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## A Framework for Analysing Interactivity in a Remote Access Field Exploration System

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**Abstract:** The research described in this paper is the investigation of interactivity between learners and system in the context of remote access to educational field explorations (field trips). The concept is described generically as Remote Access Field Trip (RAFT). The interactivity framework proposed for assessing RAFT considers it within the context of live distance education and needs to be judged in terms of set interaction criteria, e.g. Learner & Learner, Learner & Instructor, Learner & Content and Learner & Interface. This paper proposes that criteria for distance learning interaction assessment should consider also how the learner interacts with a pervasive interface. This is particularly relevant in this context because the system involves participants interacting with a pervasive system within a live field trip experience, and creates a unique human-system interaction in the educational domain.

**Keywords:** Human-machine systems, Alternative man-machine interaction, remote education, pervasive computing.

## 1 Introduction

The benefits of contextualised learning and field trips have been well documented. It has been argued that fieldwork structures have the capacity to enhance learning across a range of subjects, for example. Foskett [4] and Kent & Foskett [7] have recognised this potential and refer to the role of fieldwork in the development of “thinking skills”. However in recent years many issues, such as security, cost and staffing, have restricted the access that schools have to field trips. One solution to overcoming these problems is the idea of the “virtual field trip”. In this paper we refer to a “virtual field trip” as “integration of text, audio, graphics, still image and moving pictures into a single computer controlled multi-media product” [8], where field research is asynchronous. This paper outlines the design of an interactive field trip system, whereby students in the classroom can work synchronously with those in the field in real time, an important addition to the conventional concept of the virtual field trip.

The RAFT project aims to remotely relay a field trip experience back to the classroom in real time. The project allows students in the field to communicate to the class and importantly the class to communicate to the students in the field. Thus, the distance learning is bi-directional. To achieve the RAFT event, video-conferencing software, instant messaging and wireless data transfer are used to create a pervasive environment in which participants can interact synchronously with each other. By having a controllable window into the field event the class-based student has, as near as currently possible, an authentic exploration experience which smoothly inter-relates to their classroom interface.

Within this structure, the RAFT project aims to analyse four interactivity criteria to consider whether it is sufficient in the assessment of the RAFT system. It is proposed that the *Learner & Interface* criterion can be elaborated upon to create *Learner & Pervasive Interface*. Preece et al [12] identified pervasive computing as “seamless integration of technologies”. This is achieved by using interoperable technologies which can be used in both the field and classroom. This is an important expansion of the traditional idea of *Learner & Interface*, because students should be able to interact with their own interface, the incoming data from classroom or field and with their fellow students in an all-encompassing connectivity. Figure 1 shows how field and class-based students interact with a set of pervasive interface widgets.

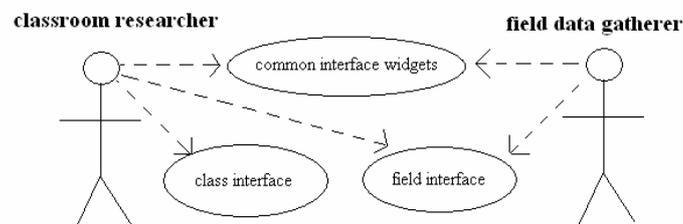


Figure 1. Interface widgets

In terms of web based distance learning, which the RAFT system essentially offers, interactivity has been defined in several contexts. Hillman et al [6] puts it as simply “engagement in learning”. Garrison [5] suggests that the purpose of interaction is to promote explanation and challenging perspectives among two or more learners. Moore [9] categorises interaction as engagement in learning through (i) learner-content, (ii) learner-instructor, and (iii) learner-learner interaction. However, Hillman et al [6] argue that Moore’s three relationships do not account for interaction that occurs between learners and the technology that delivers the instruction and/or content and they therefore added a fourth relationship: learner-interface.

## 2 Learner interaction theory

### 2.1 Learner – content interaction

The interaction with learning material is often considered the fundamental factor in achieving educational outcomes and is considered the central component to a web-based course as this is where new

knowledge, skills and abilities are presented [11]. The learning content in the RAFT system is designed to consist of three main areas: the content gained from the field site, the content researched in the classroom and the content held in an Adaptive Learning Environment (ALE).

The content gained from the field site is collected by the student and at first stored locally. That data is then meta-tagged by both students and teacher, which will allow re-assessment and analysis, before it is sent to the classroom. Similarly the student in the classroom can research the field topic (e.g. on the World Wide Web or using CD-ROMs). This information is assessed, either meta-tagged and stored or sent to a corresponding field person who requires additional information. The final element of interaction with the content is through the ALE system. Learning objects stored in the system can be used for reference in the first instance but those learning objects are also creations from the field trip event. The content can then be analysed during the field trip event, meta-tagged and saved by annotators and archivists. This can then be analysed during the field trip or re-assessed post field trip.

## **2.2 Learner – instructor interaction**

RAFT can be seen as a highly technologically-based system and because of this, the involvement of the teacher and instructor is all the more important. Moore [9] noted that the instructor adds “reality testing and feedback”. There are two key components of the system which enable the learner (student) to interact with the instructor, be it teacher or expert. Firstly, if the teacher is within the classroom, they have their own RAFT interface which enables them to view all of the learners within class and field and interact with each. They can interact with each student in the same way each student can interact with each other (chat, video, audio) but they also have increased privileges which allow them to instruct all members of the group to carry out certain tasks. They also have certain disciplinary privileges which allow them to ban or censor individuals or groups.

Within a RAFT event, a video conference system is in place which enables the teacher either in the field or classroom to interact with students (in either field or classroom). The video conference also allows a remote expert in the field, classroom or externally to instruct, interact and offer advice and guidance to the learners. This additional aspect of an external remote expert adds an extra value to the system and its interactivity by contextualising the instruction.

## **2.3 Learner – learner interaction**

Learner – learner interaction amongst members of the classroom or field is an extremely valuable resource for learning and is sometimes even essential [9]. In the RAFT system, peer assisted learning and collaborative learning are perceived as two integral pedagogies and this is reflected in the systems design. For example, for each task there is a task team relating to the work being carried out in the field or classroom. In the field, for example, a data gatherer obtains field data for a task, while in the classroom, a researcher is finding out more information about the same task. They are therefore both working collaboratively to achieve the same end result. This partnership between field learner and class learner also facilitates peer assisted learning.

To achieve collaboration at the simplest level, an instant-messaging type of system is used. Every learner within the field and class has ‘chat’ functionality within their interface. As well as this there is a task screen, which will show the learner what tasks are being carried out and what tasks the learner themselves need to complete. Furthermore, learners can interact with other learners through video conferencing. A greater level of interaction is achieved through the incorporation of this medium.

## **2.4 Learner – interface interaction**

Hillman et al [6] refer to interaction of the learner with a technical medium as a way of communicating with instructors, peers and content as learner – interface interaction. This is very much the case within the RAFT context. All roles within the system have an interface whereby they communicate with an instructor, peer or content. It may not be that their only interaction with these three elements is solely

through the interface but it is certainly a fundamental option. Within the classroom, the student can gain knowledge through a non technologically-based medium. They can access books for content, may discuss information with other students and are able to ask the teacher for assistance. They are also similarly able to gain this learning through their interaction with the interface medium. For example they are able to access the internet for their content, talk to their fellow students via a chat interface and speak to an online instructor via a video conference.

The model of learner-interface interaction has had much discussion. It has been a widely held belief [10] that the selection of instructional media has little effect on learning outcomes, hence the medium is only a vehicle for the delivery of subject matter. Taylor states [13] that “what really matters is the quality of the instructional message, rather than inherent characteristics of the instructional medium used”. Other studies suggest, however, that learner-interface interaction does have some effect on learning outcomes and course satisfaction [3]. As Hillman et al [6] point out, however, the users of distance learning are really taking two courses: one to learn the interface and then another to learn the subject matter.

### **3 System Design: background theory**

The decisions and considerations made, and how this can be applied to Moore and Hillman’s distance learning criteria, came about as a consequence of the requirements gathering, prototyping and UML modelling within Functional and Technical specifications. The following is a description of that process.

The process of system design used Interactivity Design principles outlined by Preece et al [12]. A process of student participation was envisaged so as to create an interactive classroom and field situation which mapped the ideas and requirements of the high school students who would be using the system. Preece et al define interaction design as “designing interactive products to support people in their everyday and working lives” [12]. This essentially involves four basic activities:

- Identifying needs and requirements
- Developing alternative designs that meet these requirements.
- Building interactive versions of the designs so that they can be communicated and assessed.
- Evaluating what is being built throughout the process.

To complement this within the prototyping stage, several workshops were set up. These involved children participating in the design process and designing interfaces which aimed to adhere to the principles proposed by Druin [2]. She defined the participatory design approach as “to respect users more as partners in the design process and in so doing, explicitly give them a more responsible role”. Consequently, the RAFT project used observation techniques which aimed at capturing children’s exploratory activity patterns and by immersing them in the technology to be used in a RAFT-type field trip.

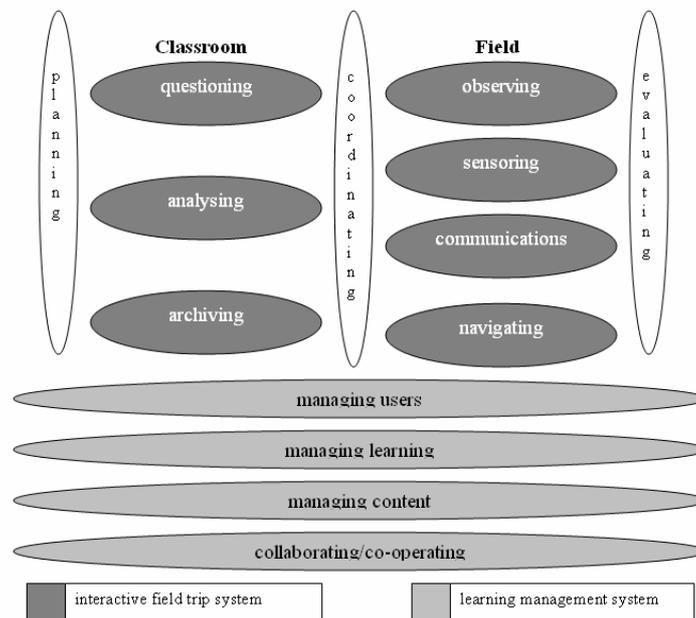
The Functional and Technical specifications were important documents for the development of the project as a whole and used Universal Modeling Language (UML) as the mechanism for illustrating and describing the system. UML can be described as a “notation for visually expressing the models of a software-intensive system” [1]. These visual expressions come in the form of Use Cases. Use Cases were first put forward by Ivar Jacobson who used the term actor to represent a generic role of user who actually interacted with the system. A use case can be seen therefore as a textual description of the relationship between the actor and system and contains a narrative of the way in which the actor would use the system in a given scenario. The actor provides the input and the system exhibits the output [1].

### **4 System Design: the process**

The design process began with a requirements gathering session with high school teachers. Through documentation of field trip ideas, a preliminary understanding of the field trip process emerged. From

this, a conceptual framework was created which encapsulated the abstract idea behind field trips and helped in enabling the system to be mapped to such an idea.

Following the documentation of the conceptual framework, a secondary requirement gathering stage took place, but now involving high school students (aged 14 -16 years). Initially these commenced with one-to-one interviews and gradually increased their size and scope to workshop level. The interviewed students drew up field trip scenarios which had the RAFT proposition of classroom activity. Their drawings and notes highlighted the need to have a classroom which “felt like it was the field”, and large screen interactive displays with constant feedback and messaging between class and field. The workshop groups drew up interfaces that could be used for the system and which provided an insight into what they expected. The requirements gathering process led to the creation of the Functional Specification. The functional areas of the system can be identified by Figure 2.



**Figure 2. Functional system blocks**

Following the documentation of the Functional Specification, a series of workshops was organised involving the participation of 6-8 school students aged 13-15 years. Several workshops were set up which attempted to follow the ideas within “The Design of Children’s Technology” [2]. Having briefed the students on the goal of the project the students were asked to create sketches about how they perceived the system should work and look. The first few workshops gave some interesting discoveries, however it was felt that the students required more information and input to help them produce sketches. Some students even noted that they “didn’t know what to draw” or “were a blank”. Template interfaces were therefore created in the later workshops to prompt the students. These were paper prototyping templates which enabled the students to choose original template, button, text and screen layout in an exploratory manner. An example of a template is shown in Figure 3. After using the template, students created paper sketches which were much more informative and complete. Drawings, sketches and ideas generated by the students gave an insight into the type of interface design which would appeal to students. It also gave important information on how the system should function.

As well as the prototyping workshops, a series of video-conferencing workshops were set up. The purpose of these was to understand how usable the software was and to gauge student reactions to using the software in such a manner. The introduction to the scenarios was purposefully rapid, although

indication of role and task of each student was given. Group sizes ranged from half a dozen to more than twenty. Each person within the video-conference scenario was given a role (as specified by the Functional Specification). One example of a video-conferencing workshop had field students interviewing current university students. While classroom students, using the incoming data, were compiling presentations about the University and life as a student, they were also using the video-conferencing software to ask questions and communicate with their field colleagues.



Figure 3. Interface paper-prototyping template

## 5 Observations and outcomes

The outcome that the system and interface should be pervasive came as a result of observation and interview from the requirements gathering stage, comments and conclusion within the prototyping and video-conferencing workshops and practical considerations from modelling the system in UML. These are summarised next.

### 5.1 Requirements gathering workshops

The students and teachers who participated in the requirements gathering stage expressed a high interest in the overall concept of RAFT. To summarise the views expressed by the teachers, they believed that if the students could see, hear and contextualise the field event within a curriculum framework, the system could be very beneficial. Both class and field sites would need a teacher present, and the preparatory stages of the event were seen as highly important so as to match the activities in the two locations synchronously. The primary views articulated by the students were that they felt class students should feel like they were in the field. They also commented that data taken from the field should be automatically stored and sent to the classroom, which would avoid using manual data capture and traditional pen and paper techniques.

### 5.2 Functional Specification

The Functional Specification followed the requirements gathering stage and the findings gained from that fed into the document's creation. The Functional Specification used UML to outline the actors for the system. Taking into consideration the wishes of teachers and students, the Functional Specification spanned the lifecycle of the field trip including, importantly, the preparation stage. It also documented the key roles involved to make the system work in terms of contextualizing the event for its inclusion within the curriculum. Finally the Functional Specification outlined how the system could facilitate creating a

valid field trip experience for both the class and field, not only by making aspects more efficient through the use of technology (automation of sensor readings, for example) but also by using innovative techniques to bring the field experience into the class.

### 5.3 Prototyping workshops

The prototyping workshops validated the proposition of needing to make the field and class aware of each other and able to augment the differing field trip perspectives. It was noted by observing the prototyping workshops that class students needed to be actively involved, or else they became disengaged. It was felt that if class students were able to see what the field was doing at any one time, the feeling of distance would be reduced. Similarly it needs to prevent students in the field from falling into a situation of being autonomous, insular and not considering the relationship that was needed with the class.

Constant communication was therefore deemed to be very important. During the prototyping stage, students vocalized this and included chat and messaging within their interface sketches. Within their sketches was the idea of “windows” into the field, such as a video or video-conferencing. Being aware of the geographic position of field students was also deemed very important. In consequence to this a tracking application using a Global Positioning System (GPS) was developed in direct response to the wishes of the school children.

### 5.4 Video-conferencing workshops

The findings from the video-conferencing workshops justified the use of roles within the system. The students involved required to know their role and to have a clear understanding of the tasks that needed completing. On occasions where students did not fully comprehend this, the video-conference scenarios were very unproductive. This was especially so when students were given key roles such as ‘field trip coordinator’. In consequence to this, the task list idea was formalized and this was proposed for incorporation within the Technical Specification. It was also suggested that the video-conference interface become simplified as the original interface had numerous features which some students found confusing.

**Table 1: List of roles for field and classroom**

<b>Field</b>	<b>Classroom</b>
Field Co-ordinator <i>co-ordinates field activity</i>	Director <i>controls main display</i>
Data Gatherer <i>collects data from field</i>	Archivist <i>stores learning objects</i>
Annotator <i>contextualizes field data</i>	Researcher <i>investigates topics</i>
Scout <i>finds new information</i>	Task Manager <i>adds and deletes tasks</i>
Communicator <i>sends video back to class</i>	Message Manager <i>creates messages to field</i>
Reporter <i>records audio interview</i>	Conference Manager <i>control video-conference</i>
	Analyst <i>field data assessment</i>

## 5.5 Roles and Actors

Fully formalized within a Functional Validation Report, the concept of roles and actors was shown to be fundamental to the successful use of the system. The final set of roles is shown in Table 1. Each role interacted with the system by an interface that comprised of a set of widgets. These widgets encapsulated the ideas that students and teachers had expressed in requirements gathering and prototyping workshops. Part of the widget set included a task widget, a chat widget and a video-conferencing widget. The widgets could then be used in both field and class systems, which would reduce development time. The widget specification allows the pervasive viewing of field and class content such as photographs, annotations and sensor information. The widgets were also specified as being synchronous so that messaging and the updating of tasks and content would occur seamlessly between class and field.

## 6 Discussion

The Learner – Interface criterion relates to the medium by which the student interacts with instructors, peers and content. However in terms of RAFT, that interface can be deemed a pervasive one. The system allows students to freely access the software from both field and class and all devices are networked using a web-based infrastructure. Field devices are all portable and use a wireless local area network (WLAN) or General Packet Radio Service (GPRS) to achieve inter-connection. The aim, therefore, is for this to combine to make a system which facilitates the class-based students to actively participate in the field event by seamless integration of the system between the two sites.

The system aims to meet the requirements of students and teachers, and does this by making the field situation pervasive. Participants are within an environment where the technology is aimed to be unobtrusive and always available. By freely allowing field students to carry out their tasks, the main purpose of the technology, in addition to augmenting traditional field techniques, is to convey and receive information between field and classroom so that both are actively involved. The need for a pervasive system can be summarised thus:

- A system where both field and class have all-pervading access to the interface medium and where both situations are providing instruction;
- A system where the environment is not impeded by the technology and the technology helps traditional field work;
- A system which has an all-encompassing technological infrastructure to convey the full field trip scenario.

The traditional medium of the interface needs, therefore, to be re-visited in the RAFT context. The reason for this is that the students need to access the system through a seamlessly integrated combination of tools to which both class and field have all-pervading access. They are also within an infrastructure, where information is delivered via wireless communication, that may not require interaction with the traditional idea of an interface.

## 7 Conclusions

The investigation described here has shown that a remote field exploration system of the RAFT form must be designed to be pervasive. Because of this, the interface interaction criteria referred to above should be explored in terms of the effects that a pervasive operation can deliver. Roles have also been identified for actors within such a pervasive context. Future work can investigate how this type of interface performs in the innovative distance learning environment of remote field exploration projects.

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