ParkLearn: Creating, Sharing and Engaging with Place-Based Activities for Seamless Mobile Learning

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ABSTRACT
The potential for mobile technology to support bespoke learning activities seamlessly across learning contexts has not been fully realized. We contribute insights gained from four months of field studies of place-based mobile learning in two different contexts: formal education with a primary school and informal, community-led learning with volunteers in a nearby park. For these studies we introduced ParkLearn: a platform for creating, sharing and engaging with place-based mobile learning activities through seamless learning experiences. The platform enables the creation of easily configurable learning activities that leverage the targeted learning environment and mobile devices' hardware to support situated learning. Learners' uploaded responses to activities can be viewed and shared via a website, supporting seamless follow-up classroom activities. By supporting creativity and independence for both learners and activity designers, ParkLearn promoted a sense of ownership, increased engagement in follow-up activities and supported the leveraging of physical and social communal learning resources.

Author Keywords
Mobile learning; outdoor learning; civic learning; Digital Civics; community curriculum

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

INTRODUCTION
Lave and Wenger's Situated Learning Theory posits that learning is normally situated and often unintentional: it is embedded within authentic activities, contexts and cultures, and occurs through 'legitimate participation' with communities of practice [23]. Lave claims that social interaction and collaboration become essential for the learner to assume a role of expertise by moving from a community's periphery to its centre [22]. As traditional classroom activities are often clearly in contrast to the goal of situating learning in authentic contexts, there has been a growing movement advocating for more outdoor learning in formal education [3,19,25]. This has been shown to have consistently positive effects on children's academic performance, social skills and self-image [13], resulting in the UK government recommending schools include it as an essential element of their curricula [27].

MobileHCI '18, September 3–6, 2018, Barcelona, Spain

ACM ISBN 978-1-4503-5898-9/18/09.
https://doi.org/10.1145/3229434.3229462

Figure 1: Children using ParkLearn to classify zoo animals (left) and a volunteer affixing a scannable sign (right)

These advantages, as well as the growing ubiquity of smart devices [35], have led to mobile learning ('*learning across multiple contexts, through social and content interactions using personal electronic devices'* [11], aka m-learning) being increasingly popular in schools: in the UK, over 70% of schools made use of tablets as learning tools in 2015 [5]. Previous work has shown that m-learning can motivate learners and allow them a growing degree of autonomy [26]. It can also be used to take advantage of multiple learning contexts: from formal education in the classroom to informal experiences based on specific locations [43]. By supporting communities as well as teachers in creating and sharing their own learning materials, m-learning technologies can also highlight local expertise and civic values in communities of practice as learning resources in authentic contexts [29].

Previous mobile learning projects have often used domain specific, pre-prepared learning materials using hardware or digital assets [2,8,30]. While this has often allowed for rich learning materials, it diminishes their adaptability for learning activities across different curricula and locations. The result is that teachers and communities would often struggle to integrate them into their regular practice. If users are supported in creating their own digital m-learning experiences, they could produce bespoke content designed for their learning goals, resources and values. However, even projects which allowed the creation of custom m-learning materials have often had their own issues, such as only offering the learner passive experiences (such as wiki pages or simple quizzes) [16] or lacking in opportunities for learner creativity [40]. An unfulfilled opportunity exists for technologies to support teachers and community experts in easily producing creative m-learning activities which have been tailored to support their individual goals and values.

In this paper, we contribute insights gained from longitudinal studies of place-based m-learning in two contexts: formal education and informal, community-led learning. Additionally, we present ParkLearn: a m-learning platform designed to support teachers, students and communities in creating, sharing and engaging with bespoke m-learning activities. We report on how ParkLearn was used by teachers and community experts in these two learning contexts, supporting both groups in achieving their own disparate goals through the democratisation of m-learning activity design. We discuss how m-learning technologies can support empowerment through encouraging creativity and content ownership; promote civic engagement and inquiry; and assist in seamless learning teaching practices by being an adaptable, supporting toolkit.

RELATED WORK

We examined some theoretical frameworks for learning and used them to analyse existing mobile learning solutions.

Sharples and Taylor's Task Model for Mobile Learning

Sharples and Taylor extended Activity Theory [12] in their task model for mobile learning [34]. In addition to the original model's interacting factors (*subject, tool, object, community, rules*, and *division of labour*), they suggest that designs for m-learning technologies should additionally consider: the physical and social aspects of the learning *context*, the amount of *control* the learner has over the activity and the learner's *communication* with others. This framework can be used to inform the design of new m-learning technologies and analysis of existing works, as Frohberg et al. [14] did in their critical analysis of the state of mobile learning. They noted that many projects offered the learner little control over the learning activities, suggesting that offering learners opportunities to creatively construct content (rather than being delivered passive learning material such as wiki pages or quizzes) can lead to deeper understanding through reflection. As noted by Chan et al. [6], the delivery of simple 'instructional content' results in the learner being regarded as simply a consumer of product, ignoring the high pedagogical value of active, productive, creative and collaborative learning. However, Frohberg et al. also noted that in most cases a degree of scaffolding or direction is still required – left without any orientation, learners might become frustrated, develop false conclusions or any meaningful learning goals for the activity may go unfulfilled. Land similarly stresses the necessity of scaffolding and offers multiple other mobile learning design guidelines, including supporting a range of learner ages and reading abilities through visually varied interfaces [21]. By categorising mobile learning projects by their *contexts*, Frohberg et al also noted that most either took place independently of the learner's environment, or relied upon its physical properties alone. Few engaged in a 'socializing' context, in which learners share relationships, emotions, values or personal history [14].

Civic Mobile Learning

Civic learning ('*that which supplies the learner with the knowledge, skills and values they need to be citizens who actively participate in their local communities and take responsibility for improving and understanding them'* [29]) has been shown to have positive influences on political efficacy, participation, involvement and knowledge [41]. Richardson et al. [29] conducted investigations of parks as infrastructure for civic m-learning through a series of design workshops with several stakeholders to further understand parks as mobile learning contexts. They proposed a design space utilising the economic, socio-cultural and political infrastructures which comprise space as learning resources. Suggesting that technologies can enable civic learning by supplying places' stakeholders with a platform for sharing values, they argue that learners can be encouraged to build relationships with space through creative activities which encourage independence and curiosity. Mobile learning has also been used for cross-cultural learning, in which these recorded values and practices become learning materials across different communities [31].

One way to give communities opportunities to share their knowledge and values may be through creating platforms which support community generated learning materials. Previous work has shown that location-based, user-generated content can be used to support informal learning [9]. However, the current nature of formal education in England means that schools may struggle to take advantage of these resources. Leat argues that the commodification of education and the overbearing regulation on schools' output has resulted in a 'performance culture' and 'teaching to the test', with intense pressure being placed upon both teachers and students alike [24]. However, he argues that student disengagement with this culture can be countered using enquiry and project-based learning, enacted through '*Community Curriculum Making*'. By schools building a 'dialogic web' which taps into communities' funds of knowledge, students can be given opportunities to learn in authentic contexts alongside expert members of communities of practice [10].

Seamless Mobile Learning

Sharples presented mobile learning as existing on a linear dimension from a fixed, curriculum-led context on one end (e.g. classroom-based), to one of informal learning in a mobile setting on the other [32]. He notes that connecting these formal and informal contexts provides new research opportunities for mobile learning, working towards Kuh's proposed binding of different learning experiences into a single 'seamless learning' narrative [20]. Wong and Looi claim that seamless learning technologies 'empower and support' users in learning, whenever and wherever they are stimulated to do so [43]. They identified ten desirable dimensions which characterise 'seamlessness' within mobile learning design: 1) encompassing formal and informal learning, 2) encompassing personalized and social learning, 3) learning across time and 4) locations, 5) ubiquitous access to knowledge, 6) encompassing physical and digital worlds, 7) using multiple types of devices, 8) switching between multiple learning tasks, 9) knowledge synthesis (e.g. combining learners' prior knowledge with new knowledge) and 10) encompassing multiple pedagogical or learning activity models. They note that more research could be done to investigate how mobile learning technologies could support four of these qualities (7 - 10) and use them to facilitate holistic seamless learning experiences [43].

Mobile Learning in Practice

In this section, we will briefly review how some other m-learning projects have supported seamless learning and the creation of user-generated content. In their investigation into the potential usage of mobile learning in rural Panama, Valderrama et al. found that 'multimedia rich' phones were welcomed by pupils and teachers for use in classroom activities, even without the installation of additional software applications [39]. However, most other studies have focused on custom, education-focused mobile apps. For example, the Sense-it mobile application takes a toolkit approach, foregoing any scaffolded structure and acting as freeform supporting tool [33]. It allows users to conduct citizen science investigations through accessing detailed sensor information from their phone's hardware, without having any overarching activity scaffolding within the application itself. While alone it acts as an unstructured toolkit, Sense-it can be combined with the nQuire-it web platform to support users in contributing to others' created investigations or even designing and completing their own. However, the nature of Sense-it's citizen science focus means that the user interactions are limited to data collection activities, resulting in the mobile technology offering little creativity.

Mobilogue supports the authoring of location-based mobile learning activities, which linearly guide learners between locations using GPS and ask quiz questions at each one [16]. As with nQuire-it, Mobilogue's website component allowed students greater control through creating their own quizzes for their peers. The authors noted that this provoked a *'learning by teaching effect'*, and that the students were particularly engaged by seeing their created quizzes in action on mobile devices. This supports Heslop et al., who argue that higher level thinking and reflection can be promoted in students through them creating 'Digital Mysteries' for each other [17]. Once finished, Mobilogue users can clear their progress, allowing devices to be shared amongst multiple students in a class. However, as learners' responses in Mobilogue aren't uploaded for later review on other devices, opportunities for follow-up, seamless learning activities in other contexts are limited. This creative element was also only available on the website, with the mobile application's delivery of passive content offering learners little control when examined using the mobile learning task model [36].

Wild Knowledge expands on the toolkit and authoring concepts, supporting varied learner activities made up of modular components [42]. These include photography, audio recording, location logging and interactions often found on standard worksheets such as multiple-choice questions. Through the platform's website, users can combine these interactions into activities for others to complete. Learners can also upload their responses for later viewing on the website, where it is displayed in a comma separated (CSV) table format. This format would likely be too complicated for younger children, suggesting that Wild Knowledge was not designed as a seamless learning tool with this age group in mind. Other than being referenced in literature (e.g. [37]), we are not aware of any research that investigates the use of Wild Knowledge in educational contexts. Furthermore, the platform's subscription model appears to focus on schools and businesses with a top-down delivery of content, rather than supporting individuals and communities in sharing information with a low financial barrier to entry.

The MyArtSpace project created a seamless learning experience between a school trip to a museum and follow-up classroom activities through the combination of a website and mobile application [40]. Using the application, students 'collected' digital content linked to physical items in the museum in response to an inquiry question. Learners could also upload their own images, text and audio recordings during the visit. On return to the classroom, students could review their collected content and use it to answer their given question. The technology successfully bridged the museum and classroom learning contexts, and increased levels of student engagement and reflection upon return to the classroom. However, its limited ability for rich, reflective data capture—users could only create 15 second audio recordings, for example—meant that learners were limited to simply cataloguing information, rather than reflecting upon it in-situ. Additionally, the application's exclusive focus on indoor activities precluded location-based interactions. The project also suffered from usability issues resulting from the app's reliance on typing and the website's interface.

STUDY CONTEXTS

We build upon the aforementioned engagements held by Richardson et al. [29] by using the design contexts of primary schools and nearby local parks as applicable examples of formal and informal learning environments. A primary school setting was chosen due to the national curriculum being less restrictive during the earlier school years, allowing teachers to experiment more with lesson planning and perform more outdoor activities. Parks were chosen as they have traditionally been used as outdoor learning resources by nearby schools. However, prolonged austerity measures have meant that local councils have resorted to cutting dedicated educational staff in their parks or introducing fees for the use of park rangers' time. As a result, the UK's parks are becoming an increasingly underutilised learning resource.

DESIGN GOALS

Based on the findings of previous works [16,33,39,40,42] and the design engagements held by Richardson et al. [29], we produced several design goals (DGs):

- DG1. Utilize local places and communities as learning resources—give places' stakeholders a platform for sharing their values through designing and sharing learning activities in authentic contexts [22,29].
- DG2. Support seamless outdoor and classroom use by encompassing as many of Wong and Looi's [43] desirable dimensions of seamless learning as possible (such as using multiple device types across locations).
- DG3. Be flexible enough to support different goals, learning processes and intended outcomes without relying on additional tools (e.g. provide evidence of learning output for teachers or promote placemaking [29]).
- DG4. Support a wide range of user ages and technical expertise through simple, consistent visual interfaces [21] which reduce the need for typing [40].
- DG5. Utilise interaction methods which support creativity, control [14] and allow for immediate activity creation, data collection and reflection in authentic learning contexts (in contrast to MyArtSpace [40]).
- DG6. Support mobile learning in resource-limited schools through allowing device sharing (as seen in Mobilogue [16]) and offline caching of data.

With these design goals in mind, we created ParkLearn: a platform designed to lower the barrier to entry of creating rich mobile learning content. The following sections of this paper will give a brief overview of the ParkLearn platform, before describing how it was used in two user studies to evaluate it against these design goals.

System Structure

ParkLearn consists of three primary components: A mobile app, a website and an online application programming interface (API). The application supports 99% of active Android devices at the time of writing [1]. The API and website are hosted on Microsoft's Azure cloud platform and share an SQL database. ParkLearn revolves around the creation, sharing and engagement with mobile learning activities ('Activities'). Activities are comparable to traditional school worksheets, in that they are made up of multiple, smaller tasks ('Actions') relating to a common learning topic. Actions can each take the form of one of many interactions ('Action Types') which make use of the mobile device's functionality (Table 1). These Action Types were chosen either because they promote creative activities (e.g. 'Take Photos', 'Draw a Picture') (DG5), emulated traditional educational materials (e.g. 'Multiple Choice', 'Text Entry') or used the device's hardware to give context-specific experiences (e.g. 'Location Hunt') (DG1,DG3).

Creating Activities

To make Activity creation as accessible and intuitive as possible, the entire process takes place inside the ParkLearn mobile app. This means no additional equipment is required and allows the designer to create the Activity in situ if they wish (DG5). After supplying a title, description and an optional image, the designer creates the Actions that make up the Activity. Every Action Type requires at least some form of written instruction/information, but some also require or allow additional customization (Table 1, DG3). Activities can be either public or privately accessible, as well as associated with nearby places of interest (DG1). Once uploaded, users can access their Activities from the 'My Activities' tab, where they can view their share codes, use them as a learner or delete them.

Action Type	**Description**	**Functionality**	**Designer Customization** (in addition to an instruction)
Read Info	a sentence / paragraph of text	Web browser (optional)	Optionally add an image and/or a link to a webpage
Listen to Audio	narration, sound effects or music	Speakers or headphones	Upload existing audio or record a one in the app
Take Photos	in response to an instruction	Camera (still)	None
Photo Match	to a photo over-laid on screen	Camera (still)	upload an image from the gallery or take a new photo
Draw a Picture	onto a blank canvas	Touchscreen	None
Draw on Photo	on top of an existing image	Touchscreen	Upload an image, take a photo or have the learner draw on a previous *Take Photos* image
Record Video	in response to an instruction	Camera (video), microphone	None
Record Audio	in response to an instruction	Microphone	None
Map Marking	onto a Google Maps view	GPS, touchscreen	The min/max number of points, optionally require that the learner can only plot their current location
Multiple Choice	between text options	Radio buttons	Write a custom number of options
Location Hunt	by observing reported distance from a given geo-coordinate	GPS, sound and animation relative to distance from target	Choose a location on a Google Map
Text Entry	in response to an instruction	Virtual keyboard	None

Table 1: The Action Types available to Activity designers

Discovering and Launching Activities

Users can find and launch Activities in the following ways:

The Highlights Feed and Location

The 'highlights feed' is a dynamic list of Activities which can be updated from the server at any time. The feed features publicly accessible Activities which have been recently published or tagged as being associated with nearby locations. It also features the four most recently opened Activities, which stay cached locally on the device for ease of use and to allow for a loss of connectivity (Figure 2, DG6).

Share codes and QR Codes

Activities can be made accessible to other users through a 'share code' system. An author can share their Activity's unique, six-character share code which allows others to launch the Activity when entered on their device (DG2). A QR code is also generated on the ParkLearn website, which can be easily printed to encourage launching Activities in authentic contexts (DG1). This code will launch its Activity when scanned in the app, or link to the Activity's page on the website if the user doesn't have the application installed. The application includes a QR code scanner for convenience, as many devices do not have one installed by default (DG3).

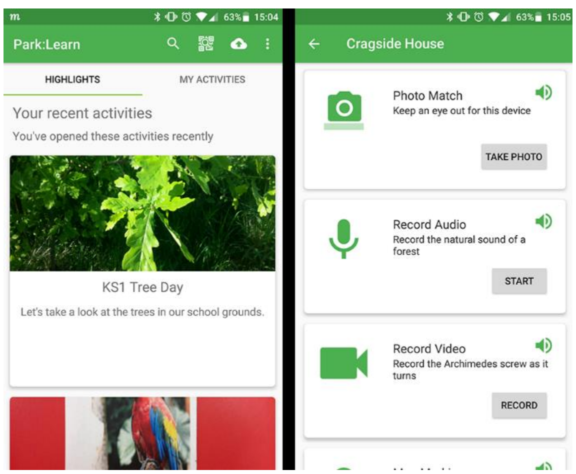

Figure 2: The ParkLearn app's highlights feed (left) and an Activity's list of Actions (right)

Completing Activities

Actions are presented to the learner in a list (Figure 2). However, most Actions can be completed in any order, allowing the learner a level of flexibility as to how they go about completing the Activity (DG3). Each Action features a short instruction for the learner and an icon which communicates the Action Type. If the learner has poor literacy skills, a text-to-speech button is available to read the instruction aloud (DG4). When finished, the work is queued for upload and the previous progress wiped, allowing other learners to use the same device to complete it afresh (DG6).

ParkLearn Website

A simple website accompanies the app, allowing users to log in and view their created activities (along with each Activity's share and QR code), others' shared responses and their own uploaded responses (DG2). Responses are presented in a similar style to the application, complete with the original Actions' instructions for easy reference (DG4). Users can also share a link to their uploaded responses, allowing others to view them without an account (DG2).

USER STUDIES

To evaluate the ParkLearn platform against our design goals, we deployed it in both of our design contexts: a formal education setting with a local primary school and a community curriculum context with the volunteer group of a large, nearby park.

Data Collection and Analysis

A member of the research team was present during each of the app's deployments, providing technical support as necessary and taking field notes. All interactions and data collection were approved by and conformed to the requirements of Newcastle University's ethics committee. Audio recorded, semi-structured interviews were held with the adult participants throughout the study to understand their reasoning behind their Activity designs and their opinions of the technology. A thematic approach [4] to coding was performed across data from interviews, children's creations within the app and observational notes. The resulting codes were reviewed and qualitatively analysed by the authors, and then grouped into candidate themes. These themes were summarised onto paper for discussion and validation before being finalised.

Community Curriculum Study Context

We worked alongside two members (male and female, aged in their 60s with little experience with mobile apps) of the local park's volunteer group, who had approached the researchers about wanting to produce a 'talking statue'. Built upon an existing monument of a key figure of the park's history, this talking statue would share his story with visitors, encourage them to further explore the park and even to join the volunteer group. However, as the volunteers had very limited technical knowledge and funds, a bespoke digital technology seemed inaccessible to them. A physically wired system would have also have interfered with the monument's status as a listed historical structure. The researchers observed and took field notes on the planning and installation of the Activity, and assisted in its creation where necessary due to their inexperience with mobile apps.

Volunteers' Experience with ParkLearn

Through ParkLearn, the volunteers created a talking statue Activity which combined a 'Listen to Audio' Action (for which a volunteer wrote and read from a script, giving an account of the park's history from the statue's perspective) with multiple 'Location Hunt' Actions, which gave the learner a playful guided tour of the park (Table 2, row 10). The recorded audio was also transcribed between multiple 'Read Info' Actions, which featured imagery from the park and external links to the volunteer group's website. Foamex signs featuring a QR code (supplied by the ParkLearn website) were printed and attached to benches near the statue (Figure 1). By making the Activity 'private' and using these signs, the volunteers could ensure that only people near the

No.	Activity Title	Used Action Types	Num. of Responses	Uploaded Responses' Cumulative Contents	Notes
1	Our School Grounds	2 'Record Audio', 1 'Take Photos', 1 'Record Video', 1 'Photo Match'	1	2 audio recordings, 2 photos, 1 video	Only used by Teacher 2 to test the application
2	Learning to use ParkLearn	3 'Take Photos', 1 'Draw on Photo', 1 'Record Audio', 1 'Record Video'	29	91 photos, 29 drawings, 29 audio recordings, 29 videos	Used in the classroom by both teachers to introduce the children to the app
3	Trip to X Hall and Gardens	2 'Take Photos', 2 'Photo Match', 1 'Record Audio, 1 'Record Video', 1 'Map Marking', 1 'Location Hunt'	8	43 photos, 8 audio recordings, 8 videos	Tablets shared in pairs
4	X Park – Statues and Monuments	4 'Take Photos', 2 'Record Audio', 1 'Record Video'	0	-	Submissions weren't uploaded
5	Exploring Park's flower garden	5 'Photo Match', 2 'Take Photos', 1 'Record Video'	5	46 photos, 5 videos	Some submissions lost as tablets were re-used prior to upload
6	Saltwell Park – First Visit	9 'Photo Match', 1 'Take Photos', 1 'Record Video', 1 'Record Audio'	7	78 photos, 7 videos, 7 audio recordings	Some submissions lost due to a software bug
7	KS1 Tree Day	5 'Photo Match', 1 'Record Audio', 1 'Text Entry', 1 'Take Photos'	15	67 photos, 15 audio recordings	Children asked to enter their name in the 'Text Entry' Action
8	Kirkley Hall Zoological Gardens	6 'Take Photos', 1 'Record Video', 1 'Record Audio'	12	173 photos, 12 videos, 12 audio recordings	n/a
9	Welcome to Class 2	2 'Record Video', 1 'Take Photos', 1 'Record Audio'	4	8 videos, 7 photos, 4 audio recordings	n/a
10	Talking Statues: George Charlton	1 'Listen to Audio', 4 'Read Info', 8 'Location Hunt'	The volunteers chose passive Action Types, meaning no uploads were necessary		

Table 2: The Activities created by the participants and the responses uploaded by the students. Rows 1 and 4-9 were used by the Year 2 teacher, row 3 by the Year 6 teacher and row 10 was the volunteers' activity. Row 2 was used by both teachers.

statue could launch the Activity. As this meant people would have to be present in the park to use it, they treated the statue as an attraction, something that would raise the profile of the park and encourage people to visit. They printed posters to advertise the project to the surrounding community, and even talked to the local press.

After the launch of the installation, the volunteers were eager for regular updates regarding its usage by park visitors. To facilitate, we updated the ParkLearn website to show the number of times each Activity had been scanned (95 scans in the first 30 days). ParkLearn allowed the volunteers to create a digital, multimedia instalment with minimal interaction or support from the local council (from whom they required permission to put up the scan points). Due to the use of pre-existing technology, the total cost of the installation was around £50 (the cost of producing the Foamex signs). The talking statue launched in the same summer in which it was conceived, rather than the original target launch date of the following year. The actual creation of the Activity took less than an hour, with assistance.

Formal education study context

We worked with the primary school (ages 4-11) over a period of four months to evaluate and further develop ParkLearn. This longer study period was chosen for two main reasons: to mitigate the influence of 'novelty' in the children's engagement with the technology [32] and to see how teachers' approaches to Activity creation would change over time. Despite being situated in an impoverished area, the school was deemed to be 'Outstanding' in their latest review by the UK's Office for Standards in Education. It was within a short drive of the park and had access to its own grounds featuring a small woodland area. Samsung had supplied the school with 20 Android tablets, which were a shared resource amongst all the school's classes (with older classes given priority). We were working with two teachers: 'Teacher 1' who taught Year 6 (aged 10-11, we engaged N=16 children) and 'Teacher 2' who taught a Year 2 class (aged 6-7, N=29). As there were more children than devices in most instances, the tablets were usually shared one-between-two, with children taking turns to use the application at their own volition. The Year 6 class and teacher were less frequently available due to the study coinciding with exams. The teachers used the application at their own volition and took on a co-researcher role, creating the Activities independently and developing their own design ideas. While the Year 6 teacher frequently used tablet devices in the classroom and had a good level of technical experience, the Year 2 teacher had very little experience with smartphone applications. Prior to the application being used in class, we sat down with the teachers for an hour to give them a brief overview of the study, the application itself and how it could be used. To serve as examples for what the app could be used for, we had created two simple Activities beforehand: one which took the learner on a bug hunt, and a more creative Activity about movie making.

Teachers' Deployments of ParkLearn

The teachers chose to use the application total of nine times between the two classes during the four-month study period: twice with the Year 6 class, and seven times with Year 2. The following observations were recorded in field notes.

Introducing the application

The teachers both decided to hold introductory lessons with the app with their respective classes. Their first Activity was very exploratory, designed for use in the classrooms to see how easily the children could use the application (Table 2, row 2). The older group of children were already extremely comfortable with using them and had very few issues understanding the application's design language. Some of the younger children were less able readers, and so struggled to understand even the simple instructions for each Action created by the teacher. To mitigate this, subsequent versions of the application featured the text-to-speech function, which read aloud the Action's instruction at the push of a button.

Year 6 Interactions

The Year 6 group used the application on a trip to a site popular with school groups thanks to its historical, natural and scientific features. The site featured an indoor museum and a large outdoor property featuring woodlands and ornamental gardens. The teacher prepared the Activity the night before, using his prior knowledge of the location to design Actions which included: 'Take Photos' of the various wooden bridges present; 'Photo Match' Actions of a modern water pump and an iron bridge; a 'Record Audio' of the natural sounds of the forest; a 'Record Video' of an Archimedes screw rotating; a 'Map Marking' Action to plot where the powerhouse was; a 'Location Hunt' to navigate the children to a mystery location (an old waterwheel); and a final Action which challenged the children to compete and 'Take Photos' of the most beautiful flower they could find (Table 2, row 3). As the location was a significant distance away from the school, the teacher created the 'Photo Match' Actions using photographs downloaded from Google Images rather than taking them himself. Unfortunately, the 'Map Marking' Action wasn't available to complete, due to its reliance on Internet connectivity to load Google Maps.

Year 2 Interactions

The Year 2 class used ParkLearn on three separate school trips, as well as during multiple activities on the school grounds. The first trip was to the park, with two different Activities: the first Activity focused on the historical monuments and memorials in the park, and asked the children to record each other explaining what they were dedicated to (Table 2, row 4); the second used 'Photo Match' Tasks to find and photograph specific flowers in the park, with a final 'Take Photos' Task asking them to choose their favourite (Table 2, row 5). The Year 2 teacher also used the application on a trip to another local park, where the ranger had invited her class to make suggestions as to how the park should be improved. The teacher made an Activity which asked her students to take photos of parts of the park and make audio recordings which would then be shared with the park ranger (Table 2, row 6). Unfortunately, a bug in this version of the app resulted in a loss of several children's work, meaning that the children's feedback was sent to the ranger as part of a classroom writing exercise instead. The Year 2 class also used the application to identify and talk about the trees they could find on the school grounds, through a mixture of Actions ranging from 'Photo Matching' trees to 'Audio Recording' how it felt to be around nature (Table 2, row 7). The teacher also used the application on a class trip to the zoo (Figure 1), with a simple Activity consisting of Actions which asked the children to take photos of each of the different animal types and record video and audio about things they found interesting (Table 2, row 8).

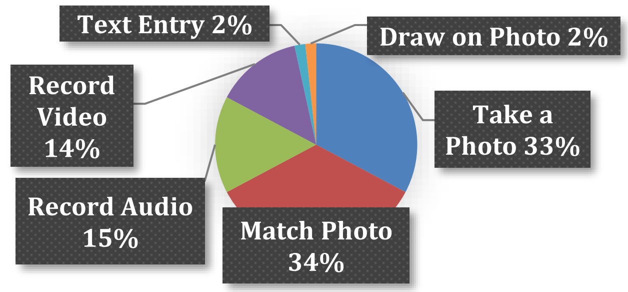

Figure 3: Teacher 2's usage of Action Types across her created Activities

The final use of the app took place at the end of the school year. The teacher created an Activity which asked four children from her class to give advice to the younger Year 1 students about being in Year 2 (Table 2, row 9). The Activity asked the children to photograph an area of her classroom and record a video giving advice about the do's and don'ts. The teacher chose the children either because they would benefit from the practice (due to a lack of confidence or, in the case of 'Child 1', a speech impediment) or because they were especially enthusiastic about using the application. Once the children's responses were uploaded, the teacher played their videos for the class via the ParkLearn website.

Observations of ParkLearn in the School Context

We've structured our observation and interview data into the three themes that emerged from our thematic analysis:

Supporting seamless learning practices

Children in both age groups were easily able to use the application to independently collect data, allowing them to make the most of being in the field: multimedia responses allowed immediate data collection and reflection, without struggling with poor writing skills and virtual keyboards. This was especially true with the younger children, many of whom weren't strong writers. When asked in a later semi-structured interview, their teacher revealed that she purposefully chose Action Types which wouldn't be technically challenging, allowing children to focus on the Tasks' content: "*It's automatic. They can just speak. [...] When I designed the activity, I basically did the video, because I wanted them not to have to write*." The Year 2 teacher particularly favoured use of the camera, taking up over 80% of her created Actions (Figure 3). The children's interactions with the technology became more purposeful as the study progressed, unhindered by a lack of familiarity and the earlier versions' bugs. This was shown in the trip to the zoo: the children were careful to correctly classify each animal into the correct Action, trying to take as good a photograph as possible and deliberately deleting and re-taking any shots that didn't meet their increasingly high standards. One pair of children even decided to reshoot their video recording twice to ensure their delivery of information was perfect. Despite this perfectionism, each pair still uploaded over 14 photos on average in addition to their audio and video recordings (Table 2, row 8). The older children also responded well to their Activity, particularly enjoying competing to take the best flower photo, the 'Location Hunt' Action's sound and animation and competing to take the most accurate 'Photo Match'.

The final Year 2 Activity proved to be a very different use-case for the application: most of the learning process took place independent of the technology, as the children created their presentations and practiced with each other using whiteboards and markers. The application was used to prompt the children for talking points and to record their final output. The ability to prepare and redo a video presentation proved very effective for the children such as Child 1, who would have normally struggled due to a lack of confidence. Reflecting on the activity afterwards, the teacher stated that not only did the children enjoy recording the videos, but that they also took pride in the final results: "[Child 1 would present his work], *but he doesn't know what he's going to say, he gets tongue-tied. The pride he'll take in actually being able to give a coherent message and seeing himself back… They far more enjoyed what they were saying and what they were doing."* While two of the children didn't want to play back their recordings for themselves, all four participating children were eager to show their videos to the rest of the class. The other children reacted with excitement at seeing their classmates on the screen, with Child 1 even receiving high-fives.

The teachers saw great value in how simple the app made creating a structured learning activity and collecting the children's responses to it. When interviewed towards the end of the study, Teacher 2 noted: *"It's powerful, really powerful. The way that packages it up at the end, and how immediate it is, is fantastic for me. I got it straight away, it wasn't a difficult process to do."* Prior to the study, the school's teachers had been manually transferring the children's created photos and videos over USB on a weekly basis, uploading the children's media to Earwig—an evidence portfolio suite used by the school. ParkLearn's small output file sizes and upload system was far simpler and better suited to the teachers' workflow: *"That simplicity takes away a lot of hassle—if I was to take photographs on my [tablet], I've got to get the lead, plug it into my hard drive, transfer the photos across, choose where I want to save them... Whereas this packages everything together."* This one-step system took a fraction of the time compared to the old backup routine, meaning children's creations would be discarded less often. Its simplicity even allowed the teachers to delegate uploading to the children. The Year 2 teacher valued that the submissions appeared on the website in the same format as they appeared on the learner's device: *"What I like about the app is you can pull together different ways of collecting and showing information. Simply by pressing that upload button, it puts it onto my screen to save and to use in that format. That's the beauty of it."* Because the application supported both open-ended and structured learning activities and was non-intrusive in her workflow, she plans to use the application regularly with her next class of students. When asked which school trips would benefit from this data collection, she responded: *"Every trip."*

Engagement and empowerment through ownership

Both teachers created Activities which ranged between being highly prescribed (e.g. A 'Photo Match' with *'Find a birch tree'*) and open-ended (e.g. A 'Take Photos' with *'Find what you think is the most beautiful flower'*). The Year 2 class's first Activity proved to be very prescriptive, with the teacher simply having the children repeat her words on video. While the children enjoyed recording each other with the tablets, they weren't very engaged with the actual educational content (suggesting a high influence of the technology's novelty factor). The Year 2 teacher noted in an interview that in these cases, the children were only really interested in viewing their own work: *"When they come back after visits where we've all done the same, children's enthusiasm is not really there for what others have done. The enthusiasm is, "Can I see what I've done?"* The children took pride in the photos they had taken, showing off their creations to each other and the adults present. She started planning future Activities which would involve the children having their own topics in small groups: *"They're given a specific task and they take ownership of it, knowing that other groups are not doing that. […] When we come back to school and we feedback, there's a great interest in what each other has produced because we're informing everybody."* She argued that covering their own topics would lead to the children becoming experts on it amongst their friends, with the ownership of the task and knowledge empowering them through the ability to teach others: *"You can kind of empower yourself through your knowledge and how you're going to present it, and then go off and do it."*

Supporting civic engagement and inquiry

The platform was used as a tool to facilitate civic participation during the class trip to the second park (Table 2, row 6), with students providing feedback and suggestions through the application. The Year 2 teacher noted that the school was struggling to engage parents in the children's contributions: *"We don't have a lot of parental support, but, where we do, we're looking to make cultural links."* After this trip to the park, she had tried to make the parents aware of their children's work through the school newsletter. While their currently used technology, *'Earwig'*, was impractical for this (*"It takes a very long time to upload a video within Earwig, so we've stopped doing it, really."*), she suggested that mobile technologies may be better suited to highlighting the children's civic engagements: *"Our parents might go along and just say, 'There's nothing there,' because they don't see the resource. However, there could be something on the app like, 'We're involved in it, so go along and see what your children have done.'"* Other activities that she suggested could be highlighted included visits to local care homes: "*Let's say, Christmas you go to the care home. We can use ParkLearn to record what we did and use that within school, upload it to our website to share it with parents.*" This highlighting could extend to cross-cultural learning engagements: "*We have a link with a school in India. The app is a perfect way of interacting with them, showing each other.*" The platform was also used to promote self-reflection on the learner's relationship with the space. For example, one Activity asked children to record audio in response to the prompt: *'Why are trees special? Listen to the sound of the leaves rustling, stand amongst them and look up – how does it make you feel? Share your thoughts with us.'*

DISCUSSION

These studies provided us with discussion points which we believe should bear consideration in future designs:

Supporting Seamless Learning Practices

The features and open nature of the application's authorship process and website component means that it arguably supports all ten of Wong and Looi's dimensions of mobile-assisted seamless learning [43]. This includes the four research and design gaps which they identified: use of multiple device types in different contexts (e.g. tablets and projector in the field and classroom), switching between multiple learning tasks (e.g. through combining Action Types, promoting different interactions and considerations on the part of the learner), knowledge synthesis (e.g. potential for children to create peer-learning Activities based around their own independent or group research) and the encompassing of multiple pedagogical or learning activity models (e.g. moving from individual work with tablets in an authentic context to collaborative classroom discussion around the uploaded responses). ParkLearn fulfilled DG2 by incorporating these dimensions of seamless learning, allowing it to be flexible enough for teachers to incorporate different devices, contexts and pedagogical approaches into their activities as they see fit.

Over the course of the study, the role of the application changed from being the learning objective to becoming a teaching support tool. In the Year 2 class's first Activity, the technology took centre stage and became the learning focus. This overbearing design meant that not only did the children have little agency in their output, but they weren't paying much attention to the learning environment. As suggested by Richardson et al., mobile learning design should aim to strike a balance between direct and technology-mediated environmental interactions if it is to take advantage of that environment as a learning resource [29]. The teacher's later Activity designs sought to strike that balance, preferring the Action Types which focussed on the learning environment (Figure 3). The technology's 'novelty' diminishing over time (a motivation for having the study taking place over several months [32]) also led to fewer distractions from the environment. The hundreds of photos, videos and audio recordings created and uploaded by the children during their trips (Table 2) suggest that the children were easily able to use the application to support their creative output, implying that it was successful at implementing DG5 and DG4.

By supporting the offline caching of teachers' Activities and children's responses on devices shared between several students, the application supported structured outdoor activities without the need for Internet access or a one-to-one device-student ratio (DG6). The technology also helped the Year 2 teacher utilise the children's existing work for new educational activities in the classroom: using the ParkLearn website on her laptop and classroom smartboard projector facilitated full class discussion of students' work uploaded from the tablets. Presenting the students' responses on the website in a similar format to how they're displayed in the application (complete with the teacher's prompts, images and the app's iconography) had two main advantages: it allowed the teacher to review the children's work in the context in which it was first presented to them, and it also gave the students a familiar reference point to support them in doing related work in a different environmental context. Land's argument that the use of visual elements can allow users of varying abilities to partake in mobile learning activities [21] suggests that young children would have struggled with the equivalent text-based, CSV style table interface on WildKnowledge [42]. Through simple interfaces which ground the learner's context (DG4), ParkLearn supported transitioning between devices, learning environments and related activities (DG2).

Engagement and Empowerment Through Ownership

Throughout the study, the students, teachers and volunteers valued having ownership of their work. For example, the children took pride in their creations and showed off them to anyone that would listen. They recaptured videos if their narration could be improved; they deleted and reshot photographs if the framing wasn't up to their own standards. As noted by Teacher 2, this pride was evident on return to the classroom where they were eager to revisit their creations. However, this enthusiasm wasn't there for viewing other children's responses to the same Activity. The teacher believed that ownership of the task was an important contributing factor to the children's enthusiasm. Her plans for ParkLearn activities with her next class would involve groups all researching different topics: she argued that this unique knowledge would lead to the children becoming experts on their given subject, with the ownership of the task and knowledge empowering them through the ability to teach their peers. A natural progression of this would be for children to create ParkLearn activities for each other, moving towards giving the students greater control and supporting deeper reflection through content construction [14,17]. Success of this approach can be seen in Mobilogue, where students' ownership of their created quizzes prompted greater engagement [16]. By supporting such different lesson structures ParkLearn successfully implements DG3.

Previous work has considered how an individual's agency (a component of empowerment [18]) can be supported in the new Internet of Things world by applying lessons learned from the DIY movement to new, digital technologies [7]. We believe that parallels can be drawn to this with our teachers and park volunteers: they were able to fulfil their goal through technology, (mostly) independent of the usual top-down institutional restrictions which would have affected their creative control and output (DG1). Uphoff argues that an empowerment process needs to provide access to *'power resources'*—the assets which create possibilities for achieving objectives [38]. For our teachers and volunteers, Activity authorship was a power resource: it allowed them to create their own content as they saw fit and release it in their own timeframe, with minimal top-down assistance. We suggest that future m-learning designs should consider how they can empower the user through content ownership. In ParkLearn, this was achieved by granting more creative control to users and elevating them from consumers to producers of educational content.

Supporting Civic Engagement and Inquiry

The technology acted as a medium which facilitated civic participation, showing an opportunity for m-learning technologies to act as 'gateways' to active engagement with civic space or communities. This supports Richardson et al.'s suggestion that m-learning can engage with spaces' social infrastructures as resources for civic learning [29]. Teacher 2 argued that an opportunity existed for technology to highlight to the parents the value of the community resources and the children's impact on them as active stakeholders. As shown in the example of the care home visit, this highlighting could also be used to learn about the lives of members within communities who have been ostracised, forgotten or underappreciated. Through supporting multimedia data collection and sharing through multiple device types, seamless m-learning technologies can facilitate the sharing of civic knowledge and values with a wider community. While *'Earwig'* had been impractical due to the lengthy upload process, ParkLearn's immediacy could support such interactions without disrupting teachers' workflow. Teacher 2 also noted that beyond simply including the children's parents, this could also be extended to sharing values and practices in cross-cultural learning engagements (DG1). As previous work has shown, multimedia data collected through mobile devices can be used as effective cross-cultural learning resources [31]. However, opportunities exist to explore how m-learning technologies can support civic inquiry. When combined with the nQuire-it platform, Sense-it supported 'citizen inquiry learning' by acting as a scientific toolkit [33]. We propose that mobile technologies could also act as toolkits to support '*civic* inquiry learning': fostering cross-cultural communities of inquiry, through the design of creative learning activities to share and enquire about civic values and practices.

Limitations and Future Work

This study was partially limited by the time limitations placed upon our participating teachers. The application did not see as much usage by the Year 6 class due to a more demanding curriculum (resulting in fewer field trips) and the beginning of their exam season. Future work will further investigate the app's use with this age group. Additionally, the installation of the 'talking statue' coincided with the end of the school term, meaning that we were unable to use it as a learning resource with the school during this study. Accessing community expertise through technology was something Teacher 2 claimed to have not considered before, but said it was *"something we would use and we would access."* Future work will endeavour to investigate how community generated mobile learning resources can be used in formal education contexts. The generalizability of these studies may also be somewhat limited by the application's park branding and imagery: the Year 6 teacher only used the application for the outdoor section of his class's trip, opting to stow the tablets away for their indoor explorations of the museum. Similarly, it took several months for the Year 2 teacher to use the application in an activity which didn't relate to parks, plants or animals. Future work could expand on these findings by investigating in other contexts with a context-neutral branding, which may counteract this issue.

CONCLUSION

We have presented ParkLearn—a mobile learning platform designed to support teachers and communities in creating, sharing and completing bespoke mobile learning activities. ParkLearn facilitated mobile learning in a formal education context as seamless support tool, flexible enough to support teachers in designing activities across different devices and learning contexts. Simplified processes and interfaces meant that uploading the children's work easily fit into the teachers' workflow, promoting follow-up classroom activities and even sharing the content in engagements between the school and the surrounding community. Through supporting creativity and independence, the platform promoted ownership of content, increasing learners' engagement in follow-up activities. This element of independence also allowed community experts to elevate themselves to producers of rich, digital educational content—supporting them in sharing their knowledge and values with a wider community by removing the technical and financial barriers previously in place. We also identified opportunities for HCI to support cross-cultural civic inquiry, encouraging learners to share their values, knowledge and questions in a manner already embraced by citizen science research.

ACKNOWLEDGEMENTS

We'd like to thank our participants for giving their time to take part in our study. This research was funded through the EPSRC Centre for Doctoral Training in Digital Civics (EP/L016176/1). Data supporting this publication is openly available under an 'Open Data Commons Open Database License'. Additional metadata are available at: http://dx.doi.org/10.17634/154300-86. Please contact Newcastle Research Data Service at rdm@ncl.ac.uk for access instructions.

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