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A Systematized Review of the Use of Mobile Technology in Outdoor Education

Imre van Kraalingen

Department of Teacher Education and Outdoor Studies, Norwegian School of Sport Sciences, Oslo, Norway

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Abstract

This inquiry reports the findings of a systematized review of recent studies concerning the affordances associated with implementing mobile technology in outdoor learning. The emergent employment of mobile technologies in education worldwide adds new layers of complexity to the field of outdoor learning that require a better understanding. The purpose of this review is to summarize and critically interrogate peer-reviewed studies that explore the use of mobile technology in outdoor learning activities, and to identify gaps in current research. Taken collectively, the 33 reviewed articles mirror the dualism that is present within the field. Whilst some studies show that the portability and accessibility of mobile devices offer new opportunities for outdoor education, others point at issues of complexity, safety, and loss of experiential quality. The findings highlight three principal strategies that offer meaningful ways to overcome the tensions between technology and teaching and learning out-of-doors: mitigation, intentionality, and adaptation. The review thus offers a deeper understanding of the ways in which outdoor learning programs can effectively integrate mobile technology to overcome the nature-technology dichotomy.

Keywords: outdoor education; outdoor learning; adventure education; mobile technology; systematized review.

Introduction

There exists an ambivalence between the perspectives of outdoor educators, researchers, and practitioners on the use of modern and mobile technology in outdoor education. Traditionally, direct and sensory experience of nature, the development of skills to manage oneself in the outdoors, and personal and social development, have long been the three cornerstones of outdoor education (Beames, Atencio & Mackie, 2019; McClain & Zimmerman, 2016). However, the field of outdoor education is not immune to the proliferation of modern technological advancements (Cuthbertson et al., 2004; Payne & Wattchow, 2008). The increasing use of digital devices does not leave people's engagement with nature untouched (Becker, 2018). This has led the field of outdoor education – and of education in general – to become far more complex. Cuthbertson et al. (2004) signify the ambivalence and complexity regarding technology and outdoor learning in terms of a 'double-edged sword', which refers to the wide-ranging impact and affordances of modern technology (Beames et al., 2019; Hills & Thomas, 2020). The theory of affordances was introduced by Gibson (1977) to illustrate that any tool or substance has an affordance for positive or negative usage to someone. In the context of this article, it considers the benefits and pitfalls of using mobile technologies.

There is increasing attentiveness being paid by researchers to the affordances of using mobile technology in outdoor learning settings (Greenwood & Hougham, 2015). While no consensus has been reached, there is a need to better understand the new layers of complexity in outdoor teaching and learning. Thus, this systematized review aims to synthesize extant research on the affordances and strategies of integrating mobile technology into outdoor learning practices, and to identify gaps within it, to provide a foundation for future studies.

Context

Outdoor education

Priest (1986) explained outdoor education as an overarching method for learning that includes various forms of education in and about the outdoors. Following this, Gilbertson et al. (2006, p. 4) outline the following characteristics of outdoor education: 1) it primarily takes place in the outdoors, 2) it is experiential and holistic in terms of using all the senses, and 3) it is about relationship between people and nature. Other studies highlight the equal importance of personal and social development in terms of developing self-confidence, solution-oriented thinking and learning to cooperate with others (Beames, Mackie & Scrutton, 2020; Smith, 1987; Wilhelmsson, 2012). In other words, the main intention of outdoor learning is to provide an alternate learning arena that complements classroom-based education, stimulates the experiential learning processes, enhances students' personal development, and inspires stronger connections to the natural environment.

For the purposes of this inquiry, the term outdoor education includes any structured learning activity conducted in an outdoor setting that aims to achieve predetermined pedagogical objectives (Hills & Thomas, p. 156). For instance, this can involve adventure education, environmental education, experiential education, and other outdoor learning programs at schools, outdoor centres, and on expeditions. In short, outdoor education is understood as a way of delivering subject areas outside the classroom while maintaining a predefined curriculum.

The commodification and technologization of outdoor life

The previous section provided an overview of the core objectives of outdoor education. In terms of the outdoors taken more broadly, from the turn of the millennium, outdoor experiences in general have been reported to be increasingly subject to commodification (Cloke & Perkins, 2002; Skogen & Jonsson, 2009; Varley, 2006) and hyper-technologization (Beery, 2013; Champ, Williams & Lundy, 2013; Lamberg & Muratori, 2012). People today are increasingly likely to explore the natural world equipped with what Elliot and Urry call *miniaturized mobilities*, such as mobile devices and GoPros (2010, p. 5). While some studies refer to technology in more general terms, also encompassing equipment and clothing (Schultis, 2001; Valenzuela, 2020), this article specifically uses the term *mobile technology* to refer to any electronic, wireless, handheld device that can serve as a tool for cellular communication, the documentation of information and that provides access to online resources (Ozdamli & Cavus, 2011; Weilenmann, 2001).

Existing studies show some clear patterns with regards to the interplay of technology and experiences of the outdoors. There is a general consensus that unmediated contact with nature is beneficial for people's – especially children's – physical, emotional and mental wellbeing (Charles & Louv, 2009; Lehmann, 2019; Maller, Henderson-Wilson & Townsend, 2009; Muñoz, 2009; Russell et al., 2013; Wells & Lekies, 2006). Consequently, the increasing lack of direct and unmediated contact with nature can contribute to various physical, emotional and mental health issues (Charles & Louv, 2009; Louv, 2016; Otto & Pensini, 2017; Soga & Gaston, 2016). Connected to this, is the argument that increasing screen-time may negatively affect people's physical, emotional and mental well-being (Edwards & Larson, 2020; Larson et al., 2019; Orben & Przybylski, 2019; Schilhab, Stevenson & Bentsen, 2018). The increasing awareness of the benefits of direct experience of nature has inspired school- and non-school-based programs across the globe to offer outdoor learning activities for their students and participants (Beery, 2013; Cuthbertson, Socha & Potter, 2004; Sandell & Öhman, 2010).

What is not agreed upon in the literature, however, is precisely *how* scholars, educators and practitioners can best embed technology in a manner that will positively contribute to attaining given educational objectives. Some studies indicate that there are positive aspects of mobile technology, especially in providing opportunities that increase safety and informativity during outdoor activities (Hills & Thomas, 2019; Leyshon, DiGiovanna & Holcomb, 2013;

Licoppe & Inada, 2016), while others suggest that young people's use of mobile devices can pose distractions and lead to a loss of experiential quality[1] (Hills, 2019; Hills & Thomas, 2020; Kahn, 2011; Lamberg & Muratori, 2012).

Whilst technology-supported learning outside the classroom is becoming increasingly popular, it also comes with some inevitable considerations. The main challenges concern being more deeply aware of how technology can mediate people's relations to nature and one another (Beames, 2017), and to better understand the implications of the digitalization of outdoor learning (Dugalić & Lazarević, 2018). Overall, the intersection of technology-mediated learning and outdoor learning remains under-examined in the literature on outdoor learning.

Rationale and aims

As shown in the previous section, a considerable number of studies have addressed the affordances of mobile technology usage in outdoor learning activities, but only a limited amount of research has been done that provides evidence-based guidance for the successful integration of mobile technology. Moreover, the studies that concern the interplay of mobile technology and outdoor learning have not yet been evaluated as a body of literature. Hence, there is a need for a clear overview of the impact of, and strategies for, the implementation of mobile technology within outdoor learning curricula.

Against this background, the purpose of this review is to summarize and critically interrogate peer-reviewed studies that explore the use of mobile technology in outdoor learning programs. Overall, the review aims to: (1) map current trends in research on mobile technology usage in outdoor learning (2) categorize and synthesize reported outcomes; (3) discuss the

[1] Experiential quality is a somewhat vague and contested term, and one that is big too to discuss in this article. The concept is mentioned here, as it was highlighted by the cited authors.

affordances and strategies for implementing mobile technology; and (4) identify research gaps in current studies.

Methodology and Methods

Aromataris and Pearson (2014) underline that literature reviews often contain relatively limited searching and reporting, which reduces reproducibility and transparency in terms of how the literature review was conducted and why certain decisions were made during the process. Subsequently, it is argued that there is a need to carry out literature reviews in a more systematic way – one that minimizes bias and error through the use of protocols (MacDonald, 2000, p. 131). The core objective of *systematic reviews* is to provide a protocol and parameter- driven, comprehensive and transparent approach to searching, selecting and summarizing literature (Bearman et al., 2012).

Initially, this inquiry set out to do a systematic review. However, a variety of difficulties were encountered. During the test searches, either no results or irrelevant results showed up. Moreover, some articles that were found in preceding 'non-systematic' literature searches did not show in the search results. Whereas these complications may be due to a complex formulation and interplay of the search synonyms of mobile technology and outdoor learning, they also indicate that the systematic review is not without its problems as a research method.

Hence, this article undertakes a *systematized review*. Grant (2009) explains systematized reviews as an 'attempt to include one or more elements of the systematic review process while stopping short of claiming that the resultant output is a systematic review' (p. 102). Crucially, however, are the a priori planning, and traceable and clearly documented review process which, together, demonstrate how the findings and interpretations are distinctly derived from the data. This aids in establishing trustworthiness, rigor and confirmability of the systematized review and analysis (Moher et al., 2015; Nowel, Norris, White & Moules, 2017).

The review borrows some of the core features of the PRISMA guidelines for conducting and reporting to identify and analyze existing literature. The PRISMA protocol guidelines are an established tool for systematic reviews and aim to increase their accuracy and quality (Aromataris & Pearson, 2014; Moher et al., 2009). The steps included in the review process are: (1) define a structured question and objective, (2) provide detailed inclusion and exclusion criteria, (3) conduct a comprehensive search to identify relevant studies, (4) conduct critical appraisal, (5) extract and synthesize the data, (6) present the findings, and (7) analyze the extracted data from the included research studies.

Search Strategy

A systematic approach to a search strategy comprises clearly defined search filters that will be used within each data base (Aromataris & Riitano, 2014). The databases searched for peer-reviewed articles were: ERIC, ScienceDirect, SAGE, JSTOR, and Taylor & Francis. These search words and synonyms were used:

- TOPIC**:** "Digital technolog*" OR "digital devic*" OR "mobile devic*" OR "handheld devic*" OR "mobile technolog*"
- *AND* TOPIC**:** "outdoor educat*" OR "outdoor learn*" OR "adventure educat*"

The descriptive features of the search strategy include the key terms on which the search process is built, language, dates and other search filters (Kesänen, Leino-Kilpi, Arifulla, Siekkinen & Valkeapää, 2014), which are outlined in the eligibility criteria. Importantly, the reference lists and citations of selected articles were also screened to find additional relevant studies.

Eligibility Criteria

The studies selected for inclusion were based on a final set of eligibility criteria which is presented in Table 1.

Table 1 Sample inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Intervention	The use of mobile technology in outdoor learning programs	The use of online games, online entertainment, phone text or calling
Methodology	Theoretical, qualitative, quantitative or mixed-method research that seeks to investigate the role of mobile technology in outdoor learning	Non-peer reviewed literature, expert opinion, meta-analysis, pilot studies
Sampling	Outdoor learning programs with curricula	Outdoor learning programs without curricula
Language	English	Not English
Sources	Peer-reviewed articles	Conference abstract, review, dissertation, opinion, book.
Publishing date	Studies from 2010 to current	Studies before 2010

Each article was required to include intervention measures that relate to the interplay of mobile technology and outdoor learning activities that have set curricula. Each article was required to be peer-reviewed and published in English between 2010 and the present moment. It is important to acknowledge the exclusion of books in the review. It was decided not to include books, because they tend to cover larger themes that make it hard to compare the findings to specific case studies. Moreover, it can be difficult to validate whether the content of, and the sources cited in, books have been peer-reviewed.

Selection Process

First, a preliminary search of the selection process was carried-out to verify the search terms and eligibility criteria. Thereafter, the identified databases were searched for sources. Next, the titles and abstracts of the articles in the search outcomes were screened. Then, the articles that met the eligibility criteria were screened fully. The reference lists of the included studies were also checked to identify additional relevant studies. A total of 33 articles were selected based on the eligibility criteria.

Critical appraisal

According to Hannes (2008), a critical appraisal consists of three main stages: filtering, technical appraisal and theoretical appraisal. The first stage consists of the selection of included studies, as described above. The second stage assesses the level of methodological grounding of the article. The third stage evaluates the theoretical congruity (Noyes, Popay, Pearson & Hannes, 2008). The assessment of stage two and three is inspired by a simplified approach to critical appraisal taken by Gill (2014). The studies included in the current review were evaluated based on the following criteria:

- Does the research have a clear research question and aim?
- Is there a clear, justified methodology?
- Is there a clear theoretical consistency?
- Is there a clear analysis?

The results of the assessment are given in Appendix B. Following Gill's approach, each of the included studies has been graded 'good', 'average', 'unclear' or 'poor' according to the following criteria:

- Good: a positive evaluation of all the criteria
- Average: a positive evaluation of most of the criteria; no poor assessment
- Unclear: the quality is unclear for three or more of the criteria
- Poor: a negative evaluation of three or more of the criteria

Data extraction, analysis, and synthesis

From the included studies, the following characteristics were extracted: author, year of publication, title, sample size, target group, country, and methods. These focus areas are presented in Appendix A. The extracted data were synthesized using a thematic analysis approach as suggested by Clarke, Braun and Hayfield (2015). Thematic analysis aims to explore explicit and implicit meanings in the research data. Descriptive thematic analysis intends to summarize and describe patterns of meaning in the data (2015, p. 226). Thus, the analytical approach is qualitative in the way it looks for themes that lie in or across individual studies, and interpretative in broadening the understanding of the identified themes and findings. First, the main descriptive characteristics of the selected studies are summarized. Thereafter, the findings are organized into the three generated thematic domains: the benefits, pitfalls, and strategies of mobile technology usage in outdoor learning programs.

Findings

Characteristics of included studies

Appendix A shows the main descriptive characteristics of the 33 included studies. The first set of 14 studies was conducted with primary and middle school children under the age of 14. The second set of two studies focused on adolescents between the ages of 14 and 21. The third set of nine studies featured university courses. The fourth set of three studies involved educator perspectives. Only one study focused on adult-learning. The final four studies are theoretical articles that did not indicate a target population. The sample size of the included studies ranges from two to 747 participants.

Dimension 1: Benefits of using mobile technology

A significant amount of research highlights various ways in which technology positively assists in outdoor learning. First and foremost, the included studies show that mobile technology can increase the motivation and engagement of participants with their environment by providing fun and interactive ways to observe and interact with the outdoors (Ardoin et al., 2014; Kumar & Chand, 2019). For instance, this becomes apparent in the participant-driven case study of Ardoin et al. (2014) on the triggers of interest in outdoor education. Their findings confirm that the integration of technological means, such as photo elicitation and online journaling spark the interest of students and contribute to memorable environmental learning experiences. Additionally, the participants of various other studies state that they experience more fun and enjoyment of activities supported by mobile devices (Anderson et al., 2015; Crawford, Holder & O'Connor, 2017; Kacoroski, Liddicoat & Kerlin, 2016; Palmárová & Lovászová, 2012; Pombo, Marques, Afonso, Dias & Madeira, 2019). Notably, each of these case studies featured children.

Secondly, the provision of information, prompts, questions, and interactive tasks on-location increases participants' interest for learning about a specific location. The findings of eight studies showed that the use of technological means deepened the learning experience and increased the participants' knowledge of a place (Hougham et al., 2018; Kamaraine, Reilly, Metcalf, Grotzer & Dede, 2018; Lai, Chen & Yang, 2014; Santos, Hernández-leo & Blat, 2014; Zimmerman, Land, Maggiore & Millet, 2019; Zimmerman & Land, 2006).

The third category of the benefits of using mobile devices in outdoor learning indicates that mobile technology encourages participants to explore the outdoors (Arnold, 2012; Crawford et al., 2017; Kärki, Keinänen, Tuominen, Hoikkala & Maijala, 2018; Santos et al., 2014), which may contribute to a stronger care and awareness of the natural environment (Adanali & Alim, 2019; Arnold, 2012; Huang, Chen & Chou, 2016).

Fourth, multiple studies identified the development of practical skills, such as: problem-solving skills (Adanali & Alim, 2019; Palmárová & Lovászová, 2012; Zecha, 2014), interpersonal and collaborative skills (Adanali & Alim, 2019; Kärki et al., 2018; Palmárová& Lovászová, 2012; Pombo et al., 2019) and map and navigation skills (Adanali & Alim, 2019;

Midgley, 2014; Schaal & Lude, 2015). The latter has received implicit attention in other included articles that use devices supported by a global positioning system (GPS). GPS embedded applications are used in ten of the case studies. Most commonly used is Geocaching, which is a location-driven game that is increasingly popular in outdoor and place-based learning programs (Adanali & Alim, 2019). Other applications inspired by Geocaching are EduPark (Pombo et al., 2019) and Treasure-HIT (Kohen-Vacs, Ronen & Cohen, 2012). All the variations of geocaching aim to offer learners a playful, educative, and interactive experience of the outdoors that enhances their overall skill development.

The fifth category of benefits focuses on how technology aids in gathering data about places and their unique characteristics and life-systems. Digital tools, such as GPS-enabled locative media, provide easy access to spatial information, which can be used – and shared – for further investigation, nature management, policy development, and educational projects (Midgley, 2014; Veletsianos et al., 2015; Zimmerman & Land, 2006).

Finally, mobile technology provides the means to take notes and visually capture the experience (Midgley, 2014; Veletsianos et al., 2015). This is an important point, because it helps both educators and learners to capture, organize and later disseminate the content of the learning experience.

Dimension 2: The pitfalls associated with mobile technology use in outdoor learning

In 15 out of the 34 studies, the negative impacts of mobile technology on outdoor learning were addressed. The principal critique is the complexity of mobile technology and, subsequently, the skills that are required from both the teachers and the students to use such tools. A total of eight out of 33 studies expressed concerns about the educator's ability to use the technology appropriately. In addition to this, Su and Cheng (2013) draw attention to the varying abilities learners may have with technology.

The second pitfall is the risk of failing equipment. Midgley (2014) and Schaal and Lude (2015) highlight the risk of having to stop an activity when the equipment fails due to, for example, a battery running out of power or a faulty connection. The pitfall of a high dependency on technology also relates to the decline of participants' skills to manage themselves without technology, which is an important feature of outdoor education (Beames, 2017; Cuthbertson et al., 2004). Furthermore, Lai et al. (2014) argue that participants do not develop the same level of active thinking and problem-solving skills if they rely too heavily on mobile technology.

Third, four studies highlight the interference of technology with a holistic, direct experience of nature (Lai et al., 2014; Midgley, 2014; Peffer, Bodzin & Smith, 2013; Schaal & Lude, 2015). These studies raise the concern that the use of mobile technology places a barrier between learners and the natural environment. From the findings of the included studies, it seems that this is more a concern for the teachers than of the participants. This is understandable, because teachers must make decisions about their pedagogical objectives, whilst the participants may be more likely to view this from a point of enjoyment of the activity.

Other concerns are raised about resource availability and costs, which may contribute to inequities in terms of a lack of access to mobile devices learning tools (Hills, 2019; Schaal & Lude, 2015; Veletsianos et al., 2015). Furthermore, problems may surface when learners need to share a device (Kacoroski et al., 2016).

Finally, Lai et al. (2014) found that the usage of mobile technology does not always align with the educational objectives. This complication will be further addressed in the next section.

Discussion

The previous section presented the benefits and pitfalls that were derived from the included studies with a certain objectivity. The following section looks beyond this dichotomy and considers the strategies for implementing mobile technology in outdoor learning. Through a thematic analysis of the included studies, various perspectives on how to best employ mobile technology became evident. The main strategies are generally aligned to three themes: mitigation, intentionality, and adaptation. The framework presented in Figure 1 outlines the affordances and offers guidelines for decision-making concerning the strategies for application.

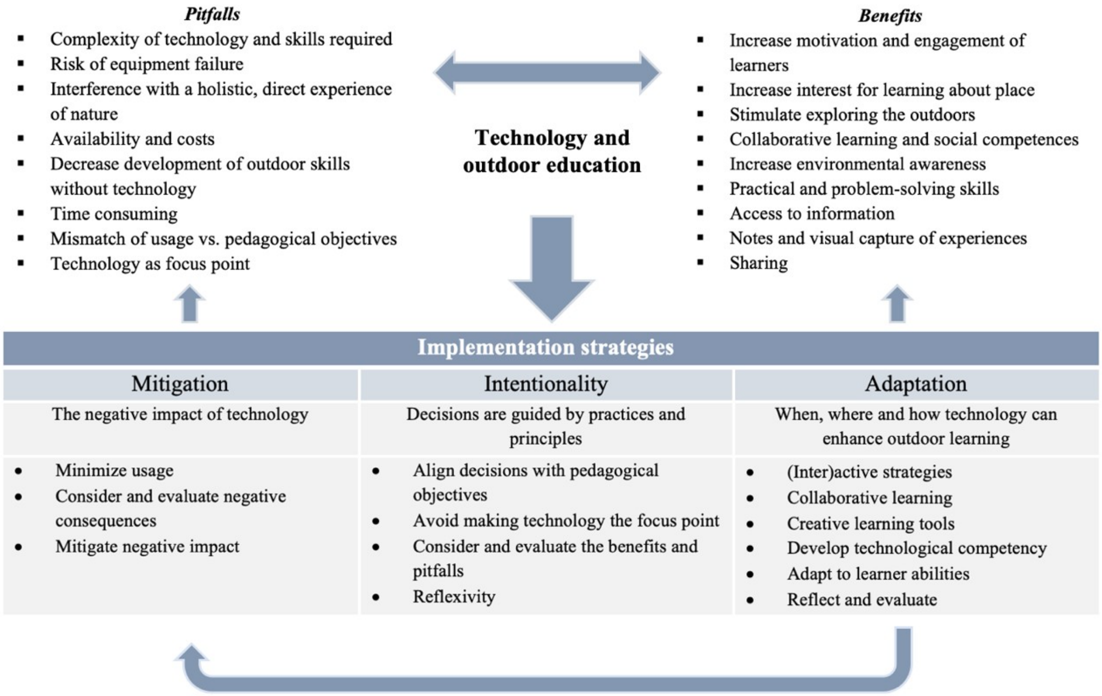

Figure 1 Considerations for implementing mobile technology

Mitigation

With respect to the considerable body of literature that draws attention to the negative impact of technology on outdoor learning and people's well-being, it is perhaps surprising that there are only four studies that explicitly highlight the importance of mitigating its usage in outdoor learning. In this article, the term mitigation refers to limiting the use of mobile technology to that which clearly aligns with the lesson plan. A key argument for mitigating the use of mobile technology is made by Greenwood and Hougham (2015), who underline that educators should avoid normalizing the use of technology in outdoor education and minimize it where it is not in service of the educational objectives.

Uncritical use of mobile technology may negatively affect the learning experience. This is exemplified by Bolliger, Mccoy, Kilty & Shepherd (2020) and Midgley (2014), who address the argument that mobile technology can be distracting and lead to a loss of the experiential quality of outdoor learning. Although, the findings of the studies reviewed in this inquiry indicate that this distraction is a concern of educators more than of students, as mentioned earlier, it is reasonable to maintain a critical stance to understanding how mobile technology reconfigures the traditional cornerstones of outdoor education. The argument that mobile technology threatens an otherwise direct experience with the natural world, and contributes to a reduction in both opportunities and the aspiration to encounter nature, is well-supported by other literature that examined outdoor learning *without* mobile technology (Smith et al., 2018; Uhls et al., 2014; Wattchow & Brown, 2011). More than 20 years ago, Robert Pyle (1993/2011) described this issue as the 'extinction of experience'. Subsequently, concerns were raised, and continue to be raised, about the interference and mediating impact of mobile technologies which may negative affect the development of people's behavioral, attitudinal and emotional relation to nature and biodiversity (Clayton et al., 2017; Soga & Gaston, 2016; Zavestoski, 2003).

The findings from Bolliger et al. (2020) show that most educators in their sample agree that mobile technology should be used as little as possible. Although the participants of their study showed willingness to use mobile devices and are open to enhancing the student's learning experience, only a very small number uses them in their programs. However, Bolliger et al. point out that younger instructors were more positive and open to the use of mobile devices compared those who had been in the profession for a long period of time.

On a final note, Greenwood and Hougham (2015) state that, before technology is adapted into an outdoor learning program, the intentionality must be clarified for both the educators and the students. This is the focus of the second theme.

Intentionality

Thomas' (2008) work on intentionality highlights the importance of educators' practices being guided by values and principles in order for them to deliver their objectives and outputs in a meaningful way. Previously, Ewert and Shultis (1999; Shultis, 2001) argued that teachers who use mobile technology may unintentionally encourage the use of nature for goals not often associated with outdoor learning, and thus obscure their learners' interactions with the immediate natural environment. This may also result in that the technological devices becomes the focus point of the activity. To avoid uncritical implementation of mobile technology, the literature indicates that educators need to better evaluate what underlying messages the use of equipment will convey to the participants and what the implications are for the learning process (Hills & Thomas, 2020; Lai et al., 2014; Thomas & Munge, 2017).

When the choice is made to incorporate technological means into educational activities, the *intentionality* behind this choice should be clarified for both the educators and the participants. With this in mind, Greenwood and Hougham (2015) argue that it is vital to assess the existing assumptions and the normalization surrounding the relationship between technology and environmental learning, and to acknowledge possible impacts of their increasing intertwinement. They write that 'critical studies of technology in relation to environment and culture are therefore a vital component of technology education, one which is mainly absent from environmental education discourse, policy, and practice' (p. 103). Thus, it is important that educators implement new technologies with adequate consideration of the negative consequences and avoid making bold claims about how easy and quick these learning tools can be used.

Additionally, Lai et al. (2014) also underline the importance of clearly defined theoretical frameworks that suit the purpose of, and help evaluate, technology-enhanced learning. With the rapid developments of mobile technology, it is perhaps not surprising that pragmatic approaches to adapting technological means in outdoor education have almost bypassed traditional theories and methodological frameworks.

In other words, we need to be aware of the values underlying the decision-making process concerning the adoption of these devices. A more clearly defined intentionality can help educators make more informed decisions about the use of mobile technology in outdoor teaching and learning.

Adaptation

It is clear that technological means are inevitably embedded in people's lives (Vetlesen, 2017), and increasingly implemented in education and outdoor learning. It is argued, amongst others, by Greenwood and Hougham (2015) that anyone engaged in this field should be mindful about when and where these means can be positively put to use. This third strategy outlines the suggestions for integrating mobile technology in outdoor learning that are described in the reviewed articles.

Most commonly mentioned is the use of active and interactive strategies, which denotes integrating tasks, questions and prompts that encourage the participants to stay engaged and communicate with each other and with the natural world (Arnold, 2012; Boyce et al., 2014; McClain & Zimmerman, 2016; Veletsianos et al., 2015; Zimmerman et al., 2019). Secondly, studies suggest focusing on using creative tools, such as online journals and blogs, (live) video recordings and photography. These can increase student motivation of the students and spark their creativity (Anderson et al., 2015; Ardoin et al., 2014; Zecha, 2014).

Thirdly, McClain and Zimmerman (2016), Santos et al. (2014), Socha, Potter, Potter and Jickling (2016), Walter (2013) and Zecha (2014) urge educators to integrate opportunities for reflection after the activities. This entails asking the students to connect the experience with the contents of the curricula post-activity, particularly because this offers educators the opportunity to evaluate and consider possible negative aspects of their courses.

A fourth point of consideration regarding the adaptation of mobile technology is the importance of adequate skill development of teachers and students, so that they may safely, responsibly and creatively use technology to serve the aims of the experiences (Hills, 2019; Meishar-Tal & Gross, 2014; Peffer et al., 2013; Thomas & Munge, 2017). It is common knowledge that devices are continuously improved and updated. Staying up to date with the continuously advancing mobile technology, and its wide-ranging applications, demands additional training for both educators and learners. In this light, Hills (2019) and Su and Cheng (2013) emphasize that prior skills and knowledge of technology are important to consider. With the integration of mobile learning there is a risk of creating a division between students who are efficient with technology and those who are not. An assessment of the student's abilities to work with technological devices and providing extra guidance before departure are simple ways to prevent avoidable complications during trips (Hills, 2019). Another important consideration is the access or lack of access to mobile learning tools, which can create inequities between learners (Tawfik et al., 2016).

Finally, it is important that educators maintain a focus on the overall skill development of learners to manage themselves in the outdoors without technology: technology should not replace knowledge and skills, so that when devices fail, the security of people is not at stake (Hills & Thomas, 2020; Isaak, 2016).

In sum, educators are encouraged to minimize the use of mobile technology where it does not serve the pedagogical objectives. Second, to avoid uncritical employment of mobile technology, educators should align any use (and non-use) to the pedagogical intentions. Third, upon employing mobile technology, educators may consider interactive, collaborative, and creative tasks that maintain a focus on the learning experience, rather than on the technological means. Finally, educators should hold space for reflection on the learning experience and the role of the mobile technology as learning tool, which, in turn, can aid in evaluating and mitigating unintended negative outcomes.

The framework presented above has outlined the affordances and pedagogical considerations regarding the use of mobile technologies, which are similar to those presented in the digital technology and outdoor experiential learning (DTOEL) framework introduced by Hills and Thomas (2020). The suggestions given in this article, complement and build on the DTOEL framework in terms of the strategies and application of decisions about employing mobile technology in outdoor learning.

Alternative findings

From the total of 33 studies, nine studies collected data among students. The participants of these studies were involved with various disciplines, such as environmental education, geography, and teacher education. This indicates that mobile technology can be implemented across various academic disciplines.

A disproportionate focus on the use of gamified mobile technology among target groups that consist of children under the age of 14 was found, which is evident in 14 out of the 33 studies. Although this may well be an effective and positive way of incorporating technology in outdoor learning for that target group, it is likely that this has contributed to the relatively affirmative outcomes. Further work can be done to evaluate non-gamified use of mobile technology in outdoor learning. Moreover, successful ways of implementing mobile technology in higher education has thus far remained under-researched and requires further inquiry.

As presented in tables 2 and 3, the technical and theoretical appraisals yielded average to good results for most of the studies. Findings from studies with average or low quality should be treated with caution with respect to the study design used and the corresponding possibilities and weaknesses regarding their technical and theoretical quality.

Table 2 Technical appraisal	
Grade	**Number of Studies**
Good	19
Average	11
Unclear	1
Poor	2

Table 3 Theoretical appraisal	
Grade	**Number of Studies**
Good	18
Average	11
Unclear	2
Poor	2

With respect to the methodological frameworks, traceability of the research process and presentation of the data, and the methods used, the overall methodological quality is average to good. Five of the included studies used a qualitative methodology, ten used a mixed-method methodology and seven used a quantitative methodology. The most commonly used methods for data collection were observations, surveys and interviews. Two studies used creative methods, such as photo elicitation, video recordings and online journaling. Finally, nine studies were solely based on literature reviews.

Although a few studies featured a solid theoretical framework, this was a neglected aspect. The theoretical frameworks that were overtly stated in the included studies are: experiential learning theory (Huang et al., 2016), (social) constructivist learning theory (Kacoroski et al., 2016; Palmárová & Lovászová, 2012) and place-based learning theory (McClain & Zimmerman, 2016). The articles written before 2015 score, on average, lower on theoretical appraisal. The ongoing, rapid technological advancements provide a noteworthy context for looking at how the focus, discussion and findings of the included studies has developed over time.

In the articles written between 2010-2014, there is a stronger focus on GPS enabled and gamified applications (Kohen-Vacs et al., 2012; Palmárová & Lovászová, 2012; Zecha, 2014). The studies conducted in the years after 2014 show the development of more complex applications, such as EduPark (Pombo et al., 2019), Actiontrack (Kärki et al., 2018) and applications that use location-based Augmented Reality (Kamarainen et al., 2018). The discussion section of the majority of these studies is predominantly oriented on the practical benefits and pitfalls of using mobile technology – especially gamified applications in outdoor learning – yet they neglect critical discussion within a distinct theoretical paradigm. Conversely, the theoretical articles published after 2017, such as those of Zimmerman et al. (2019), Thomas and Munge (2017), Hills (2019), and Hills and Thomas (2020), offer a more in-depth discussion and critical evaluation of the use of mobile technology. It can be interpreted that the more recent studies were able to gain a deeper understanding of the impact of mobile technology on outdoor learning, given that they have been able to draw on and evaluate previous studies, as well as assess technological advancements over a longer time period.

Limitations

This review has several limitations. First, not including multiple reviewers in the process carries a higher risk of bias. To reduce this risk, two steps were taken: first, following the suggestion of Aromataris and Riitano (2014), an experienced university librarian was consulted for assistance with refining the search words and criteria; second, one person who is not listed as an author and who has no conflicting interest in the trajectory of this inquiry reviewed the search process to ensure that the iterative process was properly executed.

Another limitation is the exclusion grey literature and books on the usage of mobile technology in outdoor learning decreases the comprehensiveness of this review. Future research could complement this with internet-based research, including review and analysis of social media content. Thirdly, the breadth of the search formulation and choice of synonyms puts constraints on the search, and as a result, some articles may have been missed.

Conclusions and Recommendations

This systematized review has evaluated the affordances and strategies of implementing mobile technology in outdoor education. The findings show that the employment of mobile technology can both aid and hinder outdoor learning experiences. Subsequently, it is emphasized that educators should critically reflect on the use of mobile technology in their teaching practices.

In terms of the objectives of outdoor learning – providing an alternate learning setting that complements classroom-based education and that stimulates the learning process of students – the majority of the studies indicate that technology does not compromise their objectives. Rather, they point out that mobile technology has the potential to foster meaningful, situated, personal and collaborative learning outside the classroom. However, technological complexity, risk of failing equipment, resource availability and access, and an interference with the direct and sensory experience of nature are important issues that can and should not be swiftly dismissed. The argument that mobile technology places a barrier between the learner and nature did not emerge frequently in the reviewed articles, whilst this is more extensively addressed in literature that explores the impact of technology on the relation between humans and nature more broadly. A possible explanation for this could be that many of the reviewed articles aimed to explore how mobile technology, or a certain application, can practically and positively function as a learning tool, as opposed to examining the mediating impact of such technologies on the nature experience *per se*. Nevertheless, it is important to acknowledge that this concern is strongly present in debates in the field of outdoor education, and others.

It is unlikely that a consensus will be reached on whether mobile technology positively or negatively affects outdoor learning. The main argument of this article is that the use (and non-use) of mobile technology is too easily labelled as 'good' or 'bad', and that there is a need for guidance based on reliable evidence that allows educators and practitioners to move beyond this rather unhelpful dichotomization. Hence, the attention is directed to a careful consideration of the employment of mobile technology through mitigation, intentionality, and adaptation.

The main considerations regarding the application of these three strategies have been presented in a framework.

First, it is recommended that educators mitigate the use of mobile technology where it does not serve the pedagogical objectives. Second, it is important to clearly define the intentionality for the employment of mobile technology. Any adequate integration of technological means going beyond primarily instructing teachers and students on how to use the latest device or application to more important issues of when and why it is (or is not) valuable to use. This supports the third view, which encourages educators and practitioners to focus on developing interactive, purposeful, and reflective initiatives in which mobile technology serves learning experiences in natural environments, instead of making mobile technology the primary focus point. Together, these strategies can guide outdoor educators in their decision-making process regarding the employment of mobile technology, situated within their own curricula, and offer meaningful ways to overcome and reconcile the nature-technology dichotomy.

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Appendices

Appendix A: Characteristics of included studies

No.	Author(s)	Year	Title	Sample size	Target group	Country	Methods
1	**Adanali**	2019	The student's behaviours at the instructional geocaching applied in problem-based environmental education	19	Preservice teachers in the 2nd year of the teacher program	Turkey	Mixed method: Open-ended questionnaire, out-of-class course observation form and student portfolios
2	**Anderson et al.**	2015	Exploring Techniques for Integrating Mobile Technology into Field-Based Environmental Education	31	Children in primary school 4th-6th grade	US	Mixed method: Survey and exploratory action research
3	**Ardoin et al.**	2014	Using digital photography and journaling in evaluation of field-based environmental education programs	28	Children 10-14 years old	US	Digital photography and reflective journaling
4	**Arnold**	2012	Enhancing college students' environmental sensibilities through online nature journaling	50	Students	US	Blog, Survey/Questionnaire
5	**Bolliger et al.**	2012	Colorado's Millennial Generation: Youth Perceptions and Experiences of Nature	441	Students	US	Survey and focus group methods
6	**Boyce et al.**	2020	Smartphone use in outdoor education: a question of activity progression and place	151	Outdoor instructors	US	Survey/Questionnaire
7	**Crawford et al.**	2014	Getting Students Outside: Using Technology as a Way to Stimulate Engagement	55	Children in primary school 5th grade (low income schools)	US	Qualitative: Observations, video recordings and interviews.
8	**Greenwood and Hougham**	2016	Using Mobile Technology to Engage Children with Nature	747	Children 9-14 years old	Canada	Mixed method: Field trip and questionnaire

9	**Hills**	2019	Digital technology and outdoor learning: A framework for decision-making	-	-	-	Theoretical paper
10	**Hills and Thomas**	2020	Digital technology and outdoor experiential learning	-	-	-	Theoretical paper
11	**Hougham et al.**	2020	Digital technology and outdoor experiential learning	-	-	-	Theoretical paper
12	**Huang et al.**	2018	Bridging Natural and Digital Domains: Attitudes, Confidence, and Interest in Using Technology to Learn Outdoors	136	Children 7-14 years old	US	Mixed method: Field trip and questionnaire
13	**Kacoroski et al.**	2016	Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment	21	Children in middle school	Taiwan	Mixed method: Questionnaire, interviews and field trip
14	**Kamaraine et al.**	2016	Children's use of iPads in outdoor environmental education programs	Unknown	Children	US	Qualitative observations
15	**Kärki et al.**	2018	Meaningful learning with mobile devices: pre- service class teachers' experiences of mobile learning in the outdoors	277	Preservice teacher students	Finland	Survey/Questionnaire
16	**Kohen-Vacs et al.**	2018	Using Mobile Location-Based Augmented Reality to Support Outdoor Learning in Undergraduate Ecology and Environmental Science Courses	Unknown	Undergraduate students	US	Unclear
17	**Lai et al.**	2012	Mobile Treasure Hunt Games for Outdoor Learning	-	Primary school	-	Theoretical paper
18	**McClain and Zimmerman**	2014	Exploration of Tensions in a Mobile-Technology Supported Fieldtrip: An Activity Theory Perspective	35	Children primary school 5th grade	Taiwan	Survey/Questionnaire
19	**Meishar-Tal and Gross**	2016	Technology-mediated engagement with nature: sensory and social engagement with the outdoors supported through an e-Trailguide	83	Children 8-11 years old	US	Qualitative: design-based research - video recordings and fieldtrip

20	**Midgely**	2014	Teaching Sustainability via Smartphone- Enhanced Experiential Learning in a Botanical Garden	15	Preservice teacher students	Israel	Mixed method: Workshop and questionnaire
21	**Palmárová and Lovászová**	2014	The benefits and drawbacks of using technology in outdoor education	22	Students	Canada	Survey/Questionnaire
22	**Peffer et al.**	2012	Mobile technology used in an adventurous outdoor learning activity: a case study	10	Children 10-14 years old	Slovakia	Qualitative: Case study
23	**Pombo et al.**	2019	Learning with the Augmented Reality EduPARK Game-Like App: Its Usability and Educational Value for Primary Education	290	Children in primary education: grade 1-4	Portugal	Mixed method: field trip and questionnaire
24	**Santos et al.**	2019	Evaluation of a Mobile Augmented Reality Game Application as an Outdoor Learning Tool	72	Children 9-10 and 13-14 years old	Portugal	Survey/Questionnaire
25	**Schaal and Lude**	2013	To be or not to be in situ outdoors, and other implications for design and implementation, in geolocated mobile learning	63	Adolescents	Spain	Mixed method: questionnaire and participatory design
26	**Socha et al.**	2015	Using Mobile Devices in Environmental Education and Education for Sustainable Development—Comparing Theory and Practice in a Nation Wide Survey	120	Experts and educators	Germany and Austria	Survey/Questionnaire
27	**Su and Chen**	2016	Reflections on using pinhole photography as a pedagogical and methodological tool with adolescents in wild nature	2	Adolescents	Canada	Pinhole photography
28	**Thomas and Munge**	2013	Mobile Game-based Insect Learning System for improving the learning achievements	102	Children 10-11 years old	Taiwan	Mixed method: Quasi-experimental and questionnaire.
29	**Veletsianos et al.**	2017	Innovative outdoor fieldwork pedagogies in the higher education	-	Students	-	Theoretical paper

			sector: optimising the use of technology				
30	**Walter**	2015	Lessons Learned from the Design and Development of Technology-enhanced Outdoor Learning Experiences	-	Undergraduate students	US	Theoretical paper
31	**Zecha**	2013	Greening the Net Generation: Outdoor Adult Learning in the Digital Age	-	Adults	-	Theoretical paper
32	**Zimmerman and Land**	2014	Outline of an Effective GPS Education Trail Methodology	-	-	-	Theoretical paper
33	**Zimmerman et al.**	2014	Facilitating place-based learning in outdoor informal environments with mobile computers	-	-	-	Theoretical paper

Appendix B: Critical appraisal of included studies

Author(s)	**Technical Appraisal**	**Theoretical Appraisal**
Adanali	Average	Good
Anderson et al.	Average	Poor
Ardoin et al.	Good	Good
Arnold	Good	Average
Bolliger et al.	Good	Good
Boyce et al.	Average	Good
Crawford et al.	Good	Good
Greenwood and Hougham	Good	Good
Hills	Good	Average
Hills and Thomas	Good	Good
Hougham et al.	Good	Good
Huang et al.	Average	Average
Kacoroski et al.	Average	Good

Kamaraine et al.	Average	Poor
Kärki et al.	Good	Average
Kohen-Vacs et al.	Poor	Unclear
Lai et al.	Good	Good
McClain and Zimmerman	Good	Good
Meishar-Tal and Gross	Average	Average
Midgely	Poor	Unclear
Palmárová and Lovászová	Good	Average
Peffer et al.	Good	Average
Pombo et al.	Unclear	Average
Santos et al.	Good	Good
Schaal and Lude	Good	Good
Socha et al.	Average	Good
Su and Chen	Average	Average
Thomas and Munge	Good	Good
Veletsianos et al.	Average	Average
Walter	Good	Good
Zecha	Average	Average
Zimmerman and Land	Good	Good
Zimmerman et al.	Good	Good