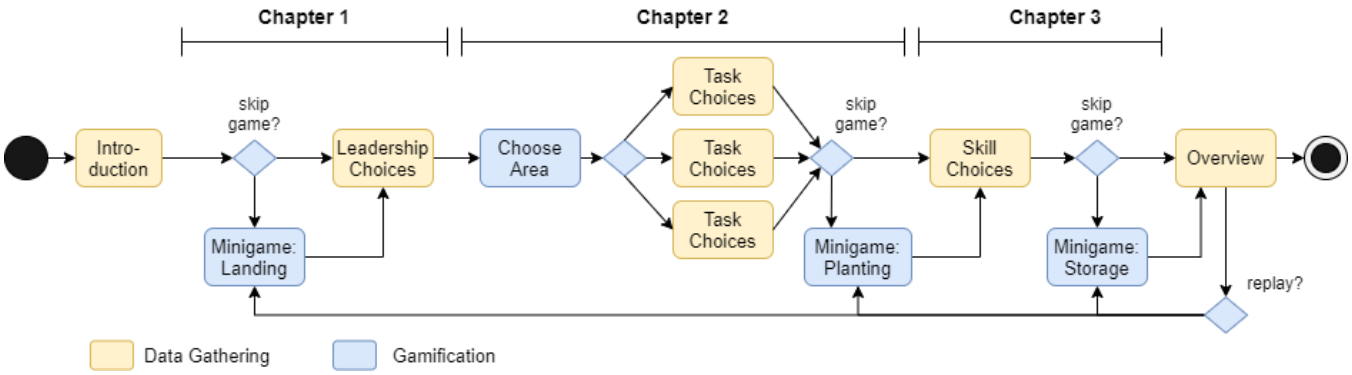

Fig. 1. A flow diagram depicting the game progress and different points of data gathering

PlanetXplorer is separated into five different stages, as shown in Fig. 1. The introduction features an in-game assistant, dubbed 'Robi', a small robot who welcomes the players as the mission's commanders and gathers demographic data by means of a multi-modal chat interface allowing for text- and image-based input. Robi is a playful way to gather data and represents a familiar interaction pattern in our age group, where over 90% report to use text-based messengers such as WhatsApp on a regular basis [4], [5]. There are three story-related chapters: 1.) The Landing, 2.) Exploration and 3.) A New Home. During the first chapter, players have to appoint the leaders for the following sections: "expedition leader", "building and construction", "medical aid and health care", "education and childcare", "farming and food" and "computer science and electronics" then, in chapter 2, they have to assign tasks, where each description fits one of the above mentioned fields. Tasks include e.g. caring for an injured team member or planning and building a shelter for the expedition team. In the third chapter, players have to train non-player characters (NPCs) different skills (analytical thinking, soical skills, leadership skills and physical fitness) by assigning each a limited amount of skill points. The final section displays a summary of all choices and allows to replay mini-games. Additional measures to improve the game-like feel of the tool were short animated clips in each chapter and optional mini-games including a scoring system. For example, in chapter 1, players may steer the spaceship during the landing or activate the autopilot to skip the game. Secondly, chapter 2 includes an additional choice on what parts of the planet to explore further (a desert, a mountainous, wintery landscape or an area around a large lake). The subsequent assignment of tasks reflects this choice by slightly adapted descriptions, e.g. repairing tech that broke due to either overheating or water damage.

As mentioned above, after conclusion of the design and research phase that will be conducted in collaboration with Viennese high schools, the tool will be provided as a free educational resource. This public version of the tool will no longer gather data to avoid privacy issues and lower potential technical obstacles for common use. Instead, it aims to provide the means to discuss student's decisions and identify potential gender stereotypes and views on careers in technical fields. This reflection is based on an analysis of students' and their peers choices and accompanied by a guide including recommendations on how to use the tool based on the results of the preceding research phase.

III. Methodology

The following chapter outlines both the research and design methodology of the PlanetXplorer tool. However, this separation mainly serves to lay out the different perspectives in our approach - in practice, these processes are closely intertwined and draw from each other throughout the process.

A. Research Design

The playful implementation of the PlanetXplorer serves several purposes:

- improving the quality of the resulting data
- addressing motivational issues when filling out surveys
- addressing response bias

Especially when working with children or adolescents, filling out surveys is often considered a tedious task which might reflect on the quality of the resulting data. Previous work reports that gamification in surveys successfully reduced tendencies towards middle responses and participants reported the surveys to be less cumbersome [6]. Thus, by providing a game-based environment, we aim to boost involvement and lower the hurdle to actively engage in qualitative data gathering. Additionally, the playful approach aims to reduce response bias, e.g. in the form of participants adjusting their answer to please or even challenge their teachers, by shifting attention from the underlying topic to the game's story.

Quantitative data, generated through in-game decisions made by players, will be complemented by prompts for open text comments on players' rationale for their choice. Following the completion of the game, group discussions will be recorded and further analyzed systematically [7]. This mixed-methods approach will help to analyse adolescents' views, knowledge and potential misconceptions regarding future career paths and thus, help to identify and tackle potential hurdles for women in the field of ICT. Based on the principles of design-based research [8], PlanetXplorer is refined in an iterative process,

TABLE I
USER STORIES TO GATHER REQUIREMENTS FOR FURTHER DESIGN DECISIONS

User Story and Role	Implementation
As a researcher, I want...	
...to gather data on participants' reasoning by connecting choices to qualitative comments	Robi asks for optional input after each decision
...to know how long participants take to make a specific decision	Each choice is supplemented with a timestamp in the database
...that gathered data is outputted in appropriate format and normalized can be easily used for further analysis	Input validation, demographic input is restricted to numbers (birth year) and buttons (gender)
As a teacher, I want...	
...that it's possible finish a run and discuss it during one lesson	Adapting design and repeated test runs to ensure a duration under 20 minutes
...the tool to allow for several students to play at once and to record the number of players	The introductory dialogue asks for team size and gathers separate demographic data for each player
...the tool to include simple, age-appropriate wording	Several test runs including usability evaluations using SUS, think alouds and group discussions
...an interaction style that ensures low-threshold and works for children that are not used to working on a PC	
...that students can easily access and review their choices	Overview of all choices on the final page including a PDF download
...that the tool can be used without any dependencies and easily installed or run	Providing a technical manual and packaging the tool so it can run locally with no network connection

scrutinized by teachers and students alike, as laid out in the following section.

B. Educational Tool Design

As previously described, the tool consists of 3 chapters, preceded by an introductory segment and followed by an overview page. Each chapter asks players to assign team members, or non-player characters (NPCs), represented by a set of images, following a different approach, namely: assignment to lead six different professional areas (chapter 1), assignments based on task descriptions associated with these areas (chapter 2) and finally, to train the skills of NPCs in four different areas. This structure mimics core elements as found in job profile databases as e.g. provided by the Public Employment Service Austria [9] and the Austrian Chamber of Labor [10].

1) Prototyping: A first prototype was built using an online survey tool[1] and adjusting the overall look and feel by integrating a story line, graphics and tailoring navigation elements to the gamified approach, e.g. the progress indicator read 'mission progress' and the 'continue'-Button read 'explore further'. Both this first prototype and later iterations include images provided by FACES [11], a scientific database providing a broad set of images which are categorized by gender (m, w), age (young, middle-aged, older) and facial expression (anger, disgust, fear, happiness, neutrality, sadness). Each run of our tool features randomly chosen images from a set filtered by following criteria: provide an equal balance between male and female persons of young age and with a happy facial expression.

This initial prototype served as a basis to gather preliminary feedback from 17 students, aged 14-15, attending a high school in Vienna. During these two test runs, we invited students to think aloud, point out potential usability issues and discuss their choices. This preliminary test underlined the tool's potential to outline views on expectations of certain professional fields as students often provided unprompted reasoning for their choices, such as that male NPCs are a good match for "building and construction" due to their physical strength and visual thinking and that women are overrepresented in primary and secondary education. However, in answer to male participants argumentation that boys' preference for computer gaming and similar topics qualified them better for careers in IT, a female student immediately pointed out that this notion was based on societal preconceptions and girls were disadvantaged by common views that they had trouble with maths and technology.

Overall, the prototype was mostly well received by students and provided first feedback towards the suitability of our chosen approach to discuss and reflect on gender topics in various professional careers. Additionally, these sessions pointed out necessary adaptions to the used set of pictures due to some NPCs being repeatedly described as 'older' or 'less attractive' in students' reasoning. Students' initiating discussions on societal expectations and gender issues implied that this prototype might not yet sufficiently draw attention from the underlying topic as intended to reduce response bias.

2) User Stories and Storyboarding: Building on these findings and individual test runs, stakeholders, which include researchers, teachers and teacher education students, brainstormed on possible improvements in the form of user stories. As shown in an excerpt of the collected user stories, depicted in Table I, some were easily adaptable as functional requirements while others where considered on a more abstract design level such as using familiar interaction patterns (chat-based) or testing and adjusting game length. These user stories also served as a basis for a storyboard that integrated the survey tool-based prototype's design and functionality and redesigned it according to stakeholder feedback and user stories.

3) Implementation: Subsequently, a standalone, browser-based prototype was implemented using Angular 10 and Java. Building on the findings from our above described test runs, we decided to increase the level of gamification to include elements such as the chat-based companion, improved graph-

[1]http://www.soscisurvey.de

Fig. 2. Task assignments (chapter 2) in the initial, survey-tool based prototype

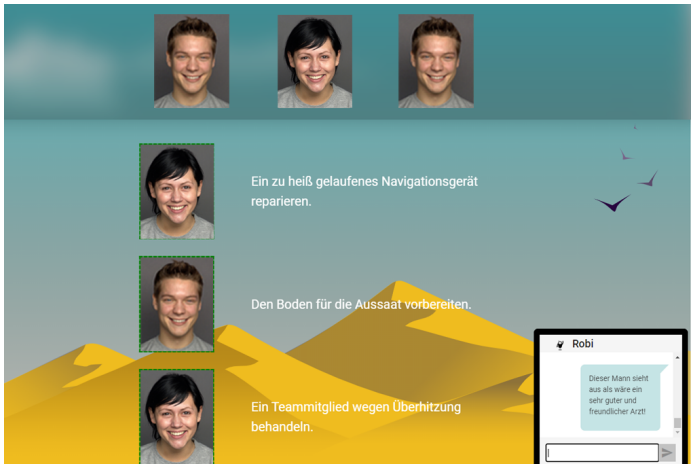

Fig. 3. Task assignments (chapter 2) in the current, standalone prototype

ics and interaction, animated clips and mini-games. Some exemplary adaptations made during the different stages of the tool are also displayed in Fig. 2[2], that depicts the task assignment as implemented in the first prototype (based on a survey tool), while Fig. 3 depicts the same step, but in the standalone prototype featuring a more interactive approach: drag and drop replaced the radio button matrix and Robi, our players' companion, provides a playful way to ask for comments, replacing the open text field displayed on the left.

IV. Discussion and Conclusion

The outcome of our work is the conceptualisation and implementation of educational materials for researching and reflecting on gender stereotypes in the field of ICT. This is aided by our playful survey and reflection environment, which plays the central role in our future research and educational activities in schools. Based on our preliminary tests, employing a playful approach with a gamified research and reflection tool offers a promising chance for both learners and researchers. Instead of letting learners fill out possibly tiresome questionnaires and perform hardly graspable reflection tasks, students now play a scenario, in which they assign tasks and jobs in order to explore and colonize a foreign planet. Additionally, gathered data in the form of students' feedback and user stories provides helpful pointers for educational tool design. In line with previous findings [12], teachers consider rather practical aspects and point out the need for e.g. appropriate session length and low-thresholds for students.

However, extensive evaluation, application and discussions with young learners are still to be conducted. These sessions in the practical educational field will provide chances for students to learn something about how they perceive the field of technology related careers and how they perceive themselves in this context and will generate valuable research data. PlanetXplorer, which is designed for ease of use in school, intends to be our proof of concept in our endeavour for overcoming gender barriers in ICT.

[2]Due to restrictions in the use of the FACES database, this publication may not depict all used images. The set of different faces integrated in the tool was thus replaced by two specific faces according to the licence agreement

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