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An Integrated GPS-supported Outdoor Exploratory Educational System—EagleEye

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Abstract: EagleEye is an integrated GPS-supported educational system for supporting students and teachers respectively in pursuing and facilitating exploratory learning in outdoor fieldtrip activities. This system has four components, including the (1) Location-based Exploratory Resource Authoring Tool, (2) GPS-supported Exploratory Platform, (3) Repository Server, and (4) Teacher Console. A preliminary study, which involved 40 participants (38 students and 2 teachers from a school) adopting EagleEye in an outdoor fieldtrip activity, was carried out to investigate their perceptions of this system. It was found that EagleEye brought desirable fieldtrip experience to the students. The teachers also perceived positively the educational potential of EagleEye for outdoor fieldtrip activities from both technical and pedagogical perspectives.

Keywords: EagleEye, exploratory learning, GPS-supported outdoor learning, mobile learning

1. Introduction

With the advancement of mobile technology in the recent decade, there have been educational researchers endeavouring to study the educational potential of mobile learning and how mobile devices can be integrated into the process of education. For example, Sharples et al. [1] developed a framework theorizing about mobile learning. This framework informs researchers of (1) the design of mobile technology for educational purposes, and (2) the analysis of learning taking place in mobile contexts. Shih et al. [2] developed a mobile learning platform for scaffolding students in the course of inquiry-based learning in the context of social science education. Looi et al. [3] transformed an existing science curriculum into a mobilized inquiry-based science curriculum for delivery via 1:1 mobile devices. Boticki et al. [4] investigated the integration of mobile learning and CSCL (computer-supported collaborative learning), namely, mCSCL, for promoting students' collaborative experience and sharpening their skills of communication, negotiation and decision-making. In this paper, we discuss our new mobile learning initiative on harnessing the Global Positioning System (GPS) technology to support outdoor fieldtrips.

The GPS is a space-based satellite navigation system, providing reliable geo-location information anywhere on the earth [5]. Based on the GPS technology, we have developed an integrated mobile exploratory educational system, namely, *EagleEye*, for empowering students and teachers respectively in pursuing and facilitating exploratory learning in outdoor fieldtrip activities. Early this year, we conducted a preliminary study to probe into students' and teachers' perceptions of using EagleEye according to their experience in an outdoor fieldtrip with the adoption of this system. This study involved 38 students and 2 teachers from a school. We used a mixed research approach with a combination of student questionnaire-based survey, teacher interview, and researcher observation.

The rest of the paper is organized as follows. In Section 2, we will elaborate on the rationale behind our initiative. Section 3 is a description of EagleEye. Sections 4 and 5 will delineate respectively the design and findings of the present study. We will give our concluding remarks and discuss further study of EagleEye in Section 6.

2. Rationale behind Our Initiative

Knowledge cannot be separated from how and why it develops [6]. Nevertheless, the knowledge taught at school are usually fragmented into small and unconnected pieces. The original intention is for making learning easier, but this often ends up neglecting the rationale behind the knowledge itself, creating unrealistic learning content and context, and rendering the whole learning process boring [7]. In the view of *constructivist education*, learning should be an active process in which students construct knowledge by interacting with rich and authentic learning environments ([8], [9], [10]). *Experiential learning* [11] is one of constructivist learning paradigms being advocated in today's education, while one of the pedagogical approaches to implement this learning paradigm is *fieldtrips* [12].

Fieldtrips place learning in contexts that can never be replicated in classrooms [13]. Evidence has shown that, in comparison with classroom activities, students in fieldtrip activities are more motivated [14], more willing to transfer, apply, and anchor knowledge [15], as well as more likely to generate greater subject matter interest [16].

Nadelson and Richard Jordan [17] categorize fieldtrips into two common genres. The first genre is indoor-based, for example, a class visiting to a museum, science centre, institution, etc. The second genre is outdoor-based, for example, a class visiting to a park, forest, wetland, villages, or other sites with specific natural or heritage settings. The latter is usually adopted in geography, ecology, or cultural education for providing students with opportunities to pursue exploratory learning in real-life, real-world environments. In this paper, our focus is on outdoor fieldtrips. For writing convenience, the term "fieldtrip(s)" refers to "outdoor fieldtrip(s)" hereafter.

Conventionally, students' fieldtrips are led by teachers [12]. Before a fieldtrip activity, a teacher will design a set of paper-based worksheets for scaffolding his/her students in groups to observe, experience, and reflect, in accordance with some specific learning objectives of the fieldtrip. Usually, these worksheets contain open-ended questions for facilitating the students during the fieldtrip to think about and response to. At the end of the fieldtrip, the students have to submit the teacher their "answers" to these questions in written format. These submissions will sometimes be used for assessing the students' performance in the fieldtrip.

Students and teachers, however, do encounter various difficulties in pursuing and facilitating conventional fieldtrips activities. Before our development of EagleEye, we conducted in-depth interviews with 5 senior secondary students and 5 secondary teachers respectively from three different schools. The students and teachers respectively had rich fieldtrip-participation experience and rich fieldtrip-facilitation experience. According to their experiences and observations in the past, they elaborated on a number of problems arising frequently in conventional fieldtrip activities, as summarized below.

Problem 1: Learning taking place in a teacher-centred manner. The student-to-teacher ratio in a fieldtrip is usually large. Typically, one to two teachers facilitate a class of 40 students (or even more). Lacking enough "manpower," the teachers will bring the whole class to the designated exploratory spots on the fieldtrip site one by one in a designated order, without allowing the student groups to plan and frame their own exploratory route. This violates largely the original advocacy of the fieldtrip approach to facilitate learners to learn in a constructivist, student-centred fashion.

Problem 2: Students' learning motivation cannot be sustained. At the beginning of a fieldtrip, students' learning motivation is usually high. They are happy and excited (see Figure 1a), because outdoor activities are rare relatively in comparison with everyday classroom activities. However, their motivation will often decrease gradually in the course of the fieldtrip. A reason is that the students have no right to control the time being spent on a particular exploratory spot in correspondence with their own learning pace and interest. The time for staying at each spot is determined by their teachers, not themselves. Further, every time when a class of 40 (or even more students) arrives at a single exploratory spot (usually a small area), it is too crowned for every student to observe and experience the context around and the happenings (e.g., social and cultural events) therein (see Figure 1b).

Problem 3: More effective scaffolds are needed. In a fieldtrip, most of the learning scaffolds (guiding and open-ended questions) are given to students through paper-based worksheets. These worksheets are mainly text-based (or sometimes with images, such as, maps, pictures, etc.) presented in a static manner. During the fieldtrip, the students can only use texts to respond to the questions by writing on the spaces aside or below the questions, or on the opposite slides of the worksheets. This kind of paper-and-pencil scaffolds, nonetheless, does not appeal to today's students who are, in Prensky's [18] terms, "digital natives." They are eager to have technological and multimedia elements for supporting their learning process.

Problem 4: Collaboration among students is weak. In a fieldtrip, although students are usually divided into groups and asked to pursue the exploration collaboratively, most of them just care about whether they can complete the worksheets in hand before the end of the fieldtrip. Instead of having much discussion with their groupmates, the students spend a lot of time on copying the information from the fieldtrip site (see Figure 1b). They hope that the information can help them to answer the questions on the worksheets.

The aim of our development of EagleEye is to mitigate the above problems. Besides the employment of mobile technology, from the pedagogical perspective, we adopt Jonassen et al.'s [19] framework, "meaningful learning with technology," *(active, intentional, authentic, constructive, and collaborative)* as the foundation for shaping the design and implementation of EagleEye. The following section will discuss the system in detail.

(a) Beginning of a fieldtrip: Happy and exciting faces *(b) During a fieldtrip*

Figure 1. Students in a Conventional Fieldtrip Activity

3. EagleEye

EagleEye consists of four core components, including the (i) *Location-based Exploratory Resource Authoring Tool (LERAT)*, (ii) *GPS-supported Exploratory Platform (GEP)*, (iii)

Repository Server (RS), and (iv) *Teacher Console (TC)*. The following will elaborate on the specific function of each component.

3.1. Location-based Exploratory Resource Authoring Tool (LERAT)

The LERAT is a PC-based software tool for teachers to create location-based exploratory resources for running on GPS-enabled tablets. Each of these resources is a combination of a *map* and a number of location-based *exploratory scaffolds* for facilitating students to pursue exploratory learning during a fieldtrip. The interface of the LERAT is shown in Figure 2. When a teacher creates a location-based exploratory resource, first of all, he/she needs to import a map (in image format)[1] into the LERAT for specifying the geo-area corresponding to his/her planned fieldtrip. This imported map becomes the base (the background) of the resource. Further, he/she needs to conduct simple calibration by inputting the corresponding real-world latitude and longitude values[2] into the corners of the map. After that, the teacher can set up, at each designated exploratory spot on the map, a location-based exploratory scaffold. Usually, each scaffold contains a guiding question for hinting the students to explore that spot. These scaffolds will then be presented as “hotspots” (see the circles in Figure 2). Various templates (multiple-choice, true/false, fill-in-the-blank, open-ended question types, etc.) are available in the LERAT for assisting the teacher in designing the scaffolds. After developing the resource, he/she will upload it the RS (see Sub-section 3.3).

3.2. GPS-supported Exploratory Platform (GEP)

The GEP is a tablet-based software application (i.e., an App). The current version of the GEP is designed for running on Apple™ iPads, and is available for free download from the Apple™ App Store. The interface of the GEP is shown in Figure 3. Before a fieldtrip, students will first connect to the RS (see Sub-section 3.3) to download the corresponding location-based exploratory resource (designed by their teacher) to their GPS-enabled tablets. During the fieldtrip, the students will open the resource with the GEP. An “avatar” (see Figure 3) will appear on the map to indicate their current geo-location in the real world. Based on the ongoing GPS signals received by the GEP, the “hotspots” (exploratory scaffolds) embedded in the resource will pop up automatically when the students step in physically the corresponding geo-locations on the fieldtrip site (see Figure 4). These hotspots will guide them to observe, experience, and reflect during the course of the fieldtrip. They can also submit their responses to the questions (presented at the hotspots) through the GEP to the RS (see Sub-section 3.3). Hence, their teacher can retrieve those responses from the RS through the TC (see Sub-section 3.3). Unlike conventional fieldtrip activities where a whole class crowds into each exploratory spot simultaneously, with the GEP students can work in small groups to plan and frame their own exploratory route according to their own learning pace and interest. They can also determine themselves how much time they want to spend at each spot.

3.3. Repository Server (RS) and Teacher Console (TC)

The RS has three main functions. Firstly, it is for teachers to upload their created location-based exploratory resources. Secondly, it is for students to download the resources to their GPS-enabled tablets before the fieldtrips. Thirdly, it is for storing the students’ on-going responses to the questions (exploratory scaffolds) during the fieldtrips. The TC is a

[1] This image source can be obtained simply by screen-capturing it from free online maps, such as, Google™ Maps (http://maps.google.com) or Bing™ Maps (http://maps.bing.com).
[2] These values can also be obtained easily from free online maps, such as Google Maps™ or Bing Maps™.

web-based (browser-based) platform connected to the RS. It aims at enabling the teachers to retrieve their students' responses to the questions after the fieldtrips. Those data will provide the teachers with useful information for assessing and debriefing their students.

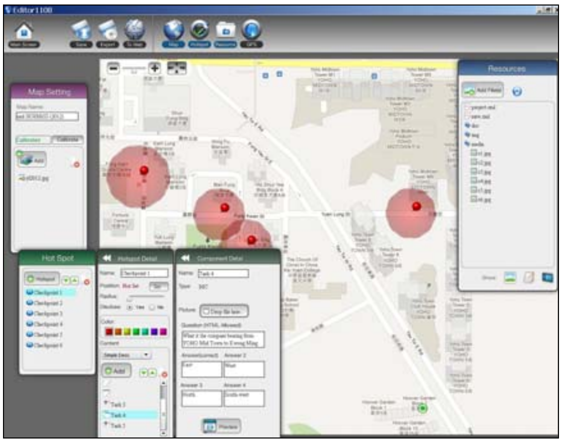

Figure 2. Location-based Exploratory Resource Authoring Tool (LERAT)

Figure 3. GPS-supported Exploratory Platform (GEP)

Figure 4. "Hotspots" Popping-up on Students' GEP

4. Research Design

The aim of the present study was to probe preliminarily into students' and teachers' perceptions of EagleEye after experiencing its use during a fieldtrip activity. A secondary school in Hong Kong was invited to participate in the study. The participants involved a class of 38 Grade-9 students (aged 16.3 in average) and 2 geography teachers. The students had some experience in participating conventional fieldtrips when they were in lower grades. The teachers had rich experience in organizing conventional fieldtrips.

The fieldtrip in this study was conducted as an extra-curriculum event of geography education. The fieldtrip site was a "semi-rural" area located at the New Territories in Hong Kong— a village called Lung Yeuk Tau. From the educational perspective, this fieldtrip aimed at letting the students explore the impacts of urbanization on the conservation of the traditional Chinese culture in Hong Kong. In fact, the teachers had organized similar fieldtrip activities (on the same site, with the same educational aim) but in a conventional fashion (with paper-based worksheets) for their former students in previous years. The following sub-sections delineate further the design of this study.

4.1. Teacher Enablement Training

Four weeks before the fieldtrip, we conducted a two-hour training session for the teachers. The training provided them with hand-on practice on the use of the LERAT, GEP, and TC of EagleEye. After that, we requested the teachers to convert their paper-based worksheets used previously in the Lung Yeuk Tau fieldtrip into a location-based exploratory resource with the LERAT for the present study. In addition, we asked them to practice the use of the GEP and TC by themselves. Within a week, the teachers created the resource.

4.2. Setting of the Fieldtrip Activity

The 38 students were divided randomly into 8 groups (4 to 5 students per group). Each group was given a tablet (Apple™ iPad). The fieldtrip activity was held in a morning, taking around 3.5 hours to finish (excluded the round-trip travelling time between the school and the fieldtrip site). The first part (20 minutes) was a briefing session (taking place in the school) in which the teachers briefed the students on the aim of the activity, the operation of the GEP, as well as some safety issues. The second part (2.5 hours) was the fieldtrip in which the students worked in groups with the GEP. The third part (40 minutes) was a debriefing session (taking place after coming back to the school) in which the teachers retrieved (with the TC) and discussed the students' responses to the questions (exploratory scaffolds) embedded in the location-based exploratory resource.

4.3. Data Collection

We observed the entire study (including the teacher enablement training, briefing session, fieldtrip, and debriefing session). A post-activity student survey was conducted right after the completion of the debriefing session. The questionnaire of the survey consisted of 10 items, in 5-point Likert scale. Table 1 describes the design of the questionnaire, while Table 2 (in Sub-section 5.1) displays the 10 items. The first eight items requested the students to rate their present EagleEye-supported fieldtrip experience in comparison with their past experiences in conventional fieldtrips. These items were designed with respect to the four problems in conventional fieldtrips that we have discussed earlier in Section 2. We wanted to study the possibility of adopting EagleEye to mitigate these problems. The last two items requested the students to rate their overall perceptions of the use of EagleEye. After finishing the survey, we interviewed the two teachers together for gathering their perceptions of the adoption of EagleEye in fieldtrip activities.

Table 1. The Design of the Questionnaire Items

Aim	Items	Corresponding Problem (see Section 2)
To study the possibility of adopting EagleEye to mitigate the problems in conventional fieldtrips	Items 1, 2	*i) Learning taking place in a teacher-centred manner.*
	Items 3, 4	*ii) Students' learning motivation cannot be sustained.*
	Items 5, 6	*iii) More effective scaffolds are needed.*
	Items 7, 8	*iv) Collaboration among students is weak.*
To study the students' overall perceptions of the use of EagleEye	Items 9, 10	/

5. Findings

We discuss the findings from two perspectives. First is the students' perceptions based on the post-activity student survey results and our observation. The latter is the teachers' perceptions in accordance with the teacher interview and also our observation.

5.1. Students' Perceptions of the EagleEye-supported Fieldtrip

The questionnaire return rate was 100%. Table 2 shows the descriptive statistics *(M: Means, SD: Standard Derivation)* of the students' responses to each items.

The results align with what we observed in the study. From the students' point of view, EagleEye did provide them with a favourable fieldtrip experience *(see Items 9 &10)*. In addition, they rated their experience in the present fieldtrip more desirable than their past experiences in conventional fieldtrips. This indicates EagleEye did mitigate, to a certain extent, the problems discussed in Section 2. Firstly, EagleEye made the fieldtrip more active and student-centred (see Items 1 & 2, mitigating Problem 1). Secondly, EagleEye motivated and engaged the students in a greater extent (see Items 3 & 4, mitigating Problem 2). The students were provided with better support through EagleEye (see Items 5 & 6, mitigating Problem 3). Lastly, EagleEye promoted the collaboration among the students (see Items 7 & 8, mitigating Problem 4).

Table 2. The Post-activity Student Survey Results

Item		M	SD
Comparing to my past fieldtrip experiences, ***in the fieldtrip today …*** **5: Strongly Agree 4: Agree 3: Neutral 2: Disagree 1: Strongly Disagree**			
1	I participated more actively because of EagleEye.	4.26	0.49
2	I had better control on the process of exploration according to my learning pace and interest because of EagleEye.	4.43	0.50
3	I am more motivated in the process of exploration because of EagleEye.	4.31	0.49
4	I was more engaged in the process of exploration because of EagleEye.	4.23	0.36
5	The location-based features of EagleEye *(the indication of my geo-locations, and the just-in-time pop-up of hotspots)* provided me with better support in the process of exploration.	4.21	0.50
6	The multimedia and interactive features of EagleEye *(the hotspots, and the questions presented therein)* provided me with better support in the process of exploration.	4.25	0.48
7	I had more discussion with my groupmates because of EagleEye.	4.37	0.67
8	I have better collaboration with my groupmates because of EagleEye	4.26	0.63
In an overall manner, ….			
9	The use of EagleEye offers me good fieldtrip experience.	4.48	0.45
10	I am eager to have more chances to have EagleEye-supported fieldtrips in the future.	4.47	0.46

5.2. Teacher' Perceptions of the EagleEye-supported Fieldtrip

Owing to the limited spaces of this paper, we discuss only the teachers' perceptions of EagleEye from the technical and pedagogical perspectives. From the technical point of view, the teachers found EagleEye was easy to use, and appreciated the user-friendliness of the LERAT, GEP, and TC. They elaborated—

> *We are not smart in IT and computing in fact. However, we didn't have any difficulties in converting the paper-based worksheets into the location-based exploratory resource with the LERAT for the present fieldtrip. We also didn't have any difficulties in getting familiarized ourselves with the use of the GEP and TC. The overall operation of EagleEye is quite user-friendly.*

The teachers' elaboration aligns with what we observed in the study. During the teacher enablement training, the teacher did well in the hand-on practice on EagleEye. During the briefing session, they were able to explain the operation of the GEP to their students fluently. During the debriefing session, they could retrieve their students' responses to the questions (exploratory scaffolds) through the TC without any problems. From the pedagogical point of view, the teachers perceived the educational potential of EagleEye positively.

Specifically, they appreciated its ability to engage and motivate the students during the fieldtrip and make the whole fieldtrip more student-centred. They elaborated—

> *We have organized fieldtrips over many years, but we have never seen students so motivated and engaged like the ones in the fieldtrip today. We are also happy to see today the students could plan and frame their own exploratory route, and have more control on their own exploration ……The performance of the students today is impressive.*

6. Conclusion and Further Study

In this paper, we have delineated our mobile learning initiative, EagleEye, an integrated GPS-supporting students and teachers respectively in pursuing and facilitating exploratory learning in outdoor fieldtrip activities. We have also discussed our perceptional study for investigating students' and teachers' experience in using EagleEye, in which we got some initial success and encouragement. However, as highlighted in the paper, the study was a preliminary one. More research work has to be done on further studying the educational effectiveness of EagleEye, in terms of, for example, advancing students' knowledge and exploratory skills, promoting students' subject matter interest and affection for the natural environments, etc. In addition, in order to enhance the existing use of EagleEye, we would like to know if we need a new pedagogical approach which is different from the typical 3-phase approach (briefing, fieldtrip, and debriefing) adopted for long in conventional outdoor fieldtrip activities. All of the above have been added to our research agenda.

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