Turning Zoos into Smart Learning Ecosystems

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Abstract. Zoos as comprehensive systems for sustainable use of the cultural and nature heritage and for environmental education have the foundation of a smart entity and the great potential to be turned into smart learning ecosystems. What the zoos require is the leveraging of technological solutions to make them smart. The paper presents an attempt to design and develop a web-based application for the zoos in the Central Baltic region to support zoo visitors' engagement in learning and to provide smart learning experiences through creating and playing games in the zoos with personal mobile devices. To understand the nature and level of "smartness" of the application, a study with students was carried out. In particular, the study aimed at exploring the students' behavioral patterns with their mobile devices while interacting with the application. The results of the study demonstrated that aiming to transform the zoos into smart learning ecosystems through the technological solution requires re-conceptualization of "smart" and identification of the most adequate factors that determine the smartness of a zoo to avoid techno-deterministic learning experiences.

Keywords: smart learning environments, smart learning, game-based learning, mobile learning

1 Introduction

Zoos are important public institutions that preserve natural heritage and protect endangered species in the region. At the same time one of the missions of the zoos is to support growth of environmental awareness through informal and formal education. Visiting the zoo is rarely consciously planned and structured. A visitor is left alone to wander through the zoo, to determine his/her own learning goals (if any), paths and means, and to learn through random direct observation. Despite of the freedom this form of visits brings along, the visitors are treated as passive learners, who acquire information through looking at the zoo habitants and information boards displayed next to them. Purposeful and organized way of using technological solutions for learning in the zoos is not common, except, sometimes QR codes have been designed to provide some additional static information about the zoo habitants. The visitors may use their mobile devices for searching additional information or recalling facts the visitor has once learned, thus, technology is used randomly in a rather traditional and limited way. However nowadays, personal smart devices could be used for active and creative knowledge building and construction instead. At the same time modern educational theories stress the importance of engaging learners in creative and collaborative knowledge building in authentic settings (Scott, 2015). Majority of the zoo visitors bring along their smart devices. These devices can be turned into excellent collaborative and creative learning tools by using specially designed smart services and applications. With the support of technology, the zoos have a potential to be turned into smart learning ecosystems.

In the following sections we are going to provide a glimpse of the potential underlying learning approaches for organizing smart learning experiences in the zoos. Based on the literature about smart learning environments we define smartness in such learning ecosystems. We further present our challenges to turn the zoos into smart learning ecosystems through the design and development of a web- and location-based application, discuss piloting results and provide further development opportunities within the context of a SmartZoos project. The article concludes that there is a need to re-conceptualize the concept of “smart learning ecosystem” in the context of zoos.

2 Approaches for Supporting “Smart” Learning

Nowadays affordable mobile technology can help learners to cultivate a broader range of skills and competencies required to navigate increasingly technology-saturated societies. Time and location are not restrictions anymore for designing and carrying out learning activities providing seamless and ubiquitous learning experiences. Technology enables to create continuous smart learning experiences across contexts, encompassing physical and digital world together with a series of different devices (Sharples, 2014) and users can exploit the always-on phenomenon to find out information in their spare time. This learning “on the fly” demonstrates how frequently content and context might alter, from formal settings to informal and back. Learning experiences are changing, thus, calling for new approaches and emergent designs in order to help learners to improve their habits and processes of knowledge acquisition. Personal devices foster learning experiences to be designed more learner-centered, personal and social in complex distributed settings, which are in nature dynamic and continuously transforming.

Gros (2016) has pointed out that in *smart pedagogies* competencies for producing knowledge play a central role. Paavola, Engeström & Hakkarainen (2012) call knowledge creation and building as a “trialogical learning” metaphor. It stresses the importance of developing an idea further either by expanding, curating or improving. The metaphor emphasizes learners’ ability to develop cultural or conceptual (digital) objects with the support of (digital) instruments of various kinds.

Along the lines of Paavola and Hakkarainen, similar concepts have emerged, for instance, learning through the authoring of user-generated content (Klopfer &

Sheldon, 2010; Fitzgerald, 2012, etc.), learning through making (Hsu, Baldwin, Ching, 2017), learner as a creator and designer (Väljataga et al., 2015; Lim, 2008; Sorensen & Levinsen, 2014; Slussareff & Bohácková, 2016). No matter how the concept is called, they all focus on learners as active participants in knowledge building and producing activities emphasizing learning through curation, creation or authoring digital or physical artifacts. While learners as creators and producers are certainly not an entirely new concept, digitization has transformed existing practices and is stimulating the emergence of new types of creation and production as learning activities. In this way, it allows learners to express themselves in a widening range of (re-)presentational modes (Väljataga et al., 2015) "on the fly" making learning more personalized and engaging learners in constantly changing contexts.

Yet another essential aspect in knowledge building process is intertwining a gamification approach (Kapp, 2012) with a learning experience, which has recently started to gain in popularity in educational settings (Hamari, Koivisto, & Sarsa, 2014). Adding gamification into a learning process brings in fun and excitement allowing for instance the zoo visitors to experience an interesting and inspiring knowledge building activity and increase visitors' involvement. Involvement refers to a person's concern and curiosity about the topic under focus or sharing activities of a group (Sillaots, 2016), thus improving visitors' learning process.

What exactly is considered as *smart learning*, its characteristics and how to operationalize and measure it is yet to be defined (Zhu et al., 2016). According to Nam and Pardo (2011), in general terms "smart" captures innovative and transformative changes. A fundamental shift in education is unavoidable referring to changes, where learners take control and become active in pulling knowledge instead of accepting top-down knowledge pushing. Personalised and social learning in open, dynamic and emergent environments indicate fundamental changes in education. Zhu et al (2016) conclude that smart education should focus on improving learners' quality of lifelong learning. Personal smart devices have been incorporated in individuals' everyday life activities so thoroughly that technological solutions play a central role for making learning experiences better and smarter. However, using technology in a smart way does not mean only just searching for information or accessing digital resources "on the fly" (in any place and at any time), but extending the use of modern technologies, i.e. using it for creative work, collaboration and multimedia productivity.

3 Potential Characteristics of Smart Learning Ecosystems

According to Gros (2016) "smart learning does not only refer to the idea of improving learning" (p. 2), but values learning in authentic, seamless real world settings in a personalized, adaptable way, where human and other resources are mobilized in a most efficient way. In the light of a big data and learning analytics' research trend, collecting records of individual's behavioral patterns, learning paths and data about ubiquitous, continuously changing socio-cultural learning contexts can be an important characteristic of a smart learning ecosystem (Harrison et al., 2010). This data should be also fed back to the users to make better decisions regarding their learning paths, content and context.

In an attempt to describe smart knowledge building communities, in any learning situation, Montes de Oca et al., (2014) emphasize three essential elements. First element of a smart environment is participants, not only individuals, but also groups and interactions between them. Technology has a power to enable and accelerate relationships between facilitators and learners, between learners themselves and between learners and others. Second element is collaboration among participants, which could be facilitated by technological solutions. These aspects are also brought out by Spector (2014), who considers conversation as one of the important pedagogical strategies of a smart learning environment i.e. it should engage learner(s) in a dialogue and collaboration on a problem under focus. Third element stresses the importance of technology being designed both as an enabling and monitoring tool.

In addition to Gros (2016), many authors have made an attempt to describe the key characteristics of smart learning and smart learning environments (for instance, Zhu, et al., 2016; Kim et al., 2014; Middleton, 2015; Montes de Oca et al., 2014; McKenna, 2016, etc). The main overarching aspects in these attempts, however, seem to be related to characteristics that provide learner-centered approaches with guidance and hints across disciplines and contexts, immersion possibilities in multidirectional interactive and authentic learning experiences and socially engaging activities at the right time and in the right form**.** The challenge here is to design and create coherent ecosystems, which integrate technology and pedagogy at the same time providing users constant feedback about their activities while operating between contexts (Kinshuk et al. 2016).

Be that as it may, in summary, smart learning revitalizes learning in families and communities and nurtures a culture of learning and knowledge building throughout life. It is characterized by fluidity of environments (work, study and everyday life), which are effective, efficient and engaging (Spector, 2014) and provides learners personalized real world based interactive, social and collaborative experiences (McKenna, 2016).

4 Turning Zoos into Smart Learning Ecosystems

Zoos as comprehensive systems for sustainable use of the cultural and nature heritage have the foundation of a smart entity and the great potential to be transformed into smart learning ecosystems. Smart technological solutions can play a role of a coach; provide some structure and guidance together with fun and excitement for purposefully wandering in the zoo. In case of formal education, learning activities can be extended from classrooms to zoos and even from one zoo to another one, engaging visitors into learning experiences and collaborative discourse forming smart knowledge building communities.

The previously described approaches and characteristics of smart learning ecosystems were also guiding the design and development of our own potential solution – a SmartZoos service package – to turn the zoos of the Central Baltic region into smart learning ecosystems. The SmartZoos service package has been developed within the context of a SmartZoos project, which aims to integrate the zoos (Skansen, Helsinki Zoo, Tallinn Zoo) of the Central Baltic region into a joint tourist attraction through developing and implementing a cross-border service package for creative adventure learning with mobile devices. The service package includes:

- a web-based application for playing location-based interactive adventure games (activities) relevant for Zoo settings (triggered by GPS-based proximity);
- an online repository of interactive adventure games;
- a web-based application for composing and conducting location-based GPS adventure games (activities) consisting of activity items (tasks and questions in chosen location points) with the purpose to engage visitors in active and exciting knowledge creation, designing and sharing knowledge objects during and after they visit the zoo.

Fostering a smart learning ecosystem of a zoo involves using technology in three ways: 1) to give learner the control over his/her learning activities, to encourage involvement and to support the creation and use of conceptual artifacts (games) 2) to analyze and scaffold individual or collaborative activities and 3) to collect data about learning paths and activities in order to monitor, orchestrate and provide feedback. The innovativeness and smartness of the SmartZoos service package lies in the following:

- The visitors of the zoos (learners, teachers, families, random visitors) are not treated as passive learners anymore; they can participate in active knowledge creation through completing or creating different activity items (tasks and questions in location points). Currently 7 different types of tasks can be created: providing a location point with some information; one correct answer; multiple correct answers; freeform answer; match pairs; embedded content; photo. The activity item also has some metadata: title, description, photo if needed; additional information if provided and the chosen location point on the map (see Figure 1).

These activity items can be then compiled into outdoor learning games (activities). They can be used for setting up the challenges to other visitors (e.g. one school designs a game for the "sister" school to play, a group of friends design a game for another group of friends, neighbor's family, etc.). All the created activity items will be kept in the repository (as long as the author of it decides to remove it), thus making them searchable and reusable by other visitors, emphasizing open educational resources. One can search for existing activity items by the location, keywords, language, and content and use them to form his activity. Activity items in the repository can be incorporated into various activities at the same time (Pishtari et al., 2017).

The activities are described by: (a) the title; (b) a description of the activity that will appear as a popup before starting it; (c) playing time; (d) the zoo, currently between three partner zoos; (e) activity items that will be incorporated in it; and (f) proximity, the longest distance from which an activity item can be activated (Figure 2). Thus, the service package takes a role of an enabler and supporter of individual and collaborative knowledge building activities.

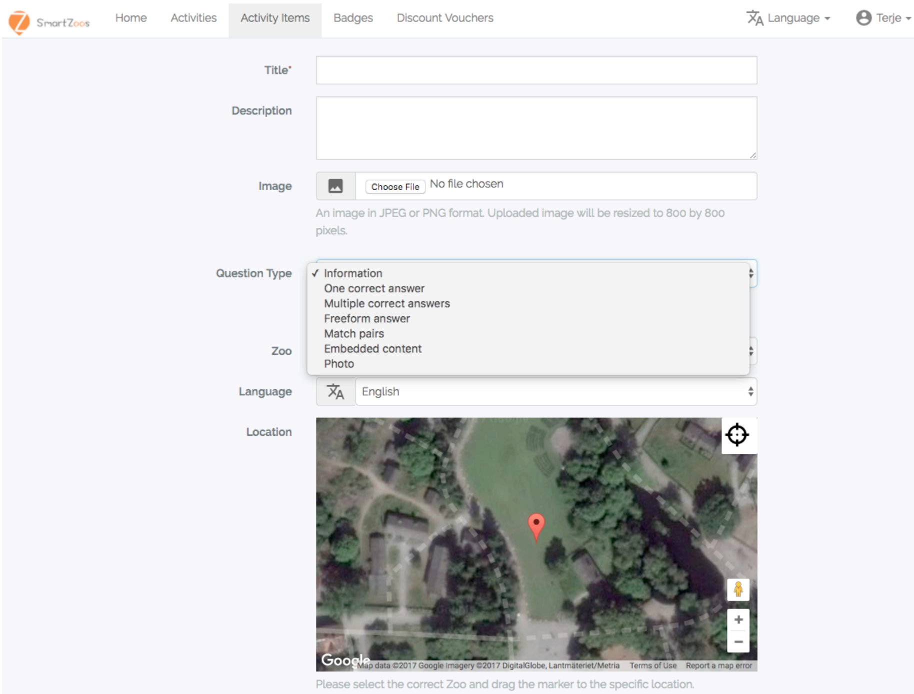

Fig. 1. Creating an activity item (a location point with a task).

- The achievements of the players will be awarded by badges in the participating zoos. The badges can be cumulated or combined across all the zoos in the consortium and traded for some real prizes (e.g. discounts in zoo tickets or ferry + zoo combined tickets to another country) in all three zoos. Additionally, the creator of a game can add a voucher to his/her game, which will be considered as a reward for the successful player. The vouchers can be also traded for some real prizes, thus encouraging visitors to play.
- It has an international character for supporting regional development - the application supports cross-use of the SmartZoos services in different zoos in different countries. For instance, the visitor of one zoo can place a challenge to the visitors of another zoo. Yet another option is to design a game in a way that in order to complete the whole game it requires going and visiting other zoos as well enabling cross-border learning and international collaborative discourse. Through these scenarios, the service package has a potential to enhance environmental awareness, support regional development and to contribute to the increase of the social capital of the region.
- It supports learners' empowerment and freedom to choose the game that deems fit with his/her time frame and interests. By choosing the role of the player, he or she can choose a game from the SmartZoos repository and start playing. Activity items in the game (activity) will be activated by proximity, when the user will be physically near enough to the selected point (Figure 3). While playing, the service package provides immediate formative feedback to the tasks completed in location points and

the player's progress. At the end of the game the player can see the overall result of the submitted answers and their correctness. In case of school groups, the teacher can monitor her learners' progress by keeping track of the submitted tasks on the dashboard. Similarly, the creator of the game can monitor the progress of players of his game.

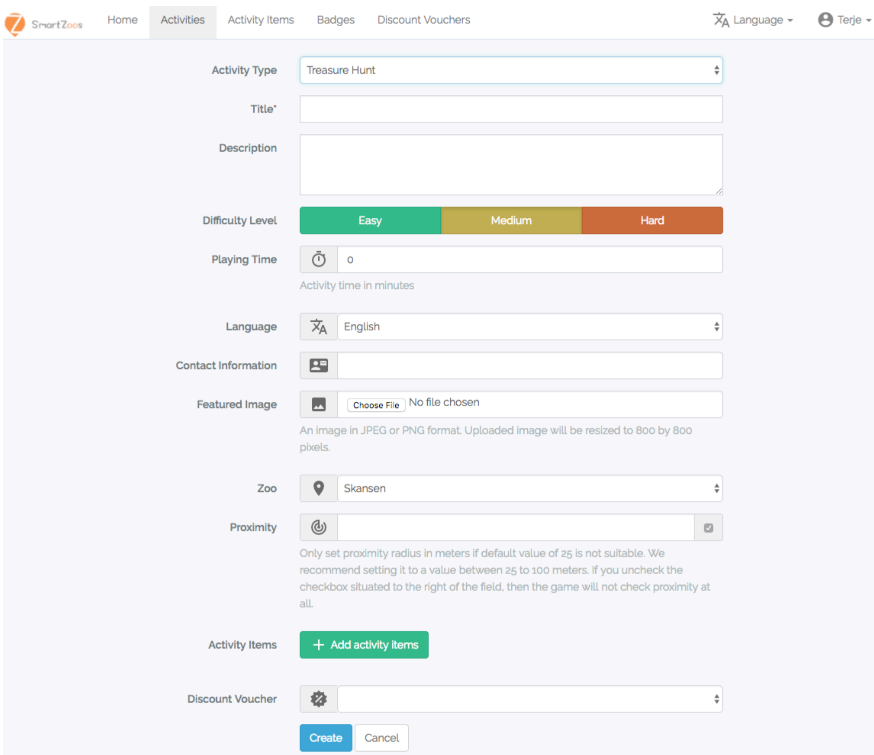

Fig. 2. Creating an activity (a game).

- Although, currently being work in progress, the service package also aims at collecting data about the learning paths, which later can be used for analysis and reflection. At the moment the service package collects and displays time spent on playing the game, the number of correct and wrong solution provided by the player at the location points, etc.

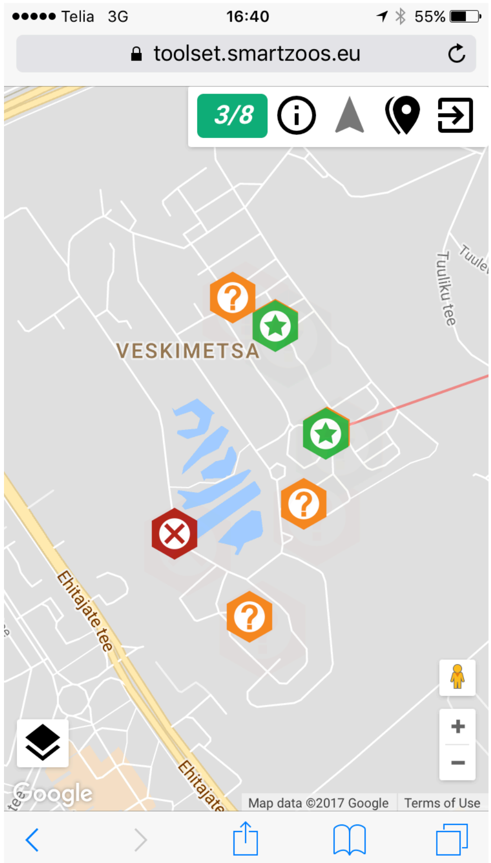

Fig. 3. A screenshot of the game.

5 Research Design and Context

To meet the needs and socio-cultural context of learners, “developing technologies in close collaboration with the people who will eventually use it in all of its messiness and complexity” is important (Kelly and Hamm, 2013). Similarly to Kelly and Hamm (2013), our methodological approach followed a “living lab” philosophy (Ley, et al., 2018), which comprised of a small team of researchers, designers, teachers, practitioners, learners, developers and zoo staff. This interdisciplinary and international team collaborated in experimenting with innovative ideas and prototyping the potential smart solution of the SmartZoos service package in real authentic settings. At the core of the living lab for designing and developing the SmartZoos application was a research-based participatory design process (Leinonen, 2010) (Figure 4). According to this approach, the overall design and development process started with an in-depth contextual inquiry. A rapid ethnographic assessment

(Squires, 2002) was carried out with visitors in the zoos - an exploration of the zoo as a learning environment and learners' use of mobile devices through observations and interviews in order to understand their behavioral patterns. In addition, an extensive literature review on outdoor mobile learning and location-based mobile games was executed to define the context, preliminary design challenges of the application, potential design constraints and its underlying pedagogical assumptions.

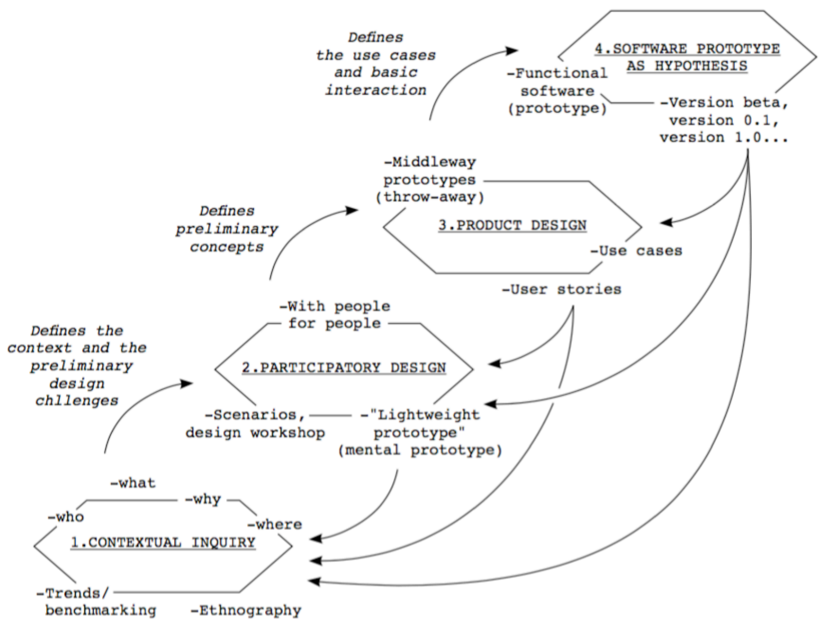

Fig. 4. Research-based design phases (Leinonen, 2010).

Second phase of the research-based design process focused on several participatory co-design sessions to get input from various stakeholders with direct focus on practical design of the application. Five participatory design sessions were organized with natural science teachers, students, zoo educators, researchers, education experts, developers to define the overall preliminary idea of the application, its affordances and functional elements. These sessions consisted of paper prototyping, developing user stories, personas and potential application usage scenarios. The sessions were partially video recorded, observation notes were taken and interviews, discussions were carried out.

In third phase, the outcome of the contextual inquiry, the participatory co-design sessions and pedagogical concepts from the literature were translated into a working prototype of the service package. Currently the development of the SmartZoos application is in the fourth phase - finalizing production of software as hypothesis - potential solution to the design challenges. First pilots of the prototype of the service package consisted of zoo staff and teachers testing the application and experts carrying out heuristic evaluations. The specific design and development phases with evidence-based design decisions and first pilots of the service package are presented elsewhere.

In this paper, we want to take a critical look at our design and development decisions. In particular, our research goal was to explore and test the smartness of our design and understand visitors' behavioral patterns and usage of their smart devices while playing a game in the SmartZoos application. Our guiding research question was:

Whether and to what extent the designed mobile application (the SmartZoos service package) has a potential to turn the zoos into smarter learning ecosystems? In particular, while engaging in one of the SmartZoos games, how much time the players actually use their smart devices in comparison to observing their surrounding and interacting with the zoo habitants?

Triggered by our first pilots we set a rather critical hypothesis, which claimed that while playing the game in the zoo the users make use of their devices more than observing their surrounding and interacting with the zoo habitants. The participants of the study were different learner groups:

- 26 students from K-12 (age 12-14)
- 12 students from formal higher education (adult learners)

We designed an attitudinal study integrating aspects from a behavioral study to measure and understand users' attitudes towards the application and to gain knowledge about its usage.

A semi-structured questionnaire was designed for the users, in which one of the aspects focused on the use of smart devices while playing the game. We asked the users' subjective opinion about how much time (drop-down menu with percentages was offered to the users, e.g. 0-10%, 20-30%, etc.) they think they spent on watching their devices while playing the game. To complement their estimations, some observations were also carried out (for 6 players), in which observers followed the players and were noting down the time frames users spent on fiddling with their devices. The researchers had a form in Google spreadsheet to fill in. The observers were provided options with 5 scales from *not at all* to *most of the time.* The observers submitted the form in every location point including the period going from one location point to another one. The goal was to check the reliability of the players' estimations regarding their time distributed between the zoo exhibition and their devices.

In addition, the questionnaire to the users consisted of (among other aspects, which are discussed elsewhere) five semantic differential questions in the form of bi-polar adjectives (Osgood et al., 1957) on a five level scale. The aim of this semantic differential technique was to reveal information on three basic dimensions of attitudes:

- Evaluation - is concerned with whether a person thinks positively or negatively about the application and its approach,
- Potency - is concerned with how powerful the application and its approach is for the person and
- Activity - is concerned with whether the application is seen as active or passive.

The application piloting followed a scripted use of the application, in which a teacher demonstrated the application in the classroom, students were asked to create a game and then play in the zoo one of the games created by another student.

6 Analysis and Discussion

6.1 Time Spent on Mobile Devices

Estimating one's own time spent on fiddling with the device while playing the game is a subjective guessing, thus, some of the results of the questionnaire was complemented with the observation data. Due to the limited resources, 5 K-12 students and one 1 adult learner were observed. A simple comparison was carried out in which observed player's estimation indicated in the questionnaire was set against observer's data. The observers' data confirmed to a great extent the observed users predictions of their time spent on using their mobile devices while playing the game in the zoo.

As expected adult learners' time spent on fiddling with their mobile devices is different from the K-12 learners (see Figure 5 & 6). 33,3% of the adult learners claimed that they spent 30-40% of their time using their device while playing the game, 16,7% even 50-60% of their time. There was also 1 player who claimed that his time was mainly dedicated to his device instead of observing the surrounding while 16,7% of the players managed to play the game while mainly interacting with their surrounding. They needed only 10-20% of their time to follow the game in their device.

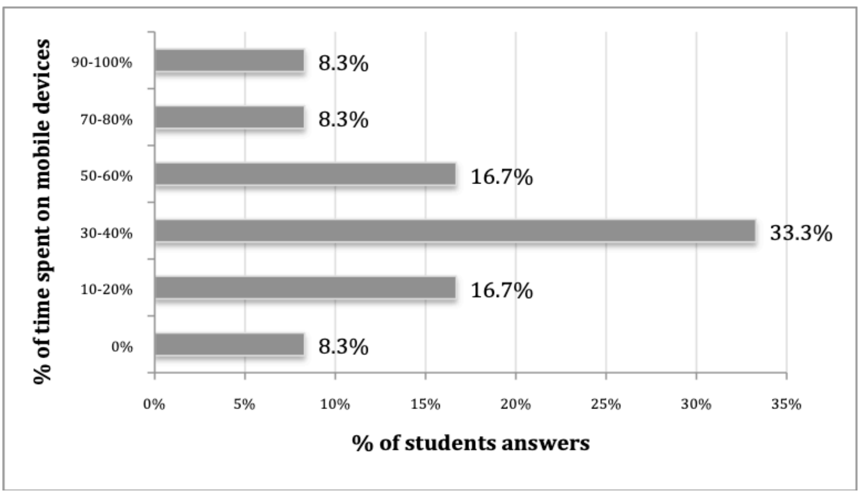

Fig. 5. Adult learners estimated % of time spent on their mobile devices during the learning activity.

In case of K-12 students, the time spent on watching their devices was much higher, 50% of them claimed to be busy with their devices 70-80% of their time. Approximately half of the time was dedicated to the mobile devices by 11,5% of the respondents, 19,2% of the learners needed only 30-40% of their time to follow the game and submit all the necessary tasks in every location point.

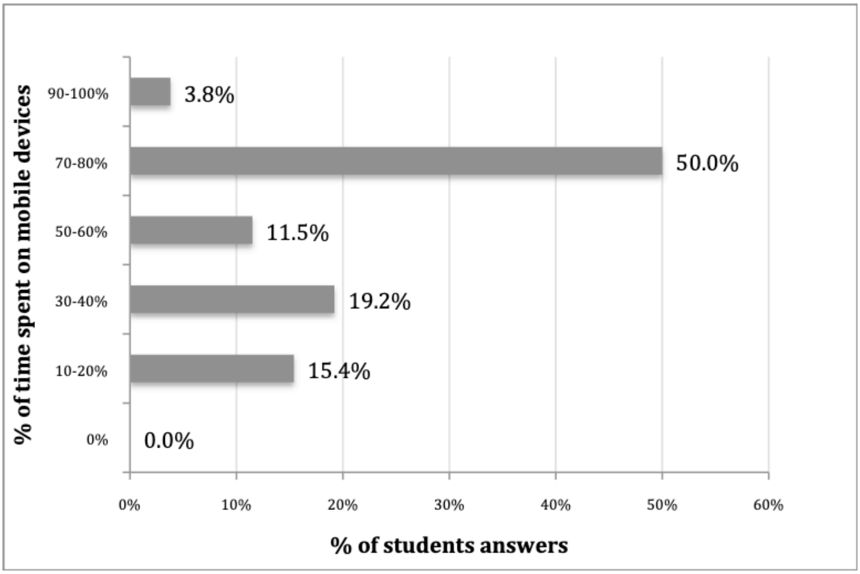

Fig. 6. K-12 learners estimated % of time spent on their mobile devices during the learning activity.

This simple analysis of the collected data confirmed our hypothesis that users tend to watch their devices relatively often and spend quite some time on fiddling with their smart devices while playing the game at the zoo. We consider these results rather critical from the perspective of smart design and development of the application for the purpose of learning in the zoo context. Zoos are environments where information is acquired through visual senses from one's surrounding. Every attempt to expand the zoos with (potentially) smart technological solutions should support and facilitate these observations without dismissing face-to-face learner-zoo habitant interactions. Technological solutions, which have a tendency to attract users' attention that much, that the users forget about their surrounding, influence negatively users overall behavioral patterns in these environments. Thus, the concept of the smart learning ecosystem and activities in it need to be reconsidered.

Furthermore, what is interesting about the outcome of the study is that the respondents themselves didn't consider spending their time watching on their devices as problematic. One of the open questions (not required to answer) in the questionnaire asked the users opinion about the time spent on their devices. Only two of the adult learners provided a comment in the questionnaire regarding this aspect. One of them justifiably pointed out that the tasks in the game should be created in a way, which makes you more observe the habitants in the zoo. The other one claimed "*too much time was spent on the phone and finally the battery of the phone run out*". Quite likely the design decisions of the application play a role here, namely, if the game creator has defined the proximity of the location point in order to be able to solve the task (the user has to be close enough to the location point to be able to click on it and see the task), then by default it invites the users to monitor their mobile devices to see the direction towards and distance from the next location point. One of the potential solutions that would contribute to spending less time on watching one's phone suggested by the respondent was "*to add some sort of sound if getting close enough to the next location point, this would avoid watching the phone all the time*". Yet another solution is to design tasks in every location point in a way, which invites the users to observe their surrounding more.

6.2 Users' Attitudes

To understand users' experiences and attitudes towards the application we extracted from the list of semantic differential questions the following aspects:

Evaluation: liking of the application and considering the application interesting

Potency: desire to use the application again in the future

Activity: excitement of using the application, application supporting learning activity.

The analysis of the semantic differential questions showed also some differences between the K-12 students (N=26) (see Table 2) and students in higher education (N=12) (see Table 1).

Table 1. Higher education students' responses.

	2	1	0	-1	-2	
Evaluation						**Evaluation**
I liked the application	N=3 25%	N=2 18,7 %	N=5 41,7 %	N=1 8,3 %	N=1 8,3 %	I didn't like the application
Using the application was interesting	N=3 25%	N=4 33,3%	N=3 25%	N=1 8,3%	N=1 8,3%	Using the application wasn't interesting
Potency						**Potency**
I would want to use the application again	N=3 25%	N=2 16,7%	N=6 50%	N=0 0%	N=1 8,3%	I would not want to use the application again
Activity						**Activity**
I was excited while using the application	N=1 8,3%	N=5 41,7%	N=5 41,7%	N=0 0%	N=1 8,3%	I was bored while using the application
Application supported learning activity	N=1 8,3%	N=6 50%	N=3 25%	N=1 8,3%	N=1 8,3%	Application interrupted learning activity

It was expected that the application with some gamification elements designed in it has a greater influence on younger students. Around half of the players liked the application (K-12 53,8% (N=14) and adult learners 43,7% (N=5)) while 41,7% (N=5) of the adult learners remained neutral in their opinion and the corresponding percentage among K-12 students were 7,7% (N=2). A bit more than half of the adult learners and K-12 learners evaluated the application as an interesting tool to be used for learning purposes, 25% of adult learners and 7,7% of K-12 learners opinion was neutral. 50% of the adult learners were not very convinced whether to use the application again or not. This number was much smaller in case of K-12 students (26,9%). 41,7% of adult learners and 53,9% of K-12 students would give it a second try, however most of the adult learners claimed that the application has a potential to support learning activities, while K-12 students were not so convinced about that.

Table 2. K-12 students' responses.

	2	1	0	-1	-2	
Evaluation						**Evaluation**
I liked the application	N=11 42,3%	N=3 11,5 %	N=2 7,7 %	N=8 30,8 %	N=2 7,7 %	I didn't like the application
Using the application was interesting	N=12 46,2%	N=3 11,5%	N=2 7,7%	N=5 9,2%	N=4 5,4%	Using the application wasn't interesting
Potency						**Potency**
I would want to use the application again	N=10 38,5%	N=4 15,4%	N=7 26,9%	N=3 11,5%	N=2 7,7%	I would not want to use the application again
Activity						**Activity**
I was excited while using the application	N=4 15,4%	N=7 26,9%	N=8 30,8%	N=5 19,2%	N=2 7,7%	I was bored while using the application
Application supported learning activity	N=12 46,2%	N=1 3,8%	N=5 19,2%	N=5 19,2%	N=3 11,5%	Application interrupted learning activity

Looking the application from the excitement point of view, 41,7% of adult learners (N=5) remained neutral while 50% (N=6) claimed to be excited while playing the game. The corresponding numbers in case of K-12 learners were 30,8% (neutral opinion) and 42,3% (N=11). Table 3 summarizes K-12 and adult learners attitudes and opinions about the application.

Despite of its development phase, the excerpts from the analysis show, that the users' attitude towards the application and its usage for supporting learning activities in the zoos is mainly more likely positive and promising, and quite many see the potential of the application to be part of the zoo's learning environment.

Table 3. Summary of all the respondents.

	2	1	0	-1	-2	
Evaluation						**Evaluation**
I liked the application	N=14 36,8%	N=5 13,2%	N=7 18,4 %	N=9 23,7 %	N=3 7,9%	I didn't like the application
Using the application was interesting	N=15 39,4%	N=7 18,4%	N=5 13.2%	N=6 15,8%	N=5 13,2%	Using the application wasn't interesting
Potency						**Potency**
I would want to use the application again	N=13 34,2%	N=6 15,8%	N=13 34,2%	N=3 7,9%	N=3 7,9%	I would not want to use the application again
Activity						**Activity**
I was excited while using the application	N=5 13,2%	N=12 31,5%	N=13 34,2%	N=5 13,2%	N=3 7,9%	I was bored while using the application
Application supported learning activity	N=13 34,2	N=7 18,4%	N=8 21,1%	N=6 15,8%	N=4 10,5%	Application interrupted learning activity

In addition, we were also interested to see the connection between the time spent on the device and users' attitudes towards the application. For that we divided the K-12 students responses into two groups: group 1 consisted of users who had spent more than 50% of their time on using their mobile devices and group 2 consisted of users whose mobile device use was estimated below 50% of their time. Individual time used with the mobile device was analyzed against 3 aspects in the semantic differential questionnaire: liking the application, considering the application interesting and being excited while using the application. These aspects demonstrate best the relation between time in which users attention was on their mobile phones and their overall attitude towards the application. On the 5 level scale data reduction was carried out by merging users' positive answers (first two choices on the scale) and merging negative answers (last two choices of the scale). Third group was formed by neutral answers. The Table 4 summarizes the results. The table demonstrates clearly that there is a connection between time spent on a mobile device and a student's attitude towards the application. For instance, most of the students who had spent more than 50% of their time on looking at their device and following the game experienced excitement, found the application interesting and in general possessed positive attitude towards the application. On the other hand the students who didn't consider the game interesting or didn't experience so much excitement, but rather felt bored, spent less time on their mobile devices and the application. Thus, we can draw a general conclusion here, which is the more one liked the application, found it interesting and exciting, the more time he/she spent on looking at it.

Table 4. Connection between K-12 students time spent on their mobile phones and attitudes towards the application.

		Time spent on mobile device was more than 50 % of the gaming time: 15 students (58%)	Time spent on mobile device was below 50% of the gaming time: 11 students (42%)
Liking the application	Positive opinion	10 students	5 students
	Neutral opinion	2 students	0 students
	Negative opinion	3 students	6 students
Considering the application interesting	Positive opinion	8 students	3 students
	Neutral opinion	5 students	3 students
	Negative opinion	2 students	5 students
Being excited while using the application	Positive opinion	10 students	4 students
	Neutral opinion	2 students	0 students
	Negative opinion	3 students	7 students

7 Lessons Learned

On the one hand the outcome of this study can be seen as positive because we have managed to engage users to create games, play them and arouse excitement. Getting excited and into a state of being fully engaged with one's device the participants might experience a flow - a positive state of mind where participants concentrate on the task in hand so deeply that they lose the sense of time and stop worrying about other things (Csikszentmihalyi, 1990). In general, in the context of learning and knowledge building, flow is seen as a positive phenomenon and a desired state of mind, however, in our particular case we have to be careful while interpreting our results and drawing inferences. The aspects of the flow such as concentration, curiosity and persistence might be influenced by the attractiveness of users mobile devices and the application itself, not much by the overall content of the activity, i.e. learning through observing animals being supported by the game. The design challenge is how to make a balance between these two - make an optimal use of technology and interact with one's surrounding for knowledge building purposes. Even though we have provided a rather exciting and engaging technological solution, which provides immersion possibilities in multidirectional interactive and authentic learning experiences, playing the game should not capture visitors' whole attention to their smart devices, away from the core idea of the zoo - observing its habitants.

Therefore, first we have to specify what exactly influenced the users behavior and invited them to rather watch their devices and the game they were playing than exploring their surrounding. Secondly we need to ascertain what kind of flow we are expecting the users to reach in order to support their smart learning and what exactly are the triggers of that flow effect. To investigate the flow of users and its causes in these kind of settings requires a more comprehensive study, determining different component states of the flow (according to Csikszentmihalyi (1990): challenge-skill balance, merging of action and awareness, clarity of goals, immediate and unambiguous feedback, concentration on the task at hand, paradox of control, transformation of time, loss of self-consciousness, and autotelic experience), their relation to the application design and activities the users should execute in the zoo.

However, what is considered smart in our particular case takes a rather different focus and to fully understand the learning process with the SmartZoos application and its potential to turn the zoos as smart learning ecosystems, it is important to identify which are the factors that contribute to determine the smartness of the zoos. Technological solutions following the characteristics of the smart learning ecosystems found in the literature are not enough from our point of view because of the zoos special nature and role. The most challenging aspect in this case is to balance the interaction between the application and the user; and between the zoo exhibits and the user.

Rethinking the zoos as smart learning ecosystems should be centered on individual's awareness and sensibility to technology and his surrounding. McCullough (2013) stresses "ambient awareness" as an important aspect in any smart context referring to a complex set of phenomena with a new attitude about attention. Ambient is understood as something, which surrounds and is invisible but does not distract. Another potential concept in our application design and development could be what Calzada and Cobo (2015) calls "unplugging". Ignoring this concept, we contribute to the notion of people's addictions to information and their devices. It is increasingly challenging to embrace spontaneous, emergent, unplugged social spaces (Calzada & Cobo, 2015), which would avoid techno-deterministic conditions in the zoos and would still contribute to the goal of being smart. These concepts (ambient awareness and technology, unplugging) might provide promising ideas in our own research, design and development of the application.

Whether the learning experience and the learning environment are going to be smart depends a lot on the overall design of the learning activities and the affordances of the environment. One of the promising options here is to follow Chourabi et al. (2012) framework for further design: (1) a comprehensive set of factors that are essential to understanding the role of the SmartZoos application for turning the zoos as smart learning ecosystems; (2) a set of components meant not to rank smart zoos but to create a framework that can be used to characterize how to envision such a zoo; (3) an integrative framework to explain the relationships and influences among these factors and the SmartZoos application; (4) the developed set of factors can be also seen as a tool to support understanding how the zoos envision their smart initiatives.

In practical and more concrete terms it means: 1. The pedagogical design of the application should be reconsidered in a way that it invites users to create tasks, which require minimal attention on the mobile display, but encourage players to study their surroundings and get into the flow effect, in which technology is not dominating. Creativity of the ones who form activity items plays a huge role here. 2. Development of additional technical features that would help learners to control their usage of the device, for instance, a notification system for players which gives a sign about the next location point if getting close enough. 3. Learning analytics systems that provide a constant monitoring of the state of flow of all categories operating in a learning ecosystem (Giovannella, 2014) and a continuous formative feedback of the activities to the user. Whether it is in the form of providing the user data about the time spent in the device, a notification feature or the solution is hidden in visualizations of learners' activity patterns, remains yet to be explored.

8 Conclusions

Following the living lab approach we have co-developed and designed the SmartZoos service package to intentionally support learners' engagement and knowledge acquisition in the zoos, thus hoping to turn their learning experiences smart while visiting the zoos. The SmartZoos application, meeting most of the characteristics inherent to a smart learning ecosystem, has a great potential to turn the zoos into smart learning environments. Having a link between three zoos of the Central Baltic region, the application could play a central role to regional development and social innovation through inviting people to play games in one zoo and continue it in another zoo of the region. In connection with physical infrastructure (e.g., smart home, smart factory), the SmartZoos aims to blur boundaries across formal and informal places of study, work, everyday life, the physical and the digital, and fostering technology integration (Gretzel et al., 2015, McKenna, 2016).

We have demonstrated that transforming zoos into smart learning ecosystems should avoid techno-deterministic learning experiences (including immersion of flow triggered by technological attractiveness) and dominant technocratic mode of users, in which relevance of face-to-face interactions is increasingly dismissed. Our study has shown that re-conceptualization of "smart" and identification of the most adequate factors that contribute to determine the smartness of a zoo is required. Additionally, a set of challenging questions emerged from our study that need to be addressed in the next phase of the design and development of the SmartZoos application: how can we design and develop more engaging, but at the same time less technology-driven smart services? To what extent face-to-face interactions with zoo habitants can be remained at the centre of human experiences while interacting with technology? Can we combine off- and online environments to create a smarter balance between technology-visitor-zoo habitants? Furthermore, future studies should help us to understand to what extent and how these types of learning experiences contribute to learners' knowledge building in a particular field?

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