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Article

Using Mobile Devices in Environmental Education and Education for Sustainable Development—Comparing Theory and Practice in a Nation Wide Survey

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Abstract: Mobile electronic devices (MED) with integrated GPS receivers are increasingly popular in environmental education (EE) and education for sustainable development (ESD). This paper aims at identifying the possible applications of these devices, as well as identifying obstacles to such utilities. Therefore, a two-part study was conducted: An expert Delphi study and a nationwide online survey in Germany and Austria. In this paper, the results of the online survey are reported and compared to the findings of the Delphi study. The questionnaire of the online survey was based on a theoretical framework comprising different dimensions for the use of MED. Overall, 120 projects were included in the study. The most common target groups were school classes and the devices most frequently used were GPS receivers. The projects addressed the criteria of ESD, such as elaboration of local/global perspectives of sustainability and competencies of EE like pro-environmental behavior or attitudes. All projects were classified according to their educational design in a 2 × 2-scheme. The most common activities were predefined routes within a narrow instructional setting. Divergences between expert views and practical realization are identified and discussed.

Keywords: education for sustainability; environmental education; technology; geocaching; smartphone; mobile learning

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1. Introduction

Connecting learners with nature and sustainability issues is an essential target of *environmental education* (*EE*) and of *education for sustainable development (ESD*). An option to avoid "nature alienation" [1] and to foster educational goals of ESD [2] would be to connect personal experiences at specific places [3]. This is an established and proven practice in outdoor learning [4]. Mobile electronic devices (*MED*) like cell phones, smartphones, PDAs or tablet PCs, as well as handheld GPS navigation devices could facilitate access to remote or interesting locations (*cf.* [5]) and increase interaction with the natural environment. Sharples and colleagues [6] and Brown [7] describe the potential of mobile contextual learning settings to enable "people individually and together, to create and maintain their own rich contexts for learning" [8] (p. 6). The direct natural environment of a learner provides a specific context and mobile technologies offer additional digital artefacts to enrich the learning experience *in situ* (e.g., historical artefacts like images of a landscape two hundred years ago or just in another season, artefacts about non-accessible or non-experiential information like a digital simulation of interactions in an ecosystem at different micro-/macroscopic levels, social artefacts like videos of a peat cutter to prelude a sustainability-related dilemma discussion or just intuitive tools for scientific analysis and data collection) [8].

In the context of environmental education and ESD, several studies reported the effects of location-based learning with mobile devices: Ruchter and colleagues [9] found an increased motivation to engage in environmental education if children use mobile devices, compared to the use of field guides and human guides. Kremer and colleagues [10] as well as Lai *et al.* [11] also highlight motivational aspects using mobile devices during outdoor education activities and Uzunboylu *et al.* [12] foster smartphone-moderated activities (taking and sharing pictures of local environmental blights) to increase awareness of environmental concerns. In an explorative study, Zecha [5] conducted expert interviews about problems and potentials of geocaching routes in EE and she concludes "the best and most effective method with regards to environmental education is when pupils create their own geocaching route" (p. 185). Geocaching has been a precursor for a location-based game. Since the year 2000 (when non-disgraded GPS signal became available globally) lots of games have been developed, implemented and tested [13,14]. Location-based games are also increasingly used for educational purposes and there is evidence for an impact on knowledge acquisition, situational interest and motivation [15–21].

On the other hand, some authors suggest a careful reflection on the use of mobile devices in (environmental) educational settings [22,23] because learners may be focused on the devices, rather than on the natural environment. Recent research results highlight the role of mobile devices as additional tools and facilitators in a pedagogical and methodological well-designed learning environment to reach EE and ESD goals [5,24], as well as to achieve more self-determined, learner-centered and collaborative learning [25,26].

Several case studies and theoretical essays dealing with purposes and shortcomings of mobile electronic devices in environmental education and ESD have been published. Some papers focus on the development of frameworks to design mobile-supported field activities [25,27] and some papers focus on different effects in randomized controlled trials. However, observational field studies are still rare that use larger sample sizes focusing on recent educational activities with mobile devices in environmental education and ESD. Additionally, little is known about the implementation of MEDs by and routines of EE/ESD-practitioners (*cf.* [24]). This research deficit was addressed by the *mobi-LU*-project conducted by Lude and colleagues [28]; the present study was one part of it (graphical overview in Figure 1). Within the *mobi-LU* project a delphi-study was conducted to reveal experts' views on benefits of, and obstacles to, educational activities using mobile devices in environmental education and ESD [29]. Experts in the fields of pedagogy, environmental sciences, technology and economics were identified (N = 54) and after a two-step procedure (12 experts participated in the second round of the Delphi study), the following potential benefits and obstacles were identified (Table 1).

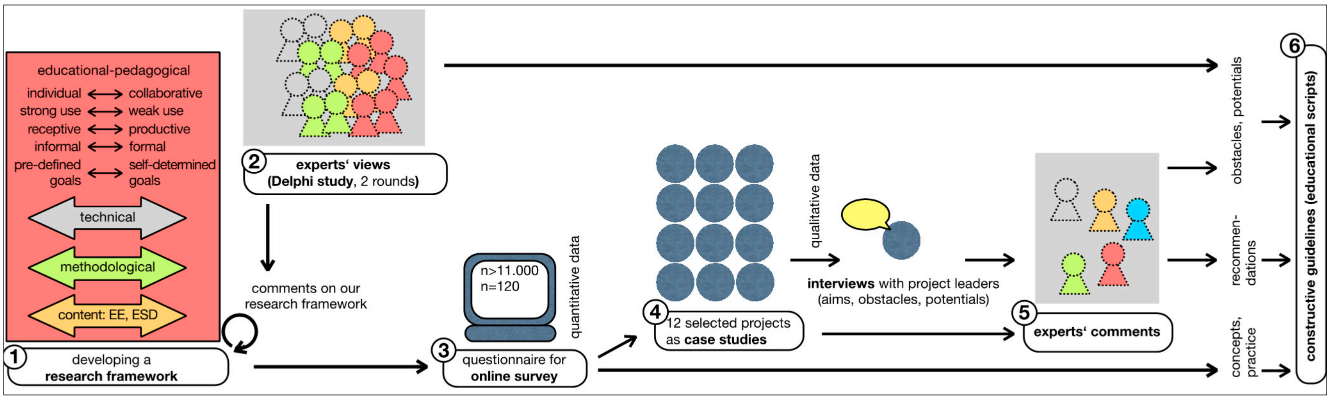

Figure 1. Research design of the *mobi-LU* project. This study focuses on steps 1, 3, 4 and 6.

Table 1. Ranked experts' views about potential and obstacles using *MED*s in *EE*/*ESD*. More than one standard deviation above the mean, respectively; taken from [29].

Potential Benefits	Obstacles
(1) Participants can (and should) work out their own content facilitated by *MEDs*	(1) *MEDs* increase the costs for educational programs
(2) Participants are motivated for outdoor activities through *MEDs*	(2) *MED* acquisition needs expertise and personal/financial resources
(3) *MEDs* allow location-based learning and situate learning at real geographical places	(3) activities with *MEDs* strongly depend on technology, and simple failures are fatale
(4) *MEDs* enable mobile learning and provide access to relevant resources	(4) *MEDs* become outdated quickly
(5) *MEDs* enable the effective combination of field work and classroom-based learning	(5) *MEDs* may cause a defective handling of nature
	(6) Focusing on *MEDs* may cause a partial loss of holistic experiences

Additionally, the experts were asked for criteria to evaluate existing educational activities in environmental education and education for sustainable development with mobile devices. After the second Delphi round, the experts agreed on seven dimensions:

(1) Goal orientation: Is an educational purpose for the MED-supported activity clearly formulated and adequately outlined?
(2) Educational concept: Is the MED-supported activity adequately structured? Are the participants' interests and requirements considered?

(3) Pedagogical orientation: Are the pedagogical capabilities of MED-supported activities adequately used? Are multiple learning-opportunities provided?
(4) Achievement: How strong is the potential for achievement within the MED-supported activity? How is it measured and are (empirical) data accessible?
(5) Motivation and interest: How strong is the potential of the MED-supported activity to motivate learners? Is the motivation just grounded on a novelty effect?
(6) Users participation: To what extent are the users able to participate and to create their own content within the MED-supported activity?
(7) Methodological use of MEDs: How are MEDs used—just for navigation or for more constructive activities (e.g., documentation, data acquisition, creating and sharing information).

These dimensions were in line with the theoretical considerations and, thus, indicate their suitability for this study. The goal of this study is to get more insights into the recent use of mobile devices in *EE* and *ESD in situ*, to compare it to the experts' views of potentials and obstacles [29] and finally to validate a theoretical framework for the use of mobile devices in educational activities in environmental education and *ESD*. This is in line with Wright and Parchomas' [30] request to focus on authentic contexts rather than on controlled experiments within the affordances of mobile learning.

2. Methodology

Formal and informal learning settings in general are determined by several prerequisites and requirements like school curricula, organizational factors or simply the learning paradigm applied for the development of a learning environment [31–33].

In order to describe and interpret the different implementations of *MED* in EE/ESD, a framework that considers different perspectives (subsequent termed as dimensions) was constructed (for details see [28]):

(a) Educational and pedagogical dimension: To what extent are constructivist learning paradigms observable within the activities and are they supported by mobile devices? Methods foster different learning paradigms in different manners (e.g., step-by-step learning or self-determined discoveries, informal setting or formal learning, exposition or exploration, collaborative or individual activities).
(b) Content-related dimension: Which content-related aspects are fostered? What are the aims of the activity? Are they fruitfully supported by the use of mobile devices and are learners' interests addressed adequately?
(c) Technological dimension: What are the benefits and limitations which mobile technology provides for the educational activities in environmental education and ESD?
(d) Economic dimension: Which are the economic prerequisites to develop a project-based educational activity using mobile devices that is viable in the long-term?

The main objectives of this study are therefore firstly to get insight into the practical implementation of mobile devices in educational activities in EE/ESD and secondly to describe the recent educational orientation of MED-supported activities in EE/ESD to derive implications for an ongoing improvement of media-assisted location-based learning and for professional development in this field.

Accordingly, this study aims to compare the evidence-based scientific requirements of using mobile devices fruitfully to the recent educational programs and the implementation of mobile technology, there. In detail, the following aspects are addressed:

(i) Target groups: Who is addressed with MED-supported educational activities?
(ii) Provider: Which institutions provide educational activities using mobile devices?
(iii) Technology: Which devices are used? Which network technology, platforms and digital tools are used?
(iv) Educational and pedagogical orientation: Which are the educational concepts underlying the educational activities supported with mobile devices?
(v) Environmental education/ESD inputs and outcomes: Which goals of environmental education/ESD are intended within the educational activities using mobile devices and which outcomes are expected?

2.1. Questionnaire Development and Online Survey

The different educational activities supported by mobile electronic devices in environmental education/ ESD were assessed with a questionnaire. It comprises the aspects mentioned above. The first part of the questionnaire focuses on the general aspects of educational activities supported by mobile devices (aspects (i) to (iii)), the second part of the questionnaire aims to get further insight into educational formats and methods (aspect (iv)) as well as the goals and the expected outcomes (aspect (v)).

The items for all dimensions were derived from the framework briefly described above and in total 40 items were formulated. For the educational and pedagogical dimension (see Table 2), each item provides two opposite poles (example: "*The educational activity is related ... vs. ... is not related to school curricula*") ranked on a four-level Likert-scale. For this dimension, 24 items were incorporated in the data analysis. In a first step, a factor analysis (extraction of principal components with varimax rotation) was conducted and it revealed a four-factor model. For further processing, only items with factor loading above 0.7 were considered and 19 out of 24 items (Table 2) were included in the final analyses. The reliability is acceptable, because the sub-dimensions assess personal statements about educational activities, including personal interpretations, and not the respondents' psychological properties (*cf.* [34]). According to Schmitt [35] a low Cronbach's alpha "may not be a major impediment" to use a number of items as a scale if reasonable arguments can be found or theoretically derived. Other non-experimental studies in educational research (*cf.* [36]) discussed the role of Cronbachs alpha in field studies, and values above 0.6 were considered to be viable under circumstances comparable to this study.

The scale for the educational and pedagogical dimensions is complemented by a scale for content-related dimensions (defining *EE*-goal achievement, like environmental knowledge, attitudes or behavior and *ESD* criteria like local/global, static/dynamic, sociocultural/ecologic/economic consequences, *etc.*) as well as the focus on *ESD*-related competences (e.g., justice, transdiciplinarity, morality) within the educational activity (Table 3). Furthermore, several items were included to assess to what extent the educational activity focuses on environmental education-related nature experience dimensions (e.g., aesthetic, social, conservation- or adventure-related, recreational, *etc.* (*cf.* [37–39])).

Table 2. Item examples of the final questionnaire to assess the educational and pedagogical dimension of *MED*-supported *EE/ESD*-activities (four-level Likert scale between two opposite poles).

Sub-Dimensions	Item Examples
social interaction (5 items, Cronbach's α = 0.90)	- participants do … *vs.* … do not discuss with others - participants are … *vs.* … are not responsible for the common result of the activity
degree of media orientation (2 items, Cronbach's a = 0.73)	- educational activity is strongly … *vs.* … not influenced by digital media
(socio-inter)active learning (3 items, Cronbach's a = 0.64)	- participants are passive … *vs.* …active during the activity - participants are receptive … *vs.* …productive
educational setting (5 items, Cronbach's a = 0.71)	- participants follow a predefined time-schedule … *vs.* … have a self-determined working speed within the educational program - MED-activity provides (formal) … *vs.* … does not provide connection to curricula (informal)
goal orientation (4 items, Cronbach's a = 0.68)	- learning goals are set … *vs.* … participants set their own goals - topics of the educational activity are predefined … *vs.* … participants work on self-determined topics

Table 3. Item examples for the scale development to assess input/output dimensions of *MED*-supported *EE/ESD*-activities (four-level Likert scale between *provided* and *not provided*).

Dimension	Item Examples
EE-dimensions (inputs) (10 items, Cronbach's α = 0.70)	Which nature experience do you foster with your activity? - aesthetic dimension (perceiving the beauty of nature) - social dimension (human-animal relationship) - recreational dimension (leisure-time in nature)
ESD-criteria (inputs) (6 items, Cronbach's α = 0.82)	Which criteria does your activity meet? - global and local aspects were involved - social, cultural, economic and ecological aspects were discussed
EE-targets (outputs) (3 items, Cronbach's α = 0.68)	Which are the goals of your activity? - environmental knowledge - attitudes towards nature - pro-environmental behavior
ESD-competences (outputs) (12 items, Cronbach's α = 0.82)	- being able to take one's else perspective - being able to participate

The methodological dimension encompasses facets of the *MED* usage (e.g., navigation, orientation, receiving information, collecting data, communication, *etc.*), of external representations (image, text, audio, *etc.*) and addressed senses (visual, auditive, olfactory, *etc.*) or about the tagging of the *MED*-supported activity (e.g., traditional cache/multicache or routing, degree of gamification, collaboration/ competition) and if Web 2.0 tools or social media are used for collaboration and communication.(e.g., facebook, snapchat, instagram). Furthermore, data about technical aspects (operating systems, software, type of devices) as well as aspects of the target groups is collected. At the end of the questionnaire, the respondents described briefly their educational activity and the free-text was analyzed with respect for the degree of participants' involvement (exploration *vs.* guided-instruction) and access to location-based information (autonomous *vs.* predefined routes).

2.2. Nationwide Survey with Online Questionnaire

The online survey was advertised within specific mailing lists, through educational institutions and relevant stakeholders (e.g., German Federal Environmental Foundation, German Association of Biological Education, National Working Committee of Environmental Education, nature conservation centers) and thus approximately >10,000 persons were contacted using these communication channels. In a next step, 150 educational programs using mobile devices in *EE*/*ESD* were identified and the educational staff was contacted via e-mail, 98 of these projects could be contacted via telephone. Finally, in total 120 project representatives or educational staff conducting educational activities supported by mobile devices in Germany and Austria participated in the online survey (data collection: January 2012 to July 2012). The educational activities were quite diverse and they covered a broad understanding of environmental education/ESD as well as different target groups (e.g., school-children in formal learning contexts, adolescents in leisure-time activities, touristic purposes). For further details of participating educational programs see www.mobi-lu.de.

3. Results

3.1. Descriptive Analyses of the Online Survey Data

Most of the respondents focus on children between 11 and 16 years (91%) while the age-groups between 16 and 50 years are also in the focus of the *MED*-supported activities (± 40%); see Figure 2. Most of the *MED*-supported activities are provided by nature conservation centers (32%), schools (23%) or others (32%) like, for instance, open youth work, zoos or touristic providers (Figure 3).

The addressed audiences (Figure 4) are lower secondary (77%) and higher secondary (68%) or comprehensive school students (55%), individual persons (55%) and families (55%). The most popular devices were GPS receivers (83%) followed by smartphones with sensitive touch display (39%), PDAs (26%), cell phones and tablets (21%); see Figure 5.

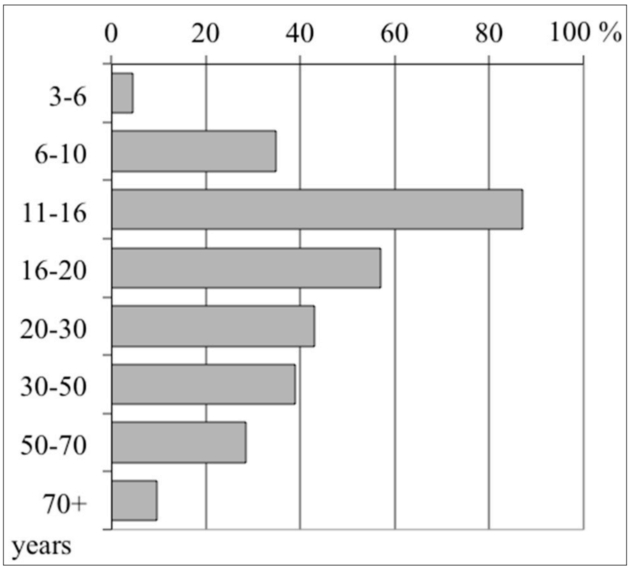

Figure 2. Age range of participants participating in educational activities with mobile devices.

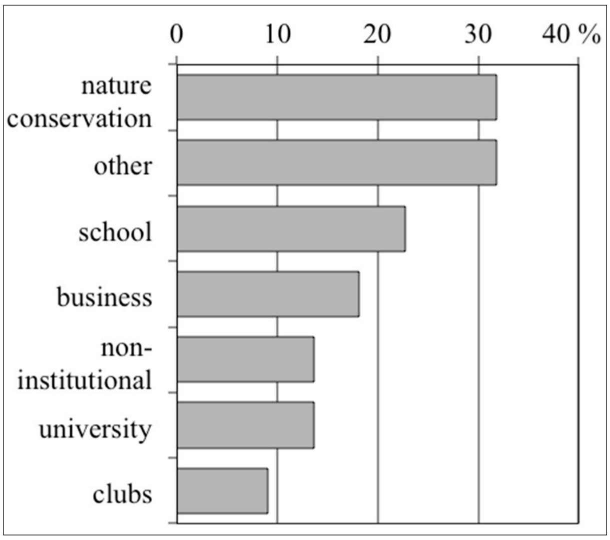

Figure 3. Institutions offering educational activities with mobile devices.

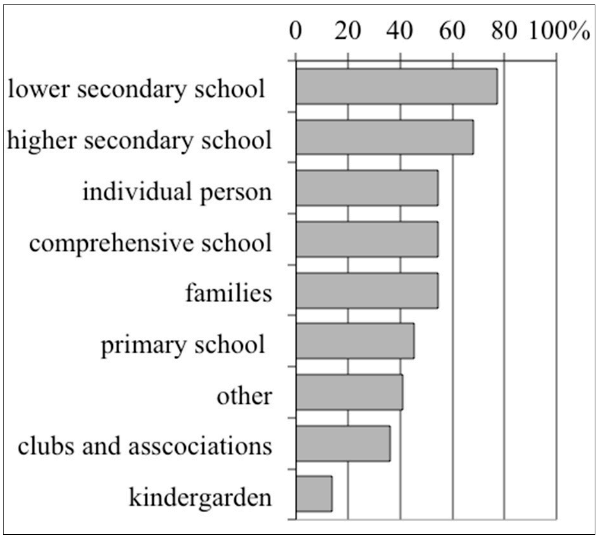

Figure 4. Addressed audience of educational activities with mobile devices.

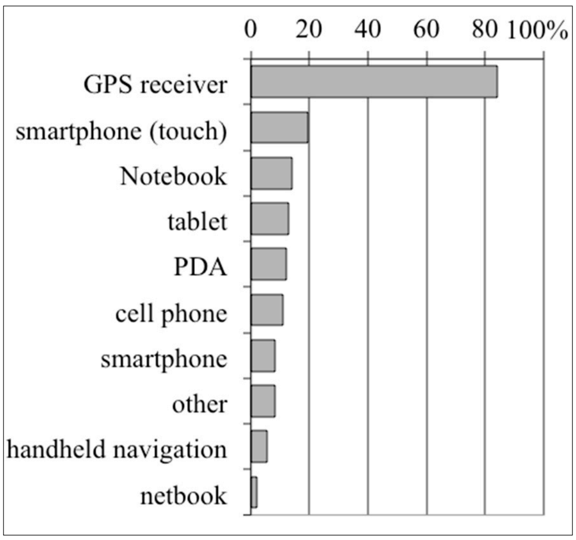

Figure 5. Type of devices used.

The providers of the *MED*-supported activities reported that they use the different devices to help their audience to find specific places (73%), to support orientation in the field (61%) and to offer specific information at their recent location (65%). All the other more engaging activities are less represented (<20%); see Figure 6. "Traditional" representations (text and image) were preferred while dynamic audiovisual representations of information are rarely used (Figure 7) and, thus, the potentials of mobile devices like smartphones remain idle.

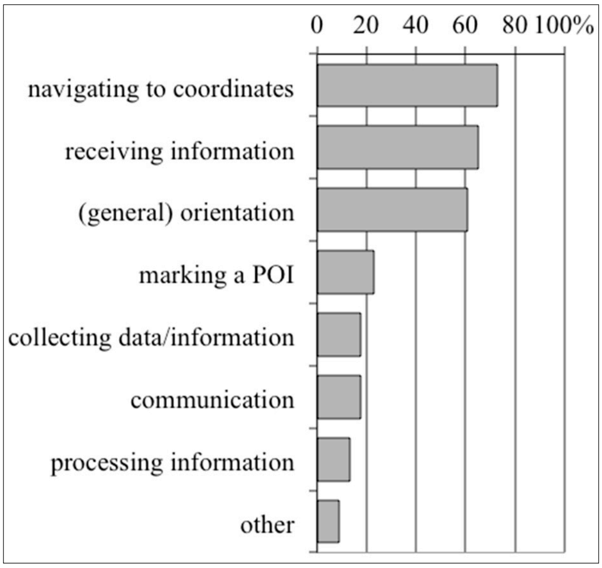

Figure 6. Different uses of mobile devices in educational activities.

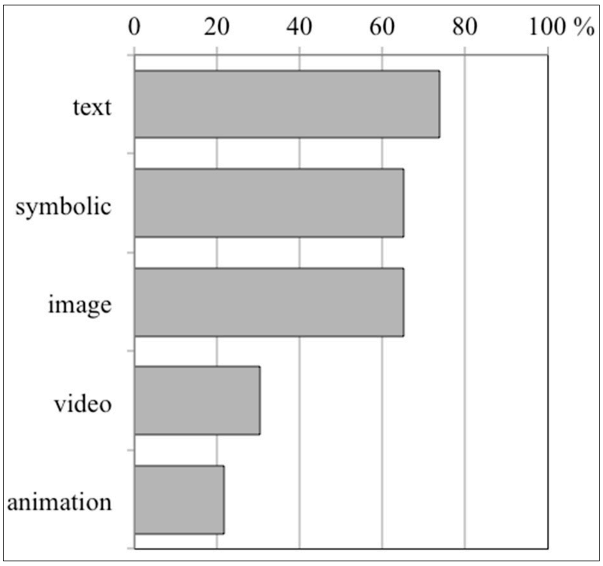

Figure 7. Type of data/information representations in educational activities with mobile devices.

As most of the educational activities use GPS-devices, it seems likely that geocaching is the prevailing type of activity (Figure 8).

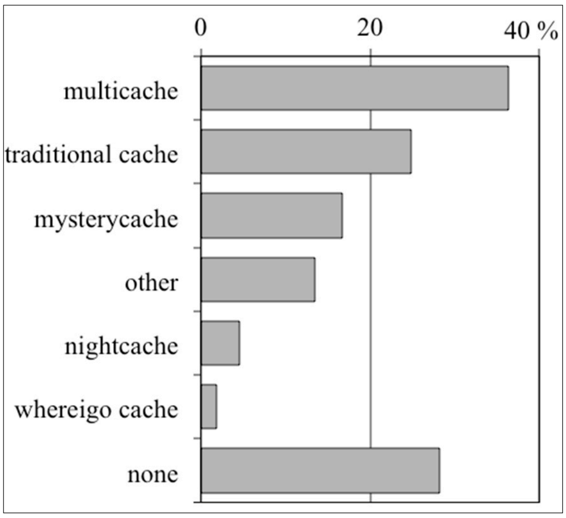

Figure 8. Type of geocaching activities.

Thus, one out of three activities (36%) provides some sort of routing using a multicache-methodology: Starting with one set of coordinates, the participants have to solve some tasks at a specific place and if they perform adequately they receive the coordinates for the next location. This provides users with a predefined linear route. However, also other popular types of geocaches are used (traditional caches—finding caches using given coordinates (23%), or mystery caches—a mystery or a riddle has to be solved to get the final coordinates (27%)).

Less than one half of the educational activities takes profits from the mobile access to the internet (Figure 9).

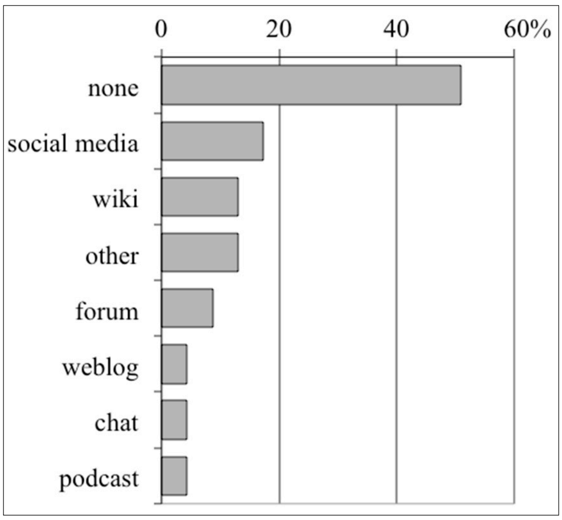

Figure 9. Online activities.

The educational activities with mobile devices predominantly address the criteria of ESD: The respondents reported that they intend, for instance, to focus on perspectives of sustainable development on a local and global scale, they intend to depict the participants' individual behavioral options toward a sustainable development providing authentic experiences ($M = 2.98 \pm 0.65$; Figure 10). In contrast to the intended input, mostly environmental education-related goals (e.g., EE-related knowledge, environmental behavior or attitudes) are reported to be achieved ($M = 3.45 \pm 0.59$; Figure 10).

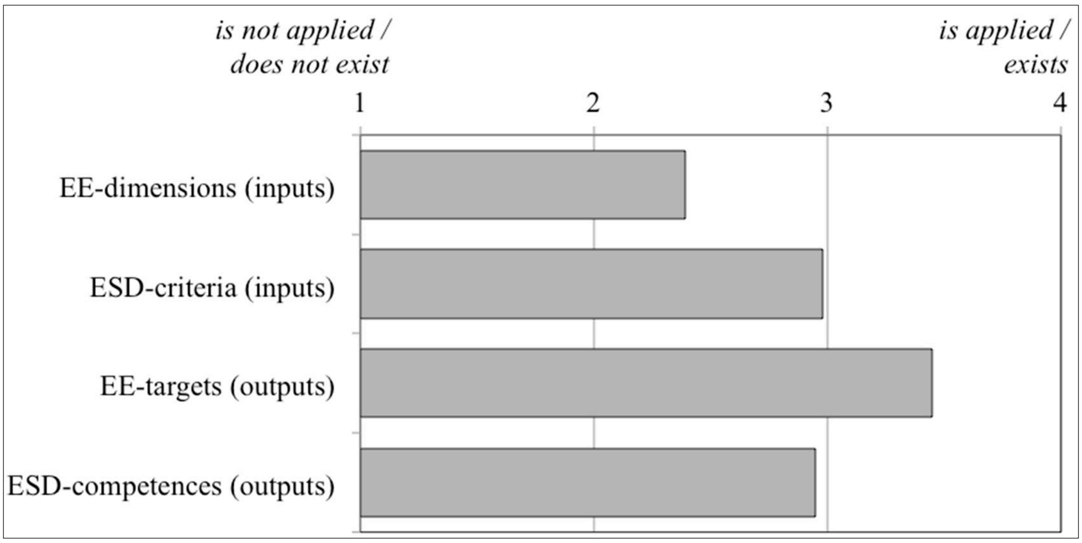

Figure 10. Inputs and achieved outputs of EE and ESD (4-level Likert-scale, mean values).

The results concerning the educational-pedagogical dimension show a strong focus on collaboration and productive learning within a foremost informal learning setting. An inconsistency in these aims is the fact that learners are intended to follow predefined goals and methodologies which reduces the degree of self-determination. The use of media is reported to be widespread ($M = 2.65 \pm 0.41$) and differs strongly between the educational activities (Figure 11).

In a nutshell, the results (Figure 11) point towards an average educational activity in environmental education/ESD to focus on school-aged children and adolescents who participate with their whole class at an out-of-school setting provided by non-formal educational staff. According to the respondents, the activity fosters social competences and collaboration, and the participants are engaged in interactive and productive learning processes. The educational activities focus strongly on predetermined goals. GPS devices are the most popular technology and the connectivity to the mobile internet is not broadly used.

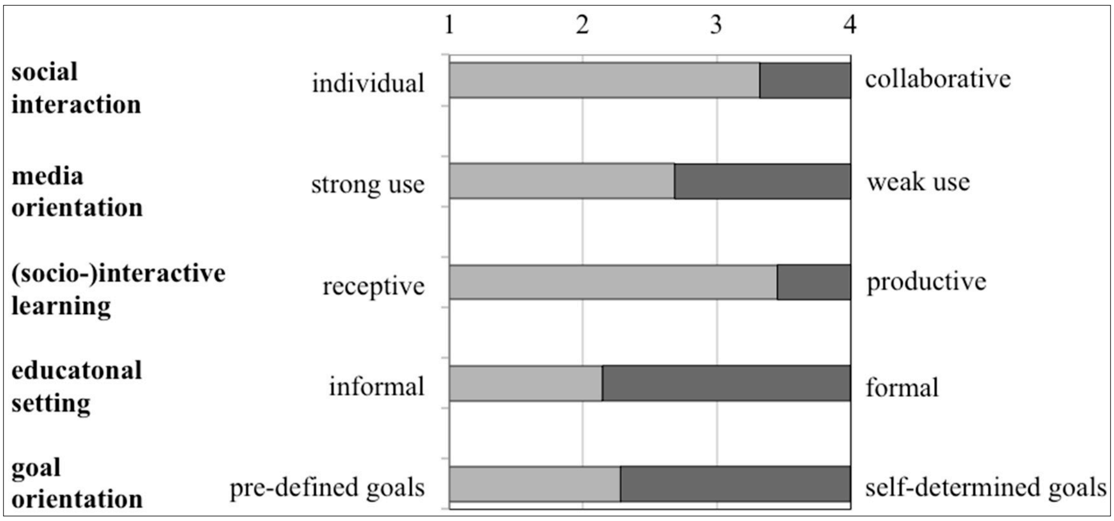

Figure 11. Educational-pedagogical dimensions of educational activities with mobile devices (four-level Likert scale, mean values).

3.2. Classification of the Educational Activities

These descriptive results give an overview of the recent use of mobile devices in environmental education and ESD. The next step within the data analysis is to identify a typology for educational activity formats. Therefore, all educational concepts were classified according to the degree of involvement and autonomy of the participants, *i.e.*, if prepared information is provided at the location or if oneself creates information directly *in situ*. For analysis, the items from the questionnaire were used and, additionally, a four-field-scheme was set up. It consists of two axes: (1) The individual's degree of autonomy was derived from the data with respect to the involvement from exploration to direct instruction; and (2) the access to different locations from unregulated-free-choice to predefined-linear routes (Figure 12). In an *instructional setting*, all tasks were predefined (e.g., to solve a question, to measure temperature on a specific spot at a lake). In an *exploration setting*, the participants have to process location-based information themselves (e.g., to create their own location-based questions or tasks that are specific to a particular location). Predefined routes consist of specific geographical locations that have to be found in a specific sequence (like using multicaches with information for consecutive geographical coordinates). In a setting with undefined routes, the participants decide themselves where to go or where to go first (like hiking in a national park with optional access to location-based information on specific places or choosing one's own places for setting up a geocaching experience for others). Thus, in the upper right (Figure 12, field 2) of our classification scheme, autonomy is at a minimum, and in the lower left (Figure 12, field 3) the highest degree of autonomy is provided. Most of the educational concepts (66%) were assigned to field 2; in fields 1 and 4 were the fewest educational concepts.

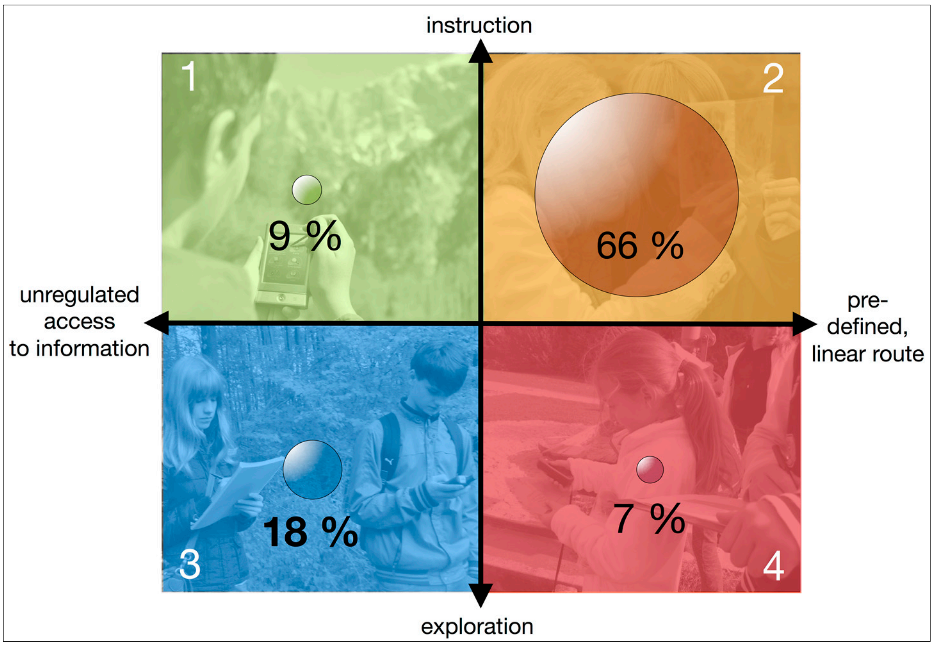

Figure 12. Four-field-classification according to the participant's degree of involvement and autonomy.

3.3. Divergences between Delphi Results and Survey Data

(1) The results of the online survey indicate that two thirds (66%) of the educational activities in environmental education/ESD that are supported with mobile devices are designed as predefined linear routes providing a high degree of instructional guidance. The GPS devices, reported to be the dominant devices, are capable of finding places and they provide text-based information at specific locations via *POI* (= Points-of-Interest). Thus, using GPS devices, in contrast to the use of smartphones with a multitude of possibilities to generate, process and share data, the options to engage users within diverse location-specific interactions are limited. So, further materials (e.g., books, papers, cameras) would be needed. Both aspects contradict the experts' most important goal of using mobile devices in environmental education/ESD as facilitators to actively create meaningful location-based content on their own. One might argue that the study was conducted in the year 2012 and, thus, smartphones were not as common as in the year 2015. According to the German Youth Media Study [40], in 2012, in two of three households at least one smartphone was available and one half of the adolescents (12–19 years) owned a smartphone. In 2014 [41], 94% of the German households and approximately 89% of the adolescents used their own smartphones. However, as the multiple potentials of the recent devices were already largely known at the time of this study, even a careful interpretation highlights this divergence between experts' assumption and everyday practice in environmental education.

The respondents of the online survey intend their educational activities to support active-constructive learning. However, online tools and social network platforms are rarely used which reveals a divergence between the intention and the real implementation of the mobile devices in environmental education and ESD.

(2) The Delphi experts highlight tangible educational goals as a central dimension for the assessment and evaluation of *MED*-supported activities. The starting point of every educational intervention should therefore be a clearly outlined goal description. The online survey results indicate an unclear view: On the one hand, the respondents focus on informal learning and at the same time the learning goals are often predefined thoroughly. A weak negative correlation can be identified between the degree formality of the educational activity and the degree of predefined goals (Spearman-Rho r = 0.24, $p < 0.5$): The more formal an educational activity with mobile devices in environmental education /ESD is described to be, the less the educators reported to set up clear goals. The data indicate that the respondents' intentions, if they provide informal learning settings within their educational activities, cover broad aspects of environmental education/ESD and they clearly foster general educational goals like improving social skills and collaborative exploration or graphical orientation skills.

4. Discussion and Conclusions

The potential of mobile devices in environmental education/ESD are manifold and well-designed engaging educational activities can be offered to different target groups. According to the experts' considerations [29], the data of the online survey in this study point towards a fruitful implementation of location-based learning with the support of digital mobile devices in different settings and for different target groups. Even though the central target group is reported to be school-aged children in formal educational settings, the distribution of different age-groups indicates a widely accepted implementation of mobile devices in many fields of environmental education and education for sustainable development—families, individual visitors of landscapes or nature conservation centers and members of (nature conservation) clubs are addressed to the same extent in their leisure time.

The data showed a strong intention of the educators responding in this study to achieve general goals of environmental education and to improve specific skills related to *ESD* using mobile devices. However, this approach seems to follow incidental learning intentions that drive the development of the educational activity itself, and hence they often neglect the opportunity to exploit the potential of mobile devices, or to avoid the obstacles reported by the experts in the Delphi study. Major aspects obviously are the restriction of location-based activities to instructional methodologies as well as neglecting the opportunities provided by recent mobile internet and web 2.0 tools. Especially, participatory location-based learning activities could be fruitfully integrated into environmental education and ESD with mobile devices. For instance, Marfisi-Schottmann and George [42] describe an approach to create collaborative mobile games with students. Heimonen and colleagues [43] present a platform which allows creating location-based learning activities where learners can collaboratively document their learning using their own mobile devices *in situ*. Clough [44] analyzed the community of geocachers using a geocaching online platform. She highlighted the role of this web 2.0 to link the virtual social space on the platform with the real physical space in the environment. Since the availability of smartphones in 2007, lots of powerful mobile learning approaches were developed and tested taking advantage of mobile access to the virtual world. In contrast, the providers of educational activities involved in this study were not aware of these possibilities, or the organizational, technical or even personal resources that allow for up-to-date educational activities supported by mobile devices were not available. One might argue that educational programs with mobile devices might be expensive (cost of the devices, devices go out of date rapidly, costs for the mobile internet provider). This can be avoided using participants' own devices which recently might be more and more workable due to the widespread distribution of smartphones. A prerequisite for these BYOD approaches (bring-your-own-device) and to take advantage of the opportunities provided by mobile devices is a certain technological expertise of the educational staff. According to Koehler and Mishra [45], technological knowledge is a part of educators' professional knowledge resulting in the widespread *technological pedagogical content knowledge—TPACK*. Hence, major components of an educator's professional skills are not only based on content-related or pedagogical knowledge but also on knowledge and experience with (mobile) technology in general and specifically with technology-enhanced learning. This, in terms, seems not to be strongly established in the group of the respondents of this study. The challenge of adopting new technologies within a domain like environmental education, fostering experiential learning and practical actions in nature, would be to combine the strengths of the "real" and the "digital" world. This should be trained, and professional development for the educational staff or at least some type of guidance during the process of creating inspiring educational programs and activities supported by mobile devices seems to be needed. According to the TPACK-model, professional development of educational staff in environmental education would be improved by adding technological knowledge (e.g., basic understanding of geo-informatics, technological support in environmental fieldwork) as well as technological content knowledge (e.g., how does mobile technology support location-based learning in environmental education/ESD) to the already existing pedagogical content knowledge. This would be the most effective way to improve the quality of programs in environmental education/ESD using mobile devices, but it is also the most expensive and the longest one.

Educational storyboards as guidance for the design of educational scenarios supported by mobile devices are a promising alternative to an extensive training. Educational storyboards are a kind of step-by-step template to help the educational staff during the design of educational programs. Starting from a clear description of the educational goals (*precise—feasible—assessable, educational or content-related focus, EE goals or ESD skill development, etc.*) the target group is described from different perspectives and according to different prerequisites. The next step is to clarify the location-specific, the organizational and the structural circumstances of the educational program using mobile devices and to relate them to the goals formulated in the first step. The third step is to outline the participants' learning activities and to specify the advantages of (learning) activities moderated by mobile devices compared to traditional tools and methods. If this last step cannot be adequately described, the technological support is superfluous and mobile devices act as gadgets just profiting from a short novelty effect. All these discrete planning steps are supported by distinct checklists to facilitate decision-making. Especially, educational staff with lower TPACK could profit from such a sequential process and it helps them to take advantage of the fascinating opportunities potentially provided by recent mobile devices and upcoming technology in the future.

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Author Contributions

Both authors contributed to the study design and wrote the manuscript together.

Conflicts of Interest

The authors declare no conflict of interest.

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