H. Söbke, J. Baalsrud Hauge, M. Wolf, & F. Wehking (eds.):
Proceedings of DELbA 2020
Workshop on Designing and Facilitating Educational Location-based Applications
co-located with the
Fifteenth European Conference on Technology Enhanced Learning (EC-TEL 2020)
Heidelberg, Germany, Online, September 15, 2020

Designing and Implementing a Gamified Educational Location-based Application for Raising Awareness on Sustainability Issues Among Students

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Abstract. Sustainability aspects become more and more relevant and an integrated part of formal education. A challenge remains how to connect the rather theoretical definition of the 17 different goals for sustainable development defined by the UN in such a way that the students see a direct implication into their lives and reflect upon their own decisions. Using location-based apps that provide the users with context relevant information may support to establish this connection between theoretical goals and practical influence on daily decisions. This article presents the piloting testing of an educational scenario and discusses how the same app can be transferred to a different environment, by simply changing the location-based content.

Keywords: educational location-based applications (ELA), experimental education on sustainability, sustainable transport.

1 Introduction

In the last decades, organizations have put effort into aligning their core values or business principles with key sustainability goals. Such actions have resulted into a high demand for a workforce that has a sustainability mindset, requiring a major shift in educational goals and practices.

The United Nations have defined 17 global sustainable development goals (SDGs) with 169 targets and 330 indicators. However, these definitions and targets represent only the first step in consolidating sustainable approaches. The key sustainability principles build upon the capacity to innovate, to reduce waste, and to function efficiently

regardless of the domain of activity [1-5]. The competence to transfer these high level, abstract goals into practical guidelines for daily behavior and decision-making criteria is essential for the future [6, 7]. Consequently, sustainability considerations are nowadays a part of both formal and non-formal education and learning initiatives using technology-driven experiential learning models [8-11].

Fig. 1. Global goals for sustainable development (Source UN [12]).

In order to be able to transform the United Nation (UN) SDG into practice (Fig. 1), according to [13], it is necessary for students to understand the following influencing factors:

- Understand the concept of sustainability, of government and social policies and legislations,
- Ensure students/ employees have the potential to implement sustainability in terms of cost, quality and culture,
- Develop financial capabilities, since social/green production methods are expensive at adoption,
- Build appropriate organizational cultures and consolidate avoidance of resistance to change,
- Find key sustainable suppliers who support the principle of environmentally and socially friendly systems.

Feedback from the students participating in lectures on the topic given by the authors indicates that the lack of practical considerations leads to increased theoretical knowledge, but not to real changes in a student's decision-making capabilities. As an effort to continuously improve the teaching methods, this paper presents the initial results for implementing an Educational Location-based Application (ELA) within a course in an effort to improve the students' ability to transfer theoretical sustainable

development knowledge into behavioral changes. The goal was to support the understanding of the concept of sustainability, while enabling students to apply sustainability principles. In the future, it is also intended to look at how the same app can be reused with different conetexts.

Chapter 2 describes the qualification needs in the existing course. Chapter 3 presents the ELA before we discuss the key findings in chapter 4. Chapter 5 outlines next steps and possible future works.

2 Qualification needs

The target groups were engineering students at master level 2. Year. This application is a part of a course on decision-making and comprises those parts of the curricula that deal with urban production and sustainability. The whole course is constructed using different games and apps. The work load of this part should correspond to 1/3 ECTS, i.e. 10h. work for each student, 1 for prep, 3 for playing and 6 for analyzing and reporting. Looking at the 17 different categories shown in **Fig. 1**, it can be argued that the matter is complex and that the decision-making process, both at an individual level and on organizational level, will influence several categories.

As seen in the introduction, the SDG comprises 17 different goals that cover a wide range of aspects, and all these goals should be addressed during the course of education. The relevant Intended Learning Outcomes (ILOs) we are considering for this part of the course (due to the underlying curriculum) are:

- Know how to design urban areas implementing and using the characteristics of green logistics and building concepts;
- Identify and observe the right factors required for calculating a set of indicators (Noise, SO_x, NO_x, CO_2, Fuel consumption, Waste etc.) related to sustainability in urban areas based on the on-site observation;
- Know and be able to apply calculation methods for carbon foot print.

Due to the complexity, it is hardly possible to come up with a single “right and optimal” solution, so key ideas behind our considerations are based on giving the student a problem that they can solve and enabling the groups to look at different perspectives and then to discuss how the individual behavioral change can contribute to improving the above-mentioned aspects and the corresponding UN SDGs.

The next section describes the learning scenario.

3 Design of the Educational Location-based Application

The aim of the study is to investigate if the students find it easier to understand and transform the abstract SDGs if they use a location-based and context-aware app instead of the normal case study. It is the first part of the study so the results are still under evaluation and more test-runs will be made at due course.

The app was constructed as an explorative, treasure hunting geo-located game, using the Authoring Tool for Context-aware Challenges (AT-CC) [14, 15], which was developed in the BEACONING project and which is employed for developing Gamified

Lesson Paths (GLP) that is used as pedagogical foundation of the ELA. Creating this gamified learning experience required one hour for learning content development and four hours for setting up and test the game.

The students are required to play the game using their own devices as part of their course assignment and they should complete the game within three hours. The second part of the assignment comprises the analysis of the observed indicators related to the SDG given in the task for a specific Points of Interest (POI). I.e. the learning that takes place within the game play is related to observation and to decide which information to collect at each POI for being able to answer the questions, while the learning that takes place in the second part of the assignment is related to analyzing the collected data and creating new knowledge.

Fig. 2. The student groups are ready to play

The new constructed GLP and the corresponding ELA consist of six different POIs located in the city center of Bremen. The POIs are selected so that different problems related to urban mobility and logistics can be better explored, connecting to a set of SDGs and with the limitation that the student only have limited time for exploring and finding the different POIs. For each POI, the students have to solve some quests on site and reflect on others for developing their solutions in their lab protocols and in the final presentation. The questions at the different locations are designed to different SDGs - for some POIs the students will decide which SDGs are targeted by the questions and for other POIs, the students are given the relevant SDG and they need to develop solutions on how these can be improved at the POI. All results need to be documented and analyzed in the lab protocol. Below, we have an overview of the different POI and the tasks that pop up when the students arrive the different POIs.

Gamified lessons path POI and tasks

The information given to the students was context-aware and the POIs were not known beforehand. The next stop was given as a quiz or a clue. The GLP has the following structure and content:

1. Kunsthalle Bremen- The collection offers an exceptional survey of European art and international modern art, spanning painting, sculpture, drawings, prints and media art from the Renaissance to the present day.

Task on site: localize parking possibilities, trams stations, accessibility issue.
Task at home: develop a new parking and accessibility concept, developing criteria for assessing different mobility scenarios. Reflect upon how this can improve SDG. 11

2. Schnoor- the oldest part of Bremen. In this location you will find some production sites. Schnoor Bräu was founded in 1999 and produces dark beer for the local market.
   Task on site: Risk analysis of having a production site in a pedestrian area.
   Task at home: Come up with the delivery concept for the deliveries using bikes/foot or tram/bus as transport means. You find a list of who they deliver to at http://www.schnoorbraeu.de/verkaufsstellen_overview.htm.
3. You are right above the Baumwollbörse. Here they used to trade Cotton, but is not more in operation.
   On site: Explore the building- what does this tell you about the relevance of trade for Bremen?
   Task to prepare: Please investigate the influence they have had from an economic, political, societal and environmental perspective, each of you take one perspective and choose the period 1914-1939 or from 1956 till 1971. Relate the analysis to different SDGs and explain why you selected these.
4. You have now reached the Alexander von Humboldt. As you know, Bremen has its wealth from a lot of the waterborne transport. How is this today? How can it be improved? Which SDGs are influenced and how does a higher utilization of water borne transport affect the SDGs.
5. On the other side of the river you see where they brew Beck's beer. Carry out risk analysis related to possible environmental impact on the river in case of an accident.
   Rathaus/Stadtmusikanten: Final you have arrived the end. Check your route and come up with solution that minimizes the distance, the time and the time used outside pedestrian area. Please analyze the contribution of the transport infrastructure to SDG 3,6,8,11,12.

The students used with their own devices, and they played in a group of at least two people. Among the reported problems we highlight high battery consumption, imprecise location of their own position, deviation of displayed position within the group, etc. Imprecise location and interference have caused trouble since students needed to be within 1-2m from a POI to be able to read the quest and to find the next POI. The students therefore shared those working properly.

4 Results

For the evaluation of the app, we assessed the students reports and presentations, used their feedback, as well as the observations carried out by the supervisor during the play. In addition, we used a questionnaire for collecting information related to the game as such. This reflects the feedback of 10 student groups that played the game. Each group was formed by at least two students. The qualitative results are based on analysis of the students presentation and the relevant parts of their lab reports, while the quantitative

results more related to the ELA itself shows the results of a questionnaire the students are asked to complete directly after playing.

Qualitative results based on the students' reports and presentations related to the ELA: The delivered reports showed that the students had developed good concepts both on alternative solutions for parking spaces, delivery routes as well as on investigating the role of the waterborne transport. The students also reported that analyzing the situation on site in a familiar environment (the city where they are studying) helped them reflect on how their own behavior (taking the bike instead of the car, or paying more attention to the need of the goods transport-i.e. respecting loading zones and parking lots). However, at the moment it is questionable if their findings documented in a report really do lead to behavioral changes. The students also reported a very high number of hours that they had used for post-analysis for coming up with good concepts, which may indicate that they found this part of the course engaging, but on the other hand, it is a negative result since the workload does not correspond to the credits. It is necessary to investigate if the high workload is due too complex and extensive tasks (given at each POI) or if it is because the students do not have the expected pre-knowledge. By this we mean that the main idea is to apply previously acquired skills and knowledge on sustainability (according to the bachelor curriculum) and thereby construct new knowledge. We did not test their actually pre-knowledge. Furthermore, even though the students reported a too high workload, most students found the experience so good that they would recommend to reuse the same. We have no long-term results on how this exercise influence the behavior of the students. Since this is only a three hour exercise with some more hours on analysis and construction of findings, it is unlikely that this single exercise will induce a change in personal decisions on a long term, but it might lead to higher awareness of the impact of their own decisions on their environment.

Quantitate results based on questionnaire. Directly after playing the ELA, the students got a questionnaire on their first impressions. The questionnaire was distributed through the app, and it was voluntary to answer. The results are anonymous. Since quite a few students did have problems with the battery of their personal devices, we do not know if the reason for having less answers than players are caused by the fact that they could not use their device or because they did not like the learning experience for various reasons. Since we re-used an app developed in a research project, we also used the same questionnaire for the app as we did during the project (for different GLPs), so that we can follow how the perception of the app change over time.

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Table 1. Results of questionnaire

Question	**Strongly disagree - 1**	**2**	**3**	**4**	**Strongly agree - 5**
The BEACONING APP increased my knowledge on Sustainability and Urban living.			4	8	7
The BEACONING helped me to understand how my decision-making process impacts on different SDGs.				10	9
Playing BEACONING was motivating.				9	10
The in game narrative and the ILOs were well aligned to the course objectives.	1			12	6

Results indicate that a game-based approach has the potential to provide engaging and motivating means to construct a mindset that focuses on sustainability. The blending of virtual and physical spaces leads to a more responsible behavior, and contribute to the students' ability to make better decisions. However, if we look at question 2, the result is very positive, but unexpected. Because this is the immediate answer collected directly after playing the game, we had expected that the students first would get an increased understanding after carrying out the corresponding analysis (which is in the lab reports, delivered later) and not based on immediate observation where the learning should take place while analyzing the tasks.

5 Conclusion and future work

The initial pilot study and the subjective reports of the students indicate that the usage of such an ELA will improve the students' abilities to transform theoretical knowledge into practical strategies and perhaps induce behavioral changes. In the next step, we also want to investigate if the positive feedback is solely related to the target group (students at master level) or if it also holds for other user groups. Consequently, we have recently developed a new scenario for the city of Targoviste (Romania) using the same ELA. The target group is high school students. The intended learning outcome is set according to the curriculum in civic culture and history with a focus on sustainability

aspects related to those subjects. In this new scenario, since we have a different target group, we uses the following narrative plot: The students will play the role of a detective and the game mission is to discover who stole an important research paper. They have to find the intruder and the documents stolen by visiting different locations in the city of Targoviste in Romania. This ELA will be used for testing the knowledge on heritage architecture, but also to draw attention to the importance that must be given to such buildings in terms of different sustainability considerations. An example of such considerations is the question of energy savings related to constructing new buildings, improve old buildings and historical values (i.e. changing windows in an old castle saves energy in daily operations, but what about the material usage, the impact on the building climate, or the visual effect this have?). These questions are actually related to the same SDGs, but requires different knowledge. The approach explores the need for learning contexts customization to address specific sustainability challenges and learning goals.

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