A System to Encourage Playful Exploration in a Reflective Environment

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Abstract: Finding information in a large database can be challenging, especially when students are not familiar with the information domain. Even when information has been retrieved, it often marks the end of the process rather than the beginning of a reflective process that supports learning. The highly original system described here, iFISH, addresses this problem by presenting a playful and explorative environment to students. The aim is to engage students to explore more widely and for longer than when using a conventional system and to reflect on their findings in terms of the inputs they used to obtain them. Preliminary research informing the development of iFISH is described as well as a description of the design prototype.

Introduction

This paper describes early research into encouraging students to engage in playful and exploratory online investigations of an unfamiliar data space. The goal is to foster this engagement by providing an environment that evokes a playful and exploratory interaction with the data. ‘Play’ is stimulated by the use of a slick, highly interactive user interface. ‘Exploration’ is supported through the ease with which the student can observe the data and make changes to see new data. This tightly coupled repetitive cycle of interaction, observation, and new interaction, is investigated here in the context of students exploring a university handbook in order to select subjects (courses) to study with an aim to add breadth to their major study. However, this style of engagement can be applied to many other situations in educational settings as discussed at the end of the paper.

The paper focuses on the design process and outcomes for this particular application. This involves an overview of other systems that perform similar tasks; the description of a pilot study to help understand how students currently approach this handbook-exploration task and what their requirements were for a more exploratory system; a description of the system that has been designed and is being pilot tested; a brief description of how we used linguistic analysis to automatically ‘tag’ handbook entries in order to enable the search process to happen; and finally some comments about the impact of this research in other areas of education and learning.

This study was inspired by the outcomes of two earlier studies. In one, we investigated the role of ‘flow’ (a highly engaging, enjoyable experience of deep concentration and focus) on learning complex ideas (Pearce & Howard, 2004). In this research we noted the precarious role of affect in maintaining a student’s interest in a learning task. In the other study, we extended the ideas of flow into a situation in which unemployed job seekers explored how their personal attributes (education, language skills, interview skills, health, etc.) affected their readiness for work (Pearce & Murphy, 2006). This highlighted the value of a user inputting personal information into a system, reflecting on its output, and then changing the inputs in order to observe the effect. We have combined these two notions of affect and personal reflection in designing this current study. Affect we regard as essential to motivate and encourage on-going interaction. The role of reflection is critical in the light of Laurillard’s ‘conversational framework’ approach to learning: discussion, interaction, adaptation and reflection (Laurillard, 1993).

Recommender Systems

In the Human Computer Interaction (HCI) community, systems that help people find information are often referred to as ‘recommender systems’. These differ from search engines in that they help users discover items that they might not have found with a targeted search, whilst also helping them to cope with information overload. One approach to recommender systems is to employ ‘social navigation’ (Dieberger, Dourish, Höök, Resnick, & Wexelblat, 2000). Such systems rely on feedback, either explicit or implicit, in order to draw on the
collective wisdom of a community to help improve the accuracy of the system and provide a better experience for the user. Explicit feedback relies on the student to rate items as interesting or relevant; implicit feedback relies on information extracted from user interactions to provide information about the quality or relevance of those items. These systems often employ a user profile that is compared to a reference characteristic that might relate to the item that they are searching for (content-based) or to the user’s social environment (‘social’ or ‘collaborative’ filtering). Although they might present the user with unexpected results, these systems tend to narrow down a search in an effort to match the user’s characteristics.

Whereas explicit feedback is considered a more accurate method, it raises the challenging question of how to encourage users to contribute their own knowledge. (Farzan & Brusilovsky, 2006). The I-Spy search engine (Smyth et al., 2004) relies on users returning to a Web site and re-ranking their search results. This is problematic with students for two reasons. First, users tend not to bother to contribute their recommendations. Second, in the context of this paper (students making choices for courses of study), the students don’t know the value of their choice until after they have completed studying the course. At that time, they are even less likely to return and enter information for the benefit of future students.

Various attempts have been made to address this problem. For example, Bretzke and Vassileva used reward mechanisms (Bretzke & Vassileva, 2003); Farzan turned the feedback into a personal goal that had meaning for the individual user (Farzan & Brusilovsky, 2006); a novel approach by Harper et al used economic modeling to combine initial understanding about a user population with data to refine that understanding (Harper, Li, Chen, & Konstan, 2005). A recommendation from this last study was the need to increase the level of fun via better user interfaces.

Our Approach

The approach that we have taken in this research is very different. Whilst the recommender systems described above rely on social trails and explicit user feedback in order to improve performance, we have taken the approach of having students enter personal information about their preferences, looking at their own results, and evaluating them in order to change and refine their exploration. We are addressing the problem of students exploring an unfamiliar domain in which we want them to broaden a search rather than narrow it down. This is done in the context of a university in which students are required to study one quarter of their degree in areas outside their major speciality (referred to as ‘breadth’ studies). Rather than a student saying “I am majoring in arts, I think I will take my breadth in science, I like animals, so I’ll take Biology 101”, we would like a student to engage with and explore a much broader range of studies that he or she might not even know exist. For example, we would rather hear the reasoning “I am majoring in arts, I need something different, maybe more quantitative and with a business flavor but with a cultural influence. I came across Accounting practices in the Middle East while exploring – sounds interesting – I’ll take that”.

Hence we ask the question: how can we design a system that encourages active exploration in order to explore a set of data that the student knows little about and hence has little motivation or knowledge with which to explore?

The aim of the project described here is to design such an exploratory system. We take concepts from recommender systems, principles of interaction and engagement from HCI and flow theory, and use them to explore the design of a system that encourages the exploration of a large, complex data set in an educational setting. The problem is to show the student how the search process works – to show how data are manipulated and hence give the student some confidence in the output and an understanding of the context of its discovery. We have employed design features relating to animation, direct manipulation and playfulness, that show the student how the data are being manipulated during the search process.

The aim is not to find a set of results that matches a student’s profile, but for the student to discover new ideas, relevant to themselves, resulting from an extended exploration of the data.

The system described is called iFISH – interactive Foraging In the Subject Handbook – and is being developed for students searching for breadth subjects (courses) within particular university guidelines. We plan to use iFISH to help us gain a better understanding of the process of discovery as students explore the data and reflect on their own feedback in order to stimulate further exploration.
Background

The nature of this exploratory system is unconventional and innovative in two aspects. First, we are dealing with students exploring a data space in an unfamiliar domain – one in which they have no clear idea of what they are looking for. This is not unique to this particular context. Government departments confront this problem when they attempt to provide improved services for citizens who don’t really know or understand what services are on offer. We met this issue in a previous research project aimed at helping people understand what they could do to improve their chances of finding employment after being out of work (Pearce & Murphy, 2006). This challenge was to design a system that not only facilitated the exploration of an unknown government information space, but that also kept the users sufficiently engaged to obtain meaningful output from it. This current research builds on that experience.

Second, our aim is to maintain the students’ engagement with the system long enough to encourage ongoing exploration. This is in contrast to a search system where the student enters information and narrows down to a result (or list of results) and then exits. We want the students to make adjustments to their input values, observe and reflect on the consequences of their changes, then make further changes to see their impact, and so on. To maintain these repeated cycles of students exploring the consequences of their actions, we need to design a system that is novel, playful, and encourages ‘flow’ experiences (Csikszentmihalyi, 1975).

Pilot Study: Exploring a Subject Handbook

A requirement for students at our Australian university is to find six subjects (one quarter of their degree, spread over three years) that complement their major study by adding ‘breadth’. The essential philosophy behind these ‘breadth subjects’ is that they should expose students to a ‘different way of thinking’ compared to that of their main studies. This is an interesting challenge for students: there are about 2500 subjects offered by the university and the students have some familiarity with the areas of study of their major discipline. But they have little idea of what is available in other areas. Their challenge is to explore a large, unknown information space for choices that they don’t really know exist.

In order to inform the design of our system, we ran a pilot exercise in which 5 students were given specific tasks related to finding breadth subjects for their degree. Our aim was to obtain some baseline data about how students go about searching using the current facilities. Their only resource was the current university online handbook. The Web exploration was tracked using the DejaClick (AlertSite) extension to the Firefox Web browser and the resulting XML files analyzed for information about navigation, search requests, time spent on different pages, etc. After they had identified their subjects, the students took part in a group discussion about the strategies they used for exploring as well as answering questions about alternative approaches to exploration based on personal preferences (described later). The information gained from this was used to design the exploratory system presented here.

Two important findings we present from this pilot study relate to how students currently use the subject handbook to search for subjects, and how they react to suggestions of using a system based on user preferences (non-content based) for their exploration.

Current Patterns of Searching the Subject Handbook

Students’ current usage pattern was strongly influenced by the navigational structure of the online handbook, which was organized in a hierarchical manner by academic faculties, then areas of study, then individual subject descriptions. Students tended to move up and down this structure following a pattern such as:

- select a faculty
- select an area of study
- select particular subject offering & read it
- go back to the area of study
- select another subject offering and read it
- go back to the area of study,

and so on.
They did not make much use of the search function (presumably it was not obvious to them exactly what to search for) and did not ‘discover’ many different areas of possible study. Figure 1 shows the navigation for one particular student, starting from the ‘Handbook start page’. He visited five out of the twelve faculty areas; the six subjects he finally chose are highlighted in a darker color. A considerable amount of time was spent navigating the system and this student reported that he gained the impression that he spent much more time navigating the system than reading the subject descriptions. Typically, the other students visited only 2 or 3 of the twelve faculties during their exploration.

Figure 1: Exploration path by a student showing navigation, pages visited and subjects finally chosen.

A System Based on User Preferences

One of the tasks given to the five pilot study students aimed to provide us with insights into how students might react to an alternative way of searching for subjects. They were asked to read three handbook descriptions of subjects and rate each of them on eight generic scales relating to (i) the discipline of study, and (ii) learning experiences. By doing this they were indicating their own preferences in these two areas. The eight ‘meta-description’ scales were:

**The discipline of study:** pure/applied; qualitative/quantitative; light/dense on imagination & creativity; factual/ conceptual.

**Learning experiences:** hands-on/brains-on; exploratory/directed; working alone/with others; oral communication light/dense.

The group discussion that followed investigated, in part, the idea of ‘meta’ descriptors, such as those above, being used to help explore the subject data space. The concept was suggested to students that these descriptors could label sliders that the student would vary to discover subjects suggested by the system. The response by the students to this idea was positive, but with several conditions. They wanted to be able to see subjects appearing and disappearing in *real-time* in order to see the consequences of their adjustments. They wanted to “capture” subjects of interest for later consideration. They also wanted to be able to filter out all subjects that were not
available to them personally (due to lack of pre-requisite studies, year-level constraints, timetabling clashes, etc.). Since these meta-descriptors had a strong subjective aspect, students expressed concerns as to who would determine the “system’s” view of each subject’s rating. They would like this to be determined by students’ views rather than academics’ views (ideas of explicit feedback and collaborative filtering, as described earlier)!

Finally, the students indicated that a playful system would encourage them to explore for a longer time – that their engagement would be deeper if the experience was a rich and fun one.

The ideas from this pilot study have been used to develop prototype software to research the effectiveness of such a system. This is described in the next section.

The System: iFish

The system developed is a Flash front-end to a PostgreSQL database containing textual information extracted from the online student handbook. Its aim is to allow students to use sliders to enter personal preferences, similar to the meta-data described above, and to see different subject choices appear, ordered according to a ranking process based on the meta-data. An important criterion is that the ordering of subjects should represent changes in real-time as students adjust their preferences, so that they can begin to appreciate cause and effect. For example, if a science major student, having set a particular combination of slider values, nudges the slider labeled ‘imagination & creativity’ towards the ‘dense’ end of the scale and brings up the subject Writing extended fiction, he or she might think “I had no idea there were subjects like that available, I wonder what I happens if I push for even more creativity?”.

Design

The challenge in this design process was how to provide real-time visual feedback of the re-ordering of 2,500 subjects when the changes in ranking could be quite extensive for small changes of input. Clearly only the top 15 to 20 subjects would be displayed, but a sudden change in this list would be hard to assimilate and might not provide clues as to cause-and-effect. At the same time, a notion of playfulness is essential in order to maintain engagement and enhance the possibility of a flow experience. Since the activity on the part of the students is not unlike a fishing expedition for finding subjects, we have used the acronym iFISH: interactive Foraging In the Subject Handbook.

To meet this challenge our prototype system ranks subject titles in three columns (3 year levels) based on the position of several sliders. We attempted to use animation to indicate by how much a subject’s ranking is going to change as a slider is moved; this aspect has not yet been successful. The dynamic nature of this system embodies many physics behaviors that can be used to improve the interaction and playfulness of the system: effective ‘mass’ of subjects; ‘springiness’ of their motion; ‘friction’ as they start and stop; ‘bounce’ as they interact.

Figure 2 shows a conceptual layout of the screen. Subjects are represented by the ‘bubbles’ to the left and grouped by the three year levels and ranked by how well they match the combination of slider values. A ‘keep’ area in the centre allows students to drag subjects in to keep for later reference. The input sliders are visible towards the lower right; drop down menus, to enter items to be filtered out, are located just above them. The behavior of the system is that subject titles ‘float’ up and down as the sliders are changed. If a subject is changing by only one or two places, it will move slowly to its new location. However, if it is being re-ordered to a much lower rank – well off the bottom of the screen – it will begin a more rapid acceleration, allowing the user to quickly ‘undo’ the action (by reversing the slider’s position) before the subject gets out of view.
Figure 2: schematic representation of iFISH showing three year levels of subjects and user controls.

Figure 3 shows the graphic design that is currently being implemented.

‘Tagging’ data

A significant issue in systems of this nature is how the data are tagged in relation to the values represented by the sliders. “Tagging”, in this context, refers to allocating a value to each subject for each of the seven slider attributes. The prospect of manually tagging 2500 subject descriptions was daunting! Hence, our prototype system, we experimented with using linguistic analysis for this task. This means that an automated process was
used to examine each subject’s short text description and create clusters of subjects based on the frequency of key words. The process was as follows:

- A frequency analysis of words used in each subject description was carried out and 1000 ‘context-bearing words’ identified.
- A ‘word vector space’ was created for a further 9000 words and from this a ‘context vector space’ was constructed for each subject.
- In order to identify input parameters for students’ exploration, the 1000 context-bearing words were clustered (using a k-cluster algorithm) to produce seven clusters of subjects.

By examining each cluster, we were able to define a descriptive term for each cluster of subjects. Whereas these terms are not quite as generic we would have liked (particularly not as ‘meta’ as the examples given earlier) they still allow the user to express preferences that are fairly well removed from specific discipline areas – hence facilitating the exploration of unknown domains. The terms used were: biological systems, culture, mathematical modeling, law and governance, performing and practicing, business, and ecology and environment.

During the operation of the system, cosine similarity is used to compare user preferences to the set of vectors stored in a PostgreSQL database to determine subject rankings.

**The Problem of Automatic Tagging of Data – Embracing Serendipity**

A non-human tagging process of this kind brings up some interesting ‘errors’. For example, subjects on scientific instrumentation and grouped with some subjects on music practice since they both refer to ‘instruments’! However, this is not necessarily a negative feature of the system. In fact, unlike most search environments, *inaccuracy* can be regarded, to some degree, as a feature rather than a fault. As a part of encouraging users to explore widely, we are interested in moving them out of their comfort zones and into areas that they might not otherwise have considered. Serendipity can play a role here. Instead of following linear paths through hierarchical structures, the system simultaneously presents suggestions based on several user preferences and hence throws up occasional ‘odd’ results due to the coarse categorization of subjects. Rather than helping the user to narrow down a search too quickly, we are broadening the search until suggestions are presented that ‘click’ with the user.

**Designing the Interaction**

The visual design of this system is not simply an interface issue but is an integral component of the experience. Its role is to maintain the student’s engagement with the system long enough to discover the hidden resources that they are seeking. This is a delicate balancing act. An interface can have a very playful nature and promote strong positive affect. However, it can only hold one’s attention for a limited amount of time before the novelty wears off and boredom moves the student to another location. The balance required is to maintain the student’s engagement with the *content* of the system and not just the interface. The distraction of the interface – sometimes described as a balance between ‘task’ and ‘artifact’ – has been observed previously in studies in a learning context (Finneran & Zhang, 2003); (Pearce & Howard, 2004). We have designed a system that we believe will hold students’ attention through evocative movement and constructive immediate feedback. Such a system should be able to support students in a flow experience through the appropriate distribution of attention between task and artifact.

**Discussion: Extending the concept**

This paper has described an approach to searching a subject handbook based on entering student preferences and exploring the resultant outputs. However, the research question being pursued is much broader and more generic than this. The highly networked world that we now live in offers students much information at the click of a button. Can’t remember how to derive a formula? Search for it in Google and download the answer. Can’t recall the definition of a concept? Wikipedia will let you copy-and-paste some useful text. The problem with these ‘just-in-time’ approaches to information retrieval is that they don’t actively promote enquiry, reflection, or exploration. There is nothing that acknowledges the learner’s background and uses that information to present
material with an affordance for browsing, comparing or reflecting upon. *iFISH* is an attempt to offer those affordances to the mundane task of searching a handbook. However, the general principle – that of personal preferences driving a reflective and exploratory experience – is applicable to many contexts.

For example, a student is studying a general science subject and has access to a database of exam questions for revision. She might know the kinds of questions that she wants to work on, hence her thinking might be “I want to look at questions that are fairly mathematical, relate strongly to social issues, and touch on mechanics and electrodynamics aspects of the course. I want to start with easy ones and confront harder ones later”. A system with the appropriate input preferences would allow the student to explore several questions before selecting a set to study. The looseness, or ‘non-precision’, of the system would support serendipitous finds, or even prompt ‘meta’ finding such as “I had no idea that electrodynamics relates to so many social issues – I am going to explore how these issues are represented in questions exhibiting a deeper mathematical formalism” (i.e. increase the “mathematics” slider input).

The initial aim of this research project is to explore and understand how a system such as *iFISH* can encourage exploration in one particular context. Future research will apply these ideas to other contexts more closely linked to discipline-based content.

**Conclusion**

We have described the design of a highly engaging and playful system, informed by a pilot study, that aims to sustain engagement and exploration in a learning context. The design principles are based on well-established theories, prior research, as well as a pilot study. The prototype system has now been developed and experiments exploring students’ use of the system are about to commence.

**References**


