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Mobile learning in environmental citizen science: An initial survey of current practice in Germany

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Abstract: Citizen science is a growing approach in science and the opportunities of new technologies and learning are considered more and more. We give an overview of the current practice of mobile learning in Germany by conducting an explorative survey among environmental citizen science projects using mobile apps. This study supports the idea that education is relevant in citizen science, and apps affect the learning experience of participants. However, several obstacles were identified that need to be considered, to be able to fully exploit the benefits of mobile learning in citizen science.

Keywords: citizen science, mobile learning, mobile apps

ACM CCS: Applied Computing → Education; Human-centered computing → Ubiquitous and mobile computing

1 Introduction

Citizen science is most commonly defined as conducting research together with the general public to produce scientific output and science outreach [3]. Non-professional scientists voluntarily collect data in large volumes and over large geographical areas, analyze large amounts of data or take part in the dissemination of a scientific project [5, 9, 26, 31]. The approach is used in a variety of disciplines but in Germany the majority of projects take place in the natural sciences [20]. Even though science remains the main driver of project designs, educational objectives are gaining more and more importance [2, 10, 13, 14, 15, 24, 25, 38]. Amongst other things, citizen science is seen as a method to provide knowledge about a research topic [12] and enhance scientific literacy [3, 7, 23]. The growing use of digital technologies in citizen science [4, 9, 10, 20, 24, 31, 35] not only affects the method of communication but also the learning experience of participants [10, 15, 27, 29]. Mobile devices support the learners to choose what, where and when to learn. Information is used in an individual context, available at the point where it is needed and can easily be shared with others [27, 29]. O'Malley and colleagues [21] define mobile learning as follows:

> Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies.

In 2013, Lude and colleagues [18] developed a model on mobile learning in environmental education and education for sustainable development based on four dimensions.

Currently, only a few surveys of citizen science [16, 22, 28, 35] and especially virtual citizen science [10, 14] exist. A comprehensive study of mobile learning in citizen science is missing. Even in the field of environmental education and education for sustainable development, observational field studies on mobile learning are still rare [27]. However, without knowledge of learning with mobile apps, it is difficult to guide citizen science practitioners to develop citizen science apps [34].

In this paper we address this research gap by focusing on current citizen science practice and the growing field of mobile app development in citizen science in Germany. Based on a survey with practitioners, we look into the current practice in environmental citizen science and address particularly the educational and pedagogical dimension of mobile learning (Fig. 1). Thereby, we aim to provide an initial inside view into the future of mobile apps and mobile learning in citizen science, for a better understanding of the educational and pedagogical aspects of this field.

2 Methods

An online survey on mobile learning in environmental citizen science projects in Germany was conducted in December 2016. Using the online platform buergerschaffenwissen.de, thirteen projects in biological and non-biological natural sciences where a mobile app was used, were identified and contacted via email in January 2017. Buergerschaffenwissen.de is the major citizen science online plat-

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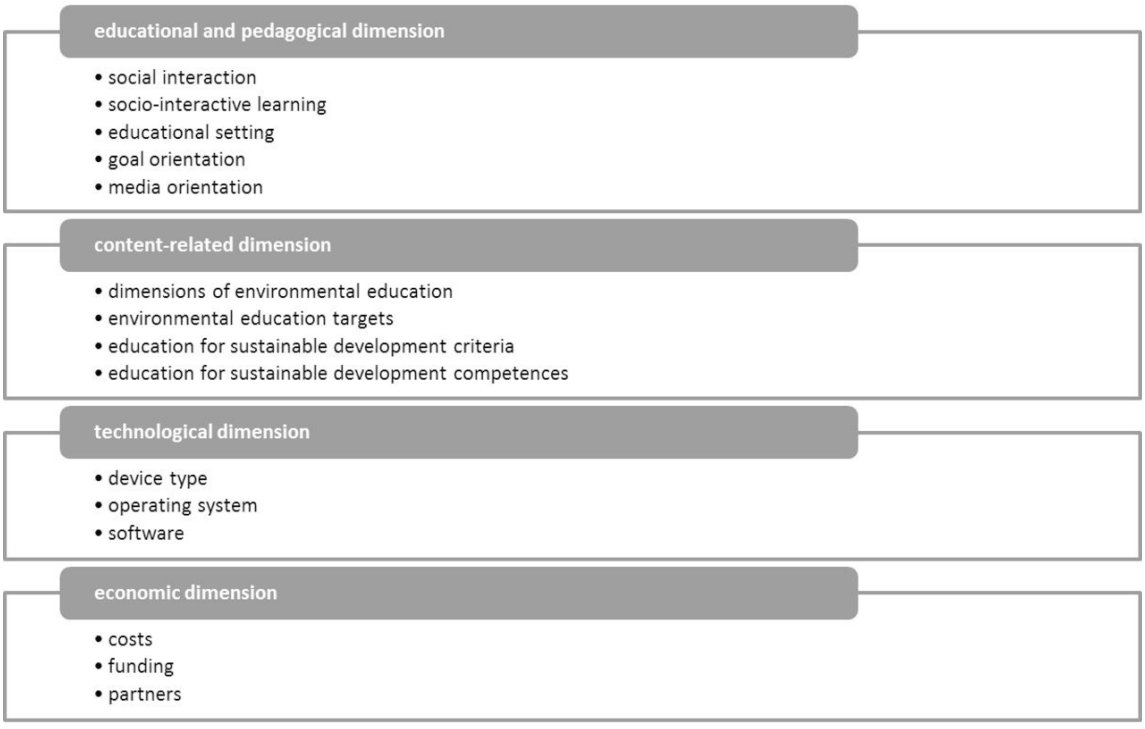

Figure 1: Dimensions and sub-dimensions of mobile learning in environmental education and education for sustainable development [18].

form in Germany and acts as a cross-disciplinary repository of citizen science activities. The projects represent a cross-section of current practice in Germany [22].

This initial survey on mobile learning focused on evaluating the perception of project initiators, planners and organizers who play a crucial role in the design of learning opportunities. Selected project initiators assessed their projects through an online questionnaire in regard to the educational setting, social interactions as well as goal and media orientation.

The survey was based on a theoretical framework and a questionnaire developed by Lude and colleagues in the mobi-LU-project where they reviewed mobile learning in environmental education in Germany [18, 27]. For the present study, the questionnaire was partly adopted and tailored to the citizen science projects. In total, the questionnaire contains 25 questions which included general aspects e. g. intended target group and used technology as well as used formats and methods. Participants were asked to identify the potential benefits and obstacles of using mobile apps in citizen science. By using qualitative content analysis, [19] benefits and obstacles were grouped in categories.

The educational and pedagogical dimension was evaluated with 18 items. Every item provides two opposite poles, ranked on a four-level Likert scale. The items were also assigned to sub-dimensions (Tab. 1). Beyond that, the answers were scored and the median per each sub-dimension was calculated.

Table 1: Educational and pedagogical sub-dimensions with specification and number of items based on Schaal & Lude [27].

Sub-dimension	range	Items
social interaction	individual vs. collaborative	6
socio-interactive learning	receptive vs. productive	2
educational setting	formal vs. informal	4
goal orientation	pre-defined goals vs. self-determined goals	4
media orientation	strong influence vs. weak influence	2

3 Results

Nine out of thirteen contacted projects participated in the online survey in January and February 2017. Four projects were initiated by scientific institutions, including universities and non-university research institutes and four by nonprofit organizations, including structured research organizations. One project was organized by an individual actor.

Table 2: Categorization of potential benefits and obstacles perceived by citizen science project initiators. Open ended answers, frequency of mentions in brackets (N=9).

Dimensions of mobile learning	Potential benefits	Potential obstacles
educational and pedagogical dimension	learning (6)	exclusion (7)
content-related dimension	data collection (8) communication (8) outreach (6)	usability of the app (8)
technical dimension		complex development (7)
economic dimension		competition (4) costs (4)

One of the major findings is that all people surveyed identified environmental education as part of their projects. In addition, six of the nine survey participants even stated that environmental education is a central aspect of their citizen science project. Two individuals surveyed answered the question "Environmental education is a central aspect of the project" with "rather correct", one with "rather not correct". All surveyed practitioners defined citizen science and environmental education as independent fields with overlaps.

The surveyed projects all have several objectives. The majority, eight of the nine projects, aim to collect extensive scientific data. Also, eight projects wish to contribute to the protection of the environment and natural resources. Six projects want to offer the opportunity to learn new things and five projects aim to strengthen the understanding of science. All nine mobile apps are aimed at participants from sixteen to seventy years of age. The target group of eight apps is even younger, starting at age eleven. Furthermore, four apps target people older than seventy. In addition, the common audiences addressed are individuals. However, five apps also address associations and four address school classes.

Eight project initiators viewed data collection and communication as the main expected benefits (Tab. 2). Learning and outreach were also mentioned as important benefits. All expressed benefits related to the content-related and the educational and pedagogical dimension. Beyond that, the project initiators project initiators expected problems within all four dimensions. Main concerns involved usability, complex development and excluding groups such as older people or participants who do not own a smartphone (Tab. 2). Economic concerns included high development and maintenance costs and competition on the app market.

Mobile apps in citizen science serve multiple purposes (Fig. 2). For instance, all projects use a mobile app to collect data. Furthermore, more than half of the apps are used to collect and provide information. The two possible answers provide coordination and orientation did not apply. Two surveyed project initiators added species identification as an additional objective. The evaluated apps are relatively similar in their functions (Fig. 3). All apps enable users to record geo-referenced data and eight apps allow users to take pictures. Two apps include species identification keys as an additional function.

In regard to the educational-pedagogical sub-dimensions of social interaction, socio-interactive learning, educational setting and goal orientation (Tab. 1), the results show an overall focus on productive learning, informal setting and individual learning (Fig. 4). The participants of the citizen science projects are intended to achieve rather pre-defined goals. For the media oriented sub-dimension the answers indicated that there is no strong media influence on the participants.

4 Discussion and conclusions

Overall, the study gives an overview of current practice in environmental citizen science in Germany – particularly the educational and pedagogical dimension of mobile learning in the perception of project initiators. Nevertheless, one has to mention that the study comprises a sample of nine participating projects, which is not very high. Therefore, it has an explorative character and demands for ongoing research in this field including an extension of the scope towards the user perception.

Indeed, the survey gives an insight into citizen science practitioners' perception of education in citizen science and supports its significance. This is also shown by Bela and colleagues [2] who outline the learning and transformative potential of citizen science argued by scientists. According to Brossard, Lewenstein and Bonney [6] citizen science projects can also contribute to an increase of factual science knowledge, although participants learning outcomes are still rarely evaluated [2].

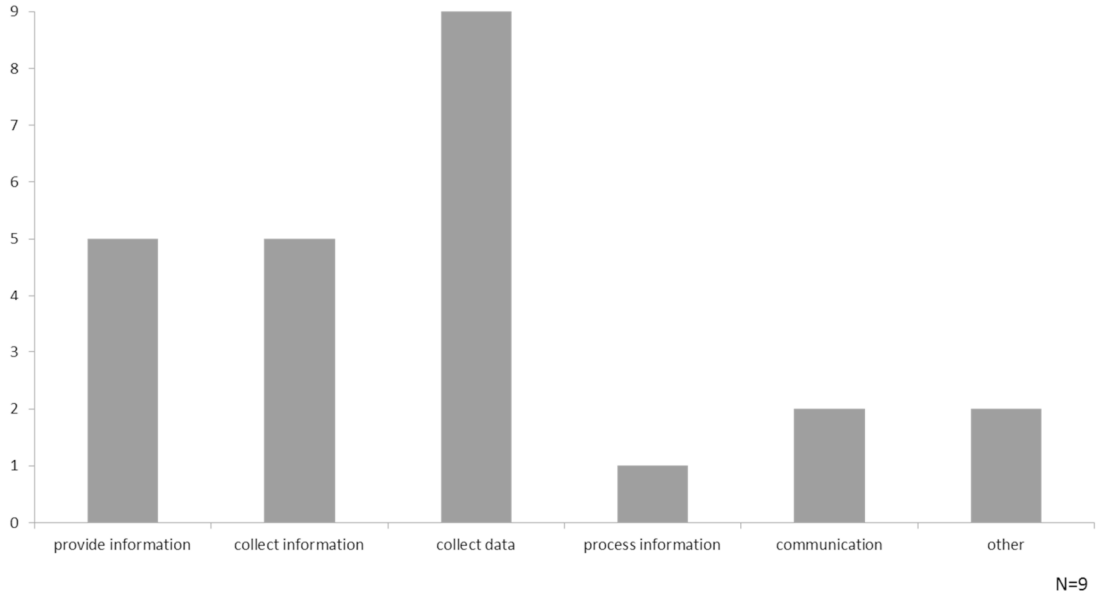

Figure 2: Objectives of mobile apps within citizen science projects. Multiple answers possible (N=9).

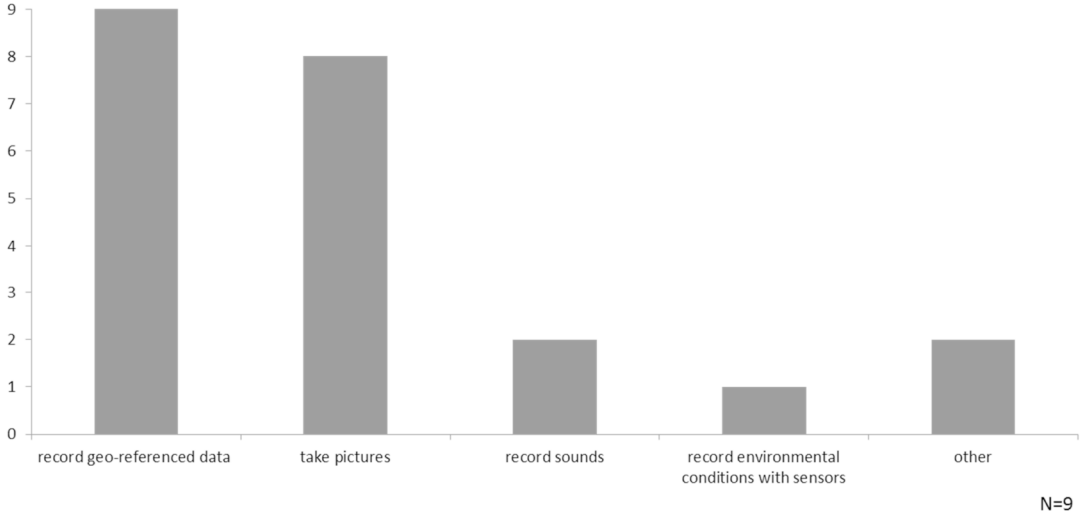

Figure 3: Functions of mobile apps used in citizen science projects. Multiple answers possible (N=9).

Figure 4: Educational-pedagogical sub-dimensions of environmental citizen science activities with apps, each in opposite poles (four-level Likert scale, median score, N=9).

The initiators of citizen science projects using mobile apps, take a positive view on the potential of apps to support learning and communication. For example, project initiators include learning and communication in their considerations for choosing an app to use. Also Dickinson and colleagues see new technologies like mobile apps as a possibility to increase participant interest, data quality, and learning impacts [8]. However, several obstacles were expressed. Despite the projects' aim to engage young and old users, the use of new technologies may exclude certain groups such as the elderly. These challenges may vanish in the future due to the growing technological expertise in all ages [1, 11, 33]. In addition, the use of different target-group-specific tools within one project could help to overcome this obstacle. But practitioners face even more new challenges due to the complex technical development and the highly competitive app market. Most of them have a scientific background and therefore are seldom trained in technical development, marketing or teaching.

The results raise the question why the use of mobile apps in the citizen science projects is so similar. One explanation could be the fact that all of the citizen science projects follow a relatively similar approach, in which the main purpose of these apps is to efficiently collect data. Participants collect data, e. g. report species or measure amounts of fine dust, to support the data basis for science and environmental protection. These actions, focused on the defined project goal, are tied neither to a specified date nor to a place and are conducted mostly by individuals [17, 36]. This approach is also mirrored by the characteristics of the educational-pedagogical dimension of mobile learning by focusing on a more informal, individual learning with rather pre-defined goals. Even though literature strengthens the potential of collaborative mobile learning [2, 27, 30] recent approaches still focus more on individual learning. Yet a more cooperative approach is often part of the associated platforms [32, 37]. Additionally, the study by Schaal and colleagues [27] which investigated mobile learning environmental education, show that the full potential of mobile devices is seldom exploited.

In the near future, further in-depth investigations of the motives for using apps, including the associated platforms, is needed to better understand the mechanisms and obstacles. Therefore, additional interviews which are based on the recent findings may be necessary to gain a thorough understanding of mobile learning in citizen science. A survey among participants would also provide more detailed insights into their needs and motivations, and may highlight missed opportunities and changes to support learning in citizen science.

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