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Mobile G-Portal Supporting Collaborative Sharing and Learning in Geography Fieldwork: An Empirical Study

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ABSTRACT

Integrated with G-Portal, a Web-based geospatial digital library of geography resources, this paper describes the implementation of *Mobile* G-Portal, a group of mobile devices as learning assistant tools supporting collaborative sharing and learning for geography fieldwork. Based on a modified Technology Acceptance Model and a Task-Technology Fit model, an initial study with *Mobile* G-Portal was conducted involving 39 students in a local secondary school. The findings suggested positive indication of acceptance of *Mobile* G-Portal for geography fieldwork. The paper concludes with a discussion on technological challenges, recommendations for refinement of *Mobile* G-Portal, and design implications in general for digital libraries and personal digital assistants supporting mobile learning.

Categories and Subject Descriptors

H5.2. User Interfaces – user-centered design

General Terms

Design, Human Factors.

Keywords : Mobile learning, collaborative learning, personal digital assistant, geospatial digital libraries, technology acceptance model, task-technology fit model.

1. INTRODUCTION

The classroom of today is constantly undergoing changes. Instead of traditional methods of chalk and talk and teaching from textbooks, educationalists are exploring ways in which information and communication technology (ICT) can be used to support experiential and student-centered learning for students, allowing them to construct their knowledge more competently, independently and in an enjoyable way. ICT has changed the way teaching and learning is taking place in local classrooms. Presently, the Internet, educational multimedia software and presentation applications have become common teaching and learning resources in the classroom.

Computer laboratories are built to support the use of these resources for learning. Desktop computers are common tools that students use for learning and completing assignments. Recently, the development of mobile communication technology has seen an infusion of smaller computing devices into the education landscape. In many schools, notebooks serving similar functions and purposes as desktops are now easily available for students and teachers. Handheld computers are mobile, flexible devices that can provide real-time, one-to-one support for students from within the context of their learning activities [18].

Similarly, smaller handheld devices such as the Personal Digital Assistants (PDAs) have also gained popularity and have shown great potential for a wide spectrum of use in education due to low costs, organizational features and portability. The present level of hardware and software development in mobile devices, especially the Mobile G-Portal, has reached the level of a personal computer in the 1990s. With good support for communication, they provide an ideal platform to enable mobile learning.

Fueled by development in mobile device technologies, mobile learning, which focuses on mobility of learning anywhere and anytime, is a new education paradigm gaining momentum in recent years. In contrast with traditional e-learning systems focusing on content delivery and progress monitoring, mobile learning also emphasises a wider range of tasks (including outdoor activities away from the classrooms) supporting "on-the-move" learning.

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In this paper, we describe the implementation of *Mobile* G-Portal, a group of mobile devices as learning assistant tools integrated with G-Portal, a Web-based geospatial digital library (DL) of geography resources accessible via personal computers, supporting collaborative sharing and learning in geography fieldwork [17].

The remainder of the paper describes the design, development and testing of *Mobile* G-Portal, a group of mobile devices, presently implemented with specific application on the personal digital assistant (PDA). Section 2 describes *Mobile* G-Portal's underlying educational design rationale and contrasts it with related work in PDAs for education and geography-oriented educational digital libraries. Section 3 provides an in-depth treatment of *Mobile* G-Portal including its design and architecture. Using a modified Technology Acceptance Model (TAM) and a Task-Technology Fit (TTF) model, an initial study involving students in a local secondary school is described in Section 4. This study examines the degree of technology acceptance of the *Mobile* G-Portal for Geography fieldwork. The final section concludes with a discussion on technological challenges, design recommendations for refinement, and design implications in general for DLs supporting mobile learning.

2. RELATED WORK

In recent years, with the development of mobile technology, we have witnessed an infusion of smaller computing devices applied to teaching and learning in classrooms across different age groups, and different subject domains.

In higher education, for example, medical students from the Wake Forest University School of Medicine used PDAs linked to a centralized data server to access, retrieve, record and store patients' information as they made their rounds in the hospital [12]. In another application, law students from the New York Law School downloaded legal resources and information from the school's website using the PDAs while on the move. The PDAs were linked to applications that allow them to organise and manage data and to plan their schedules [12].

Through a study of field biology practices, the ButterflyNet project at Stanford [30] is a mobile capture and access system that integrates paper notes with digital photographs captured during field research, so biologists can leverage a diverse set of tools, organizing their effort in paper notebooks.

At the secondary and primary school levels, PDAs have been used for various learning activities such as writing during journalism lessons [28]; simulation games on life-cycle and reproduction of fishes during science lessons in the classroom [4] and data collection for Science field trips to aquarium or Geography field trips to streams [1]. Thus, PDAs are being used to make the learning processes more organized, interesting and student-centered in order to achieve better learning outcomes.

Other studies (e.g. [1], [3], [28]; etc.) had identified the potential of PDAs for use in education for classroom learning as well as for outdoor education in Science and Humanities (e.g. Geography and History) field studies. Despite the common use of handheld devices such as data loggers in Science and Geography field studies for measuring, recording and storing of quantitative data, the use of PDAS to conduct educational field studies has grown in popularity due to its organizational capability and useful functions [24].

Students ranging from primary level to university level are using PDAs with applications especially designed for specific tasks in field research. Some examples are the Geney project for primary students [4] and the MOOsburg++ project for adult learners [9]. In these field studies, PDAs were mainly used as tools to record, share, process, read and interpret field data as well as to answer field observation questions. Studies of PDAs in fieldwork applications had reported the potential of the PDA as data collection and learning tool in the field that could result in better collaboration, improved learning attitude and better understanding of learning [24].

3. G-PORTAL PROJECT

In this section, we briefly revisit our previous work on G-Portal, and subsequent development of *Mobile* G-Portal, to provide a background for our study design and findings, and the issues explored within it for DLs and mobile learning.

3.1 G-Portal

G-Portal [17], a Java-based DL system, allows identification, classification and organization of geospatial and geo-referenced content on the Web, and the provision of digital services such as searching and visualization. In addition, authorized users may also contribute resources so that G-Portal becomes a common environment for knowledge sharing. G-Portal resources are defined as Web content, annotations and metadata. Accommodating metadata of different formats using XML and XML Schemas, G-Portal's flexible repository subsystem organizes metadata into projects and layers, and supports an integrated and synchronized classification and map-based interfaces over the stored metadata. By providing an interactive platform engaging students in active manipulation and analysis of information resources, G-Portal aims to support collaborative learning activities.

3.2 *Mobile* G-Portal

Current work on G-Portal includes extending the Web-based G-Portal platform to the mobile environment. The *Mobile* G-Portal system was inspired by the increasing focus on the mobility of new digital devices to provide "just-in-time/just-enough" information for effective learning and teaching. Focusing on the fieldwork component in the geography syllabus for secondary schools students in Singapore, a new application on the *Mobile* G-Portal was built to study the outdoor microclimate around the neighborhood of a local school. With the assistance of two geography school teachers, requirements for the "microclimate fieldwork" application was designed and built for the HP6515 Mobile G-Portal (see Figure 1).

Figure 1. Map Editor User Interface of *Mobile* G-Portal

The study area was a residential area known as Serangoon North Avenue 1 where the school was located, comprising high-rise apartments, parking lots and garages, roads, open fields and single or double storey houses at the western and south-western part of the study area. A total of 30 study locations were identified for data collection on the map-based interface of the *Mobile* G-Portal (dots shown in Figure 1).

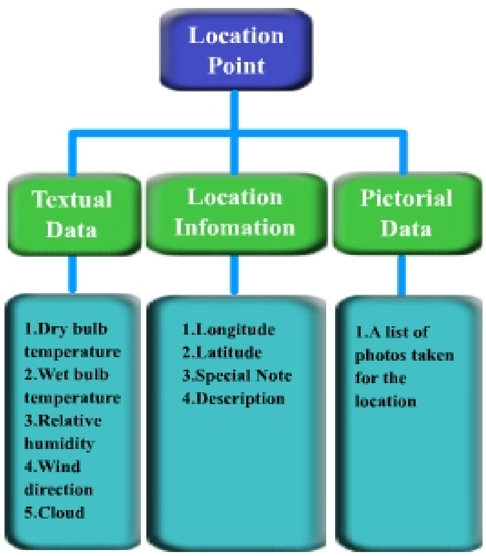

Figure 2. Data Associated with Each Location

Each location is represented by a unique ID. It is overlaid on the map to help the students navigate around the study area. A set of operations and data are associated with individual locations to assist in updating and viewing. The detailed data association is shown in Figure 2. Necessary features like zooming and panning are also supported to facilitate an easy-to-use interface, and offer more flexibility compared to a traditional hard-copy map.

Mobile G-Portal, implemented as a client system on the PDA, is responsible for data collection, temporary storage and data formatting for transfer (see Figure 3). It accepts location information (e.g. longitude and latitude of all the location points of interest and special notices for them if there are any), and uploads the collected data for the fieldwork in XML format to a PC containing middleware – the *Mobile* G-Portal Desktop Client.

After all the data collected for the fieldwork has been obtained, the *Mobile* G-Portal Client combines the data from different groups, converts it into a standard format compatible to the G-Portal system and uploads it to G-Portal. The G-Portal System with its wide range of capabilities is the final destination of the fieldwork data. Students can access and analyze the collected data over a period of time from G-Portal. Teachers are also able to interact with students and work together on the collected data via G-Portal.

The system architecture of the current Serangoon Collaborative Mobile Learning project implemented in G-Portal (referred to as the *Serangoon project* for short) is divided into three layers, as shown in Figure 4. The Microsoft .NET Compact Framework (CF) was used as the development platform

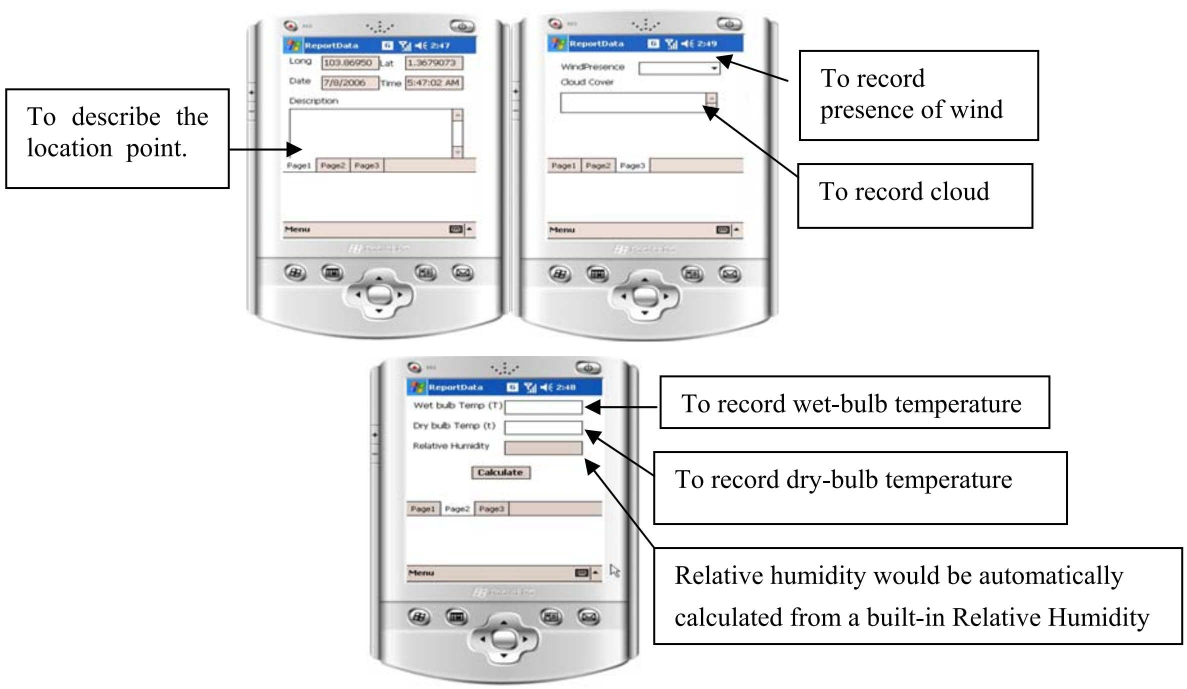

Figure 3. Client Application of the *Mobile* G-Portal Implemented in HP6515 PD

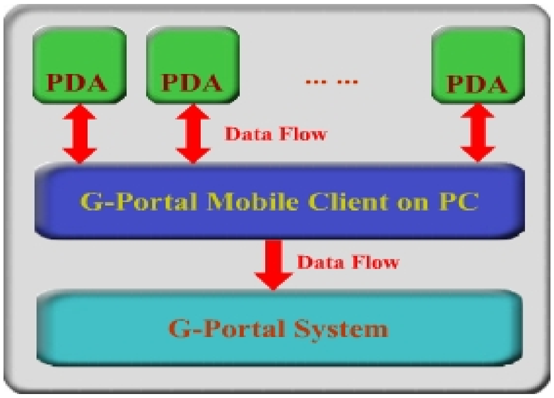

Figure 4. System Architecture for the Serangoon Project

For location-aware applications, vector maps are the preferred choice as they incorporate more geospatial and service information. However, in the case of the Serangoon Project, the information provided by the vector maps was not very useful. On the contrary, the maps become too large in size to be efficiently stored onto the *Mobile* G-Portal clients. Therefore, a new scheme was devised to give the map a small memory footprint and yet include essential geospatial information.

Here, we use a combination of JPEG images with an accompanying XML file which contains the top-left and bottom-right corner GPS coordinates of the map as well as the coordinates of each individual location defined on the map. To automate the process of editing a JPEG file into a format usable by the mobile application, a map editor application was designed. The editor provides a what-you-see-is-what-you-get user interface so GPS coordinates are specified easily and accurately (see Figure 1).

Two types of data are captured in this project. Textual data refers to the different characteristics of each location to be monitored. Most of them can be captured using equipment such as pyschrometers. Others like cloud cover may rely on students' observation skills. Essentially, a hardcopy data sheet is converted to a digital form. To further simplify the process and reduce the number of items students have to carry, frequently used lookup tables are stored on the mobile devices.

As shown in Figure 5, to obtain the relative humidity (RH) value, the student needs only to enter the wet and dry bulb temperature readings and the RH value is generated by the system rather than having to cross reference from an actual RH table.

Pictorial data, on the other hand, is essential when recording vegetation features of a particular location. Since most PDAs are equipped with cameras, this functionality can be easily incorporated. As the .NET Compact Framework does not facilitate direct manipulation of the camera hardware and different devices may have different APIs for doing so, a generic procedure is put in place to store pictures. When a student takes a picture of a location, it is saved into a default folder (e.g. My Documents). Afterwards, the student can add this picture to a location via the map interface. Another copy of the picture is saved in the local database for the client application and changes made to the original picture have no effect on the personal saved copy (see Figure 6).

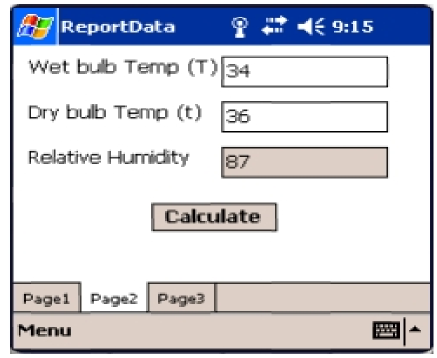

Figure 5. Temperature Input and Automatic Calculation of Relative Humidity

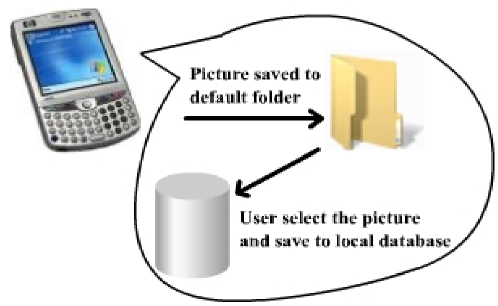

Figure 6. Modus Operandi of Picture Acquisition

4. RESEARCH CONTEXT

Most studies on the use of PDAs for education are mostly conducted and reported from the perspectives of educators, instructional designers through observation and feedback from students. Recent studies (e.g., [3], [28]; etc.) identified PDAs for classroom learning and field studies due to their organizational capability and useful functions [18]. According to [24], the use of PDAs could result in better collaboration, improved learning attitude and better understanding of learning. In other studies involving fieldwork (e.g. [4], [9]; etc.), PDAs were used to record, share, process, read and interpret field data.

In Singapore, the use of technologies for innovative teaching and learning started as early as 1997. Masterplan I for information technology (IT) in Education (1997 – 2002) was implemented to promote understanding, creativity, independent and active learning in pupils through the setting up of IT infrastructure in schools, introducing and encouraging the adoption of various IT-related activities in the classroom, building a repository of learning resources and equipping teachers with IT skills through training [21]. The successful implementation of Masterplan I in Singapore led to the launch of Masterplan II for IT in Education, highlighting a more holistic and systematic approach to use IT effectively with the objectives of integrating curriculum, assessment and instruction to bring about engaged learning in students [23]. The introduction of the 'Teach Less, Learn More' initiative further emphasized the importance of IT in enabling learning by encouraging inter-disciplinary lessons and multi-faceted learning activities while teachers take on a more facilitating role [22]. Consequently, various technological innovations were adopted for teaching and learning, including the increasing use of mobile devices such as the tablet PCs and PDAs.

In contrast with other studies, our study conducted in Singapore after the launch of Masterplan II, aimed to investigate the use of technologies such as PDAs for learning and teaching of geography. Specifically, we wanted to investigate the degree of acceptance of the *Mobile* G-Portal for geography fieldwork among secondary school students in Singapore. To achieve the objectives of our study, we investigated two well-established models:

- *Technology Acceptance Model* (TAM). TAM [5], commonly used in information systems research for the work environment, has also been applied to better understand the potential use of technology in education. TAM aims to determine users' attitude, intention to use and actual use of technology through their perceptions of usefulness and usability of the technology as well as external variables that may influence users' perceptions, attitude and usage. Many research studies on the acceptance of information technology by adult learners in higher education had been conducted using TAM as the theoretical framework. Some of these studies include research on acceptance of e-learning (e.g.,[20]; etc.), Web-based learning [26]and computing tools [1]
- *Task-Technology Fit (TTF) model*. TTF model aims to fill the gap in TAM which is lacking in emphasis on performance attributable to actual use and whether the capabilities of the adopted technology matches the demands of the task concerned [8]. For example, Goodhue and Thompson [11] conducted a study on university students' use of the integrated information center using the TTF model. In addition, to provide a more powerful explanation on users' utilization and choices of IT that benefits them in their jobs, Dishaw and Strong designed the integrated TAM/TTF model [8], recently revising the model to include computer self-efficacy [27].

4.1 Objectives and Hypotheses

Applying the integrated TAM/TTF model, our study aimed to achieve these two objectives:

- To investigate students' attitudes and behavioral intentions to use *Mobile* G-Portal for geography fieldwork by considering the factors of perceived usefulness, perceived ease of use, intrinsic motivation, prestige, tool functionality and task-technology fit.
- To examine the suitability of PDA as a client application of *Mobile* G-Portal in supporting data collection for geography fieldwork.

To address these two objectives, four hypotheses and sub-hypotheses were generated to investigate students' acceptance of *Mobile* G-Portal for use in geography fieldwork (see Figure 7):

- Hypothesis 1. Students' attitude towards the use of *Mobile* G-Portal is significantly affected by perceived usefulness, perceived ease of use, intrinsic motivation and prestige.
- Hypothesis 2 postulates that perceived usefulness of *Mobile* G-Portal is significantly affected by perceived ease of use, intrinsic motivation, prestige and task-technology fit (TTF). It aims to find out how factors of perceived ease of use, intrinsic motivation, prestige and task-technology fit (TTF) could influence perceived usefulness. Students who perceived the *Mobile* G-Portal as easy to use may think that it is useful. Similarly, students might find *Mobile* G-Portal useful for geography fieldwork as they were already intrinsically motivated to use it. The prestige gained from using *Mobile* G-Portal may influence the perception that the *Mobile* G-Portal was useful for fieldwork. TTF was proposed to influence perceived usefulness as if the students felt that the tool (*Mobile* G-Portal) fitted the tasks given during fieldwork, they might conclude that the *Mobile* G-Portal is a useful tool.
- Hypothesis 3. Students' perceived ease of use of *Mobile* G-Portal is significantly affected by tool functionality and task-technology fit (TTF). There could be a relationship between perceived ease of use, tool functionality and TTF. A *Mobile* G-Portal with good tool functionality might result in greater ease of use of the tool which enables smooth completion of tasks.
- Hypothesis 4. Students' behavioral intention to use the *Mobile* G-Portal for future fieldwork is significantly affected by their attitude towards its use, task-technology fit (TTF) and perceived usefulness. In Hypothesis 4, three constructs were identified to explain students' behavioral intention to use *Mobile* G-Portal for geography fieldwork in future. A good attitude or feeling about the *Mobile* G-Portal might result in an intention to use it in future. A good match between the tool and the associated fieldwork would result in future intention to use the tool. Perceiving that the *Mobile* G-Portal is useful would strongly explain behavioral intention to use. The constructs that individually relate to behavioral intention are shown in three sub-hypotheses.

Students' acceptance of *Mobile* G-Portal was examined using the constructs of perceived usefulness, perceived ease of use and TTF. Perceived usefulness is defined by 'user's subjective probability that using a specific application system will increase his or her job performance within an organizational context' [5].

Perceived ease of use is the 'degree to which the user expects the system to be free of effort' [5]. Perceptions on how useful the information system is and how easy it is to use the system affect attitudes towards intention to use the system. Attitude is 'an individual's positive and negative feelings about performing the target behaviour' [10].

Besides attitude, students' behavioral intention to use *Mobile* G-Portal to carry out future fieldwork could be determined by TTF. The task-technology fit (TTF) refers to "associations between task requirements, abilities of individual and the functionality of the technology' [11]. Individuals will only use ICT if and only if the functions available to the users fit or support the activities of the users [8].

The study consisted of two parts, gathering both quantitative and qualitative feedback on *Mobile* G-Portal: (i) Part I - Questionnaire survey testing the hypotheses to understand subjects' perceived acceptance of *Mobile* G-Portal for geography fieldwork; and (ii) Part II – Open-ended questions to prompt further insights into issues faced, and suggest improvements to improve *Mobile* G-Portal.

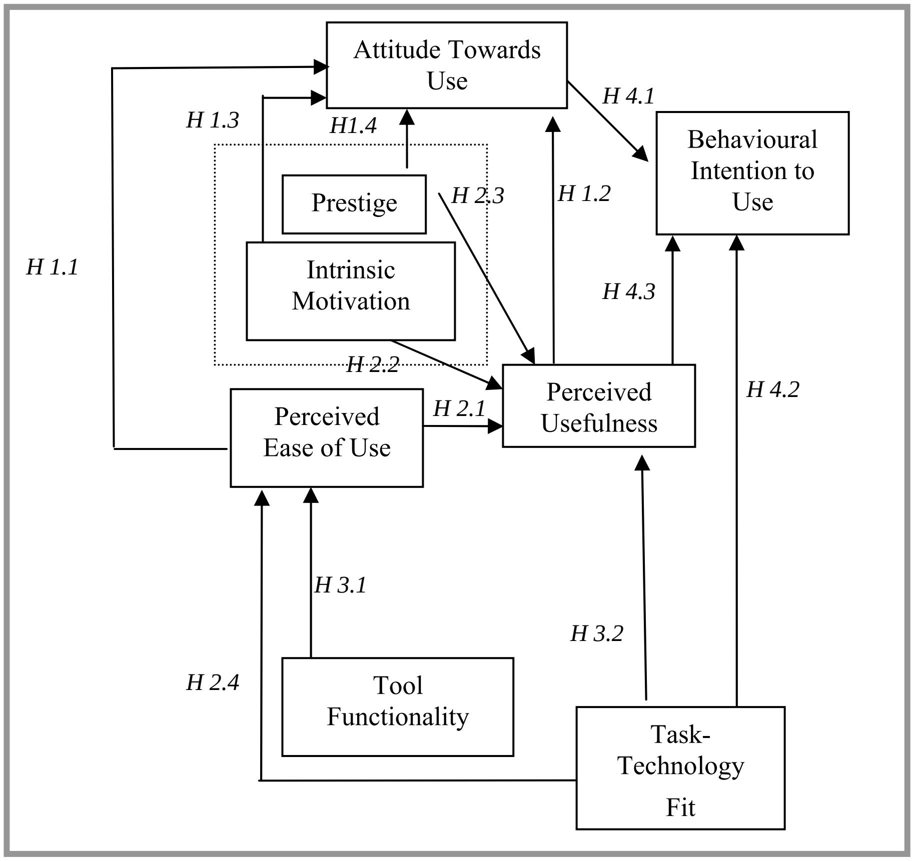

Figure 7. Modified TAM/TTF Model and Hypotheses

4.2 Profiles of Subjects

This study was conducted with a group of 39 Secondary Three (Grade 9) geography students in a co-education government school in the north zone of Singapore, representing a typical school. The class consisted of 25 boys and 14 girls.

4.3 Protocol

The fieldwork topic was derived from the Secondary Three Geography syllabus on 'Climate'. Prior to the fieldwork, the students were taught the topic covering concepts on climatic elements such as temperature, relative humidity, rainfall, wind and air pressure. The students were briefed on the fieldwork objectives and received training on how to use the sling psychrometer (an instrument to measure wet and dry bulb temperatures).

As there were only five sets of PDAs implemented with *Mobile* G-Portal available, two sessions of fieldwork for the same 30 locations were conducted on separate two days (22 and 24 May 2006). The 39 students were divided into 10 groups with 9 groups of 4 and 1 group of 3. In each session, there were 5 groups of students with each group collecting data (that is, wet-bulb and dry-bulb temperatures) for 6 locations. Every student in each group was assigned different roles so that each student would have the chance to use the *Mobile* G-Portal for data collection. The roles of the students in each group were as follows (Figure 8):

- The *recorder* was in charge of identifying the location point on the map and recording data for that location.
- The *spinner* swung the sling pyschrometer.
- The *time keeper* counted the time while the spinner swung the sling pyschrometer.
- The *observer* ensured that the correct data collection procedure was carried out.

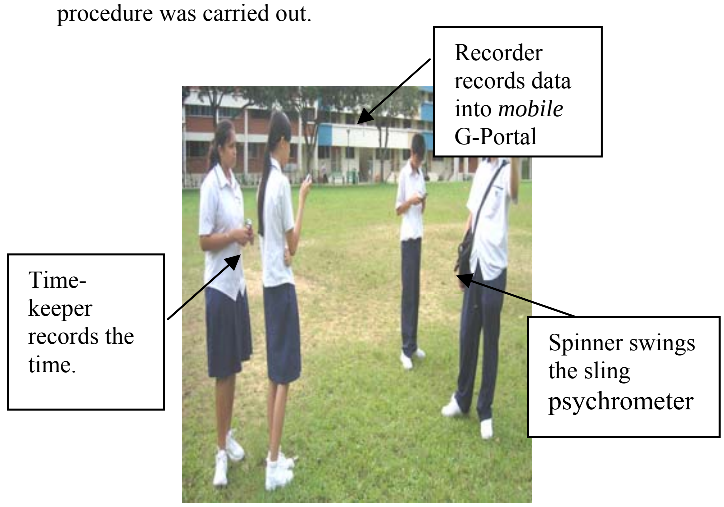

Figure 8. The Roles of Various Students in a Group

5. FINDINGS AND ANALYSIS

We report our results and analysis of subjects' feedback under the following sub-sections: (i) Data Preparation; (ii) Quantitative Results: Hypotheses Testing; and (iii) Qualitative Comments.

5.1 Data Preparation

Data from the 39 respondents were analyzed using SPSS. Responses to five-point Likert-type scale questions were entered as ordinal data with an absolute value (Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5). In the questionnaire, several items were used to measure each variable except for two variables on 'prestige' and 'behavioral intention to use'. Thus, a mean value for each variable was derived by summing the absolute value of each response to the question and dividing it by the number of the responses. A study on the distribution of each measurable variable showed that normality was not compromised. A reliability analysis using Cronbach's α to measure the reliability of each measurable variable with more than one item was carried out. Table 1 shows that the Cronbach's α for this questionnaire instrument exceeded the recommended 0.60 (Nunnally & Bernstein 1994), indicating good reliability of the survey items.

Measurable Variable	No. of Items	Cronbach's α
Intrinsic motivations	4	0.845
Tool functionality	8	0.755
Task-technology Fit	2	0.807
Perceived usefulness	4	0.836
Perceived ease of use	5	0.857
Attitude towards use	2	0.835

Table 1. Reliability Analysis for Variables with More than One Item

5.2 Quantitative Results: Hypotheses Testing

Multiple regression analysis was used to determine if each independent variable was significant in explaining the dependent variable. All proposed relationships were assumed to be linear. The dependent variables were normally distributed which satisfied the assumptions required for regression analysis. A 0.05 significant level or 95% confidence interval was used to determine the best fit for the research model. Table 2 gives a summary of the results using multiple regression analysis, and the following sections discussed some of the selected findings.

5.2.1 *Determinants of Attitude Towards Use*

Perceived usefulness (p=0.007) significantly and positively explained for attitude. Perceived ease of use (p=0.147), intrinsic motivation (p=0.135) and prestige (p=0.681) were not significant determinants of attitude. The model was not due to chance because of the significant F-value. A large R-value of 0.798 indicated a strong relationship. The R-square value of 0.637 implied that 63.7% of the variance was explained by the model.

5.2.2 *Determinants of Perceived Usefulness*

Perceived ease of use (p=0.003) and task-technology fit (p=0.001) were the strongest determinants of perceived usefulness. Intrinsic motivation and prestige did not significantly influence students' perceived usefulness of the *Mobile* G-Portal.

Hypotheses Tested (see Research Model)		p-value	Significant
H1.1.1:	Perceived usefulness has a significant relationship with attitude.	0.007	Yes
H1.2.1:	Perceived ease of use has a significant relationship with perceived usefulness.	0.003	Yes
H1.2.4:	Task-technology fit (TTF) has a significant relationship with perceived usefulness.	0.001	Yes
H1.3.1:	Tool functionality has a significant relationship with perceived ease of use.	0.019	Yes
H1.3.2:	Task-technology fit (TTF) has a significant relationship with perceived ease of use.	0.046	Yes
H1.4.1:	Students' behavioral intention to use *Mobile* G-Portal for future fieldwork is significantly affected by their attitude towards its use.	0.001	Yes
H1.4.2:	Students' behavioral intention to use *Mobile* G-Portal for future fieldwork is significantly affected by task-technology fit (TTF).	0.019	Yes
H1.4.3:	Students' behavioral intention to use *Mobile* G-Portal for future fieldwork is significantly affected by perceived usefulness.	.000	Yes
H2.1:	Tool functionality has a significant relationship with task-technology fit (TTF).	0.001	Yes
H1.1.2:	Perceived ease of use has a significant relationship with attitude.	0.147	Yes
H1.1.3:	Intrinsic motivation has a significant relationship with attitude.	0.135	Yes
H1.1.4:	Prestige has a significant relationship with attitude.	0.681	No
H1.2.2:	Intrinsic motivation has a significant relationship with perceived usefulness.	0.420	No
H1.2.3:	Prestige has a significant relationship with perceived usefulness.	0.428	No
H2.2:	Task experiences have a significant relationship with task-technology fit (TTF).	0.612	No

Table 2. Summarised Results for Hypotheses Testing

5.2.3 *Determinants of Perceived Ease of Use*

Hypothesis 3 was supported as tool functionality (p=0.019) and task-technology fit (p=0.046) were both positive and significant determinants in explaining students' perceived ease of use. There was a moderately strong relationship in this regression model (R=0.635). The R-square result also showed that 40.4% of the variation in perceived ease of use was explained by tool functionality and task-technology fit. Hence, the significant F-value of 11.507 did not occur due to chance.

5.2.4 Determinants of Behavioral Intention

Attitude (p=0.001), perceived usefulness (p=.000) and task-technology fit (p=0.019) significantly explained students' behavioral intention to use *Mobile* G-Portal. The high F-value (31.579) showed that the variation explained by the regression model was not due to chance. The high R value of 0.861 indicated a strong relationship between the dependent variable and independent variables. The model explained 74.2% of the variation in attitude. However, TTF had a negative unstandardised coefficient which implied a negative relationship with intention to use *Mobile* G-Portal.

5.3 Qualitative Comments

Students' responses to the open-ended questions captured their experiences during the fieldwork, positive and negative opinions about the device and what they wished to improve in the *Mobile* G-Portal.

5.2.1 Problems Encountered

The greatest and most common problem students encountered during the fieldwork was the inability to load or view the photographs after they had taken and saved them (20 responses). It was also reported that on several occasions, the application failed to work during use (3 responses) (Table 3). These problems were technical hiccups but not related to users' ability to use *Mobile* G-Portal (difficulty to use *Mobile* G-Portal) and functionality of the *Mobile* G-Portal (difficulty to use map) which were each mentioned by a student.

No.	**Questions/Responses to Questions**	**No. of Responses**
Q1.	**Describe any problem(s) you encounter when using the** *Mobile* G-Portal **for Geography Fieldwork.**	
1.	Could not view picture after taking or adding it.	6
2.	Could not view and locate saved pictures.	14
3.	The *Mobile* G-Portal kept hanging during recording of information.	3
4.	Difficult to remember the steps of using *Mobile* G-Portal.	1
5.	Difficult to use map.	1

Table 3. Problems Encountered During Fieldwork

5.2.2 Advantages Using Mobile G-Portal for Fieldwork

The ease in task completion (23 responses) and time saving of *Mobile* G-Portal (16 responses) were most commonly mentioned. This was followed by ease of use of *Mobile* G-Portal (6 responses), *Mobile* G-Portal was fun to use (4 responses) and that *Mobile* G-Portal was a better choice than using paper (8 responses). The many functions of *Mobile* G-Portal (3 responses), portability (5 responses) and usefulness of *Mobile* G-Portal in map reading (1 response) were other advantages mentioned by a minority of the students.

5.2.3 Disadvantages Using Mobile G-Portal for Fieldwork

Comments on disadvantages included usability issues such as failure of functions to perform (6 responses), difficulties faced in reading the map (3 responses), keying in and saving information (4 responses) and navigating the menu (4 responses). The size, weight, cost and shape of the *Mobile* G-Portal were concerns of a few students. Three students also raised a common but valid issue that if *Mobile* G-Portal malfunctioned, information would be lost. Two students even mentioned that they experienced anxiety when using the system.

5.2.4 Suggestions for Improvement

Students preferred more capacity in *Mobile* G-Portal to store information (7 responses), improved software features (1 response), creating shortcuts (1 response) and more functions for better performance in the device (5 responses). Five students would like to have a clearer map for viewing. Suggestions on making *Mobile* G-Portal smaller and lighter were also made (2 responses).

6. DISCUSSION

Consistent with many studies (e.g. [5]; [6]; [7]; [8]; etc.), students seemed more positive in their attitude if they perceived the device to be useful in helping them complete their tasks during fieldwork.

A weaker effect shown by perceived ease of use as compared to perceived usefulness on user attitude implied that students' attitude towards using *Mobile* G-Portal was unlikely to improve because the device was easy to use. This could be because students were more technology-savvy and had more experience using mobile phones. Thus, for this group of young users, usefulness was more important than usability as their main criteria in accepting and adopting of mobile technology. To these students, no amount of fun, enjoyment and sense of pride could affect their attitude about *Mobile* G-Portal.

In addition, the students' opinions on perceived enjoyment, sense of prestige and their perception on the ease of using *Mobile* G-Portal could be dampened by the technical faults, for example difficulty in uploading which they experienced during the fieldwork. This implies a need for students to be involved in the usability design of learning applications on mobile devices. Students could be invited to provide design ideas or prototypes through school projects and action research.

The easier it was to use the device, the more one would feel self-competent which would result in more exploration on what the system was able to perform and thus increase perceived usefulness. Consequently, giving students more time to explore and experience using the features in the device might help improve their perceptions on the usefulness of *Mobile* G-Portal. This warrants a greater usage of the mobile tool for field learning in schools.

Although perceived of ease was not a parallel and direct influence on attitude with perceived usefulness, it has an indirect and casual influence on attitude through the ease of use → usefulness → attitude relationship which was analogous with the chain of causality (ease of use → usefulness → usage) as theorized by Davis [5]. Studies had demonstrated the positive and significant relationships between task-technology fit (TTF) and perceived usefulness (e.g. [15]; [16]; etc.). The significance of task-technology fit on perceived usefulness in this study was logical. If users think that the technology suited the task they performed, they would naturally believe that it was a useful technology.

Both task-technology fit and tool functionality of *Mobile* G-Portal significantly explained for the students' perception on the ease of use of the device. When the fit between the tasks and the tool was high, it meant that the students were able to complete their tasks with ease. Similarly, more tool functionality that could support the tasks would increase the ease of use of the device. Thus, this research has again emphasized the need for more robustness in the hardware and software functionalities of the *Mobile* G-Portal to support the tasks of reading, recording, saving and storing information during fieldwork.

The significance of attitude on intention to use logically implied that a positive or negative attitude towards the use of the *Mobile* G-Portal would influence users' future intention to use the device. The significance of perceived usefulness on intention to use was consistent with many studies (e.g. [14]; [15]; [29]; etc.). There was an indirect relationship between TTF and intention through a causality chain. For example, TTF significantly explained for perceived usefulness which determined intention to use (TTF → Perceived usefulness → Behavioral Intention to use).

7. CONCLUSION AND ON-GOING WORK

This paper describes the implementation of *Mobile* G-Portal, a group of mobile devices as learning assistant tools, currently implemented in a PDA, to support collaborative sharing and learning for Geography fieldwork. Based on a modified Technology Acceptance Model and a Task-Technology Fit model, an initial study with *Mobile* G-Portal was conducted involving 39 students in a local secondary school. Findings from regression analysis showed that these students seemed to place more value on tool functionality and usefulness of the device in helping them complete their tasks during geography fieldwork. Perceived usefulness of the mobile device was most significant in influencing its acceptance as compared to intrinsic motivation, prestige and perceived ease of use. On the other hand, perception on ease of use and TTF influenced perception on the usefulness of *Mobile* G-Portal. Both TTF and tool functionality also significantly affected the perceived ease of use of *Mobile* G-Portal. Their attitude affected their intention to use *Mobile* G-Portal for future fieldwork. Lastly, tool functionality also determined the match of the technology to the fieldwork tasks.

The findings from this research suggest that digital libraries could go beyond desktop applications, providing "just-in-time/just-enough" information through mobility of new digital devices such as PDAs for more effective learning and teaching. Based on the study, we highlight several implications on the use of PDAs for geographical education in local schools:

- Firstly, for students to use *Mobile* G-Portal for fieldwork, they had to be convinced of its usefulness in helping them complete their fieldwork tasks efficiently and effectively. To these technology savvy teenagers who had ample experience in using mobile phones, whether *Mobile* G-Portal was easy to use no longer influenced their attitude and subsequent intention to use the device. Giving students more time to explore and experience using the features in the device might help in improving their perceptions on the usefulness of *Mobile* G-Portal. This also implied greater usage of the mobile tool for field learning in schools.
- Secondly, *Mobile* G-Portal must have sufficiently strong functions to support the tasks of reading, recording, saving and storing information during fieldwork. Moreover, geography fieldwork could encompass other tasks such as interacting with the study map through orienteering and navigation, communicating or sharing information with other team mates, handling of data from longitudinal studies, observing trends and detecting changes in the field. Savill-Smith and Kent [25] stressed the importance of good educational software with the necessary educational functionalities that would justify to educators the usefulness and relevance of palmtops in education. Several student respondents also suggested more functions as what they thought could be done to improve the use of *Mobile* G-Portal for geography fieldwork (see Table 8). Thus, this research has again emphasized the need for more robustness in the hardware and software functionalities of *Mobile* G-Portal, be it for fieldwork or other subject domains.
- Thirdly, findings from this study also highlighted the need for students to be involved in the usability design of learning applications in mobile devices as how keen the students were to use *Mobile* G-Portal for learning in the field was no longer influenced by intrinsic motivation or sense of prestige but rather, the usefulness of the device. Research (e.g. [18, 19]) on mobile devices for education stressed the importance of user-centered designs and students' involvement in the design process in order to meet pedagogical requirements such as collaborative learning and improved learning outcomes. With emphasis on creativity and the 'Teach Less Learn More' initiative in Singapore, students could be invited to provide design ideas or prototypes through school projects. For example, students who designed a board game for a topic would provide useful design requirements and information on user needs that could be input into *Mobile* G-Portal software applications. Therefore, in the local educational setting, any development or introduction of mobile technology for learning in schools would require strong research and user evaluations with involvement from students as part of the design teams.

Future work can be done by including a more diverse group of students in the study, developing applications for other subject areas and measuring actual usage by allowing students to choose between *Mobile* G-Portal and another mode such as paper for their fieldwork. A study of gender differences in acceptance of PDAs in fieldwork is worth investigating and might provide a new insight for educators in Singapore [18]. A triangulation research methodology that includes questionnaire and interview would provide greater insight into these students' perceptions and acceptance of the PDA technology. Future studies might also look into how *Mobile* G-Portal can be used to improve learning outcomes and academic achievements from fieldwork and other areas of learning. The Technology-to-Performance Chain model developed by Goodhue and Thompson [11] would be a useful model to test the performance impacts of new technology adoption in education. With emphasis on a diverse mode of assessment in the present educational setting, more studies can be carried to examine the use of *Mobile* G-Portal as a tool for examination and assessment.

With the prevalent use of mobile devices to enhance learning in education, it is hoped that the use of established research models like the TAM and TTF would provide more valuable insights into factors that influence students' acceptance of mobile technology for learning which would have implications for curriculum planning and diffusion of such technology into the local education system.

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