Evaluating User Learning Behaviour in Relation to the Use of Multimedia Hyper-Lecture Package with a Tracking Facility

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Abstract: E-learning packages are increasingly using audio and video presentations in addition to graphical and textual media to enhance the learning experience of students. However, a current assessment of the literature suggests that little has been done to evaluate the effect of this type of delivery on learning. In this paper, we discuss the design and development of a multimedia hyper-lecture system, which incorporates a computational method for tracking a user's interaction with the application. This system serves as a tool to investigate the behaviour of users in relation to characteristics associated with learning styles such as activist, theorist, reflector and pragmatist, in a multimedia environment.

Background Study

It is well known that different individuals adopt different styles in their approach to learning, and a number of systems that classify learners according to characteristics that they display in a learning environment have been established [Kolb, 1984; Fleming, 2001; Honey, 2002; Siever et al, 2003]. More recently, some studies have attempted to investigate how learning style particularly influences a user's response to ICT and e-learning technologies [Dillon & Gabbard, 1998; Reuther, 2002]. Ideally, it would be desirable to develop intelligent e-learning systems capable of adapting the presentation of materials to optimally match a user's preferred learning style. As a first step towards this, we present a framework through which we aim to study the pattern of use of various types of multimedia content in an e-learning context in relation to a student's learning style.

Learning Style

In this study, we use the dimensions devised by Honey and Mumford [Honey & Mumford, 1982], i.e. activist, theorist, reflector and pragmatist, to classify learning style. According to Honey and Mumford, activists tend to be open-minded and enthusiastic learners who enjoy novel experiences. They also learn best when they are involved in competitive tasks, and are frequently impatient. These characteristics might suggest that, in an e-learning environment, they would benefit from exposure to a variety of media and content that give rein to their imagination, but that their attention span and the duration of their engagement with a particular activity may be brief. Theorists, on the other hand, tend to take a more structured, logical approach to learning. They are likely to break complex problems into small elements and focus on each in turn. Characteristically, they favour theoretical concepts, models and procedural thinking. It is therefore more likely, for example, that they will proceed step by step through a set of options if materials are structured accordingly. Reflectors tend to collect all necessary information required before making a decision. They view things from many perspectives before reaching a conclusion. Finally, pragmatists are very practical in their approach to learning and problem solving. When given the opportunity, they will experiment with a variety of ideas and techniques

to determine if they work in practice, rather than in theory. Like activists, pragmatists also tend to be impatient.

With these characteristics in mind, it is proposed that within an environment that provides access to learning materials through a variety of navigational structures and media, we will see differences in the pattern of behaviour exhibited by students with different learning styles for a given task. In particular, we would expect to see differences in the time spent interacting with different types of content, the order in which elements of content are accessed, and behaviour in test situations where feedback is provided.

The purpose of the Multimedia and Learners (MAL) system described below is to provide a flexible multimedia e-learning environment in which to observe and record a user's path through the materials, giving special consideration to the duration of interaction with a given element of content, and the order of access. The study will focus on the topics from the field of Information aimed at 1st level undergraduate students, delivered through a multimedia hyper-lecture framework giving access to media content, using a variety of linear, hierarchical and closed-web navigational structures. Complex tasks and multiple-choice questions will be used to stimulate activity aimed at differentiating between different learning styles.

Multimedia Hyper-lecture

A multimedia hyper-lecture [Ulvund, 1997; Thampuran, 2001] is an integrated framework that brings together a variety of multimedia elements that together support an interactive on-line lecture. The MAL system takes such an approach. The first major component of the system is a hypermedia video, based on the work of Du et al [Du et al, 1998], which consists of four tracks: video, audio, URL and text. In a general hypermedia video, the URL track may be used to store links to internal or external web pages that may contain other related documents.

In order to constrain the problem domain, the MAL system is designed for standalone use, with no access to external links. The system contains a recording of a lecture by video camera, in which internal links to further content including text, graphics, and audio resources are embedded and synchronized to appear in parallel on the screen. In this case, the text track is used to store pointers to the text of a narration or to annotations that explain concepts introduced in the audio-visual components of the lecture. The aim is to enable students to extend their understanding of the lecture by accessing additional context related materials at any point in time. All multimedia elements are interconnected using hyperlinks, and content is provided in a variety of forms. Hence, for example, when students are reading text-based notes on a particular subject, they may optionally click on a button to hear the associated audio presentation. In short, at any time in the session, the students are at liberty to change the content and type of media being presented.

The second major component of the system is a tracking facility that allows a user's path through the system to be recorded. When a user logs into the system, an automatic record is initiated in the database that registers all of the links visited during the session along with a timestamp and a record of the media type and classification of the content. This enables us to gather data about

the length of time a user spends on a particular media type, the frequency of access to a particular media type and the order in which the media are visited. The tracking system is activated when a user logs into the MAL system. From this point in time, each mouse click event is recorded. When the user clicks on an interactive link or button, the unique identifier of the corresponding content element is recorded in the database along with a timestamp. This data is related to a separate table holding the media (text, graphic, animation, audio, and video) and content (e.g. diagram, talking head, menu item and narrative) types of each content element. The system is implemented using multimedia authoring software (Macromedia Director 8.5) that facilitates the integration of interactive multimedia components such as described above.

Users are free to change the content being viewed at any point in time. The live video contains a head and shoulders presentation of lecture material. Text notes may be navigated in a linear or ad hoc manner. Screen capture video is used to demonstrate the operations described in the live video presentation. Feedback is given on the Multiple Choice Questions contained in the self-test, which can be retaken. A glossary provides more detailed text-based descriptions of terms used in the presentation.

Experiments

This experiment looked into the way in which the use of materials in various modalities in an e-learning package is influenced by preferred learning style. Potentially, there are a number of effects that may be observed in the test scenario, such as different patterns of behaviour in relation to the self-test, or concentrated effort associated with particular elements of the presentation (e.g. video or text notes). The experiment makes use of the MAL system, and includes elements similar to Kushniruk's Televaluation [2001].

This study considered the behaviour of 20 undergraduate students enrolled in the first year of a Computing and Information Technology programme at a private university college in Malaysia. This experiment ran for 2 semesters. These students were competent in English and in the general use of computers. Participation in the hyper-lecture session was voluntary, and the materials did not form part of any assessed work to be carried out by the students within their course of study. Each student participating in the study was required to complete a standard Learning Styles Questionnaire (LSQ) prior to the session. This questionnaire (which is generally accepted by the education community) requires the subject to answer a set of randomly presented questions that aim to reveal tendencies associated with different approaches to learning. The questions require only yes/no answers. Positive responses to questions associated with each type of learning are counted, and the dominant learning style is that for which the student scores highest. The results of the analysis of the LSQ were made known to the subjects only after they had completed the hyper-lecture session. After completing the questionnaire, students were given a further 40 minutes in which to explore the materials provided. No prescribed tasks were defined. After System Interaction questionnaires were filled in by the experiment subjects, an investigation on how they think and how they would behave when interacting with MAL will be carried out.

Results of the Study

Scores collected are computed as in Table 1. As can be seen from Table 1, based on the LSQ an cluster analysis, not all students displayed a dominant learning style preference, but rather hybrid of one or more styles. In this case, we must consider how the tracking output should b interpreted in relation to the LSQ scores. One possibility is to associate a preferred learning styl with the student based on the category in which their highest score was recorded. Alternatively it may be more appropriate to establish a combined measure that takes into account the fact tha students display different levels of preference in each of the learning style categories as a matte of course. The analysis of tracking outputs presented in this study focused only on student displaying a dominant preference as indicated by the score for that category within the LSQ (i.e subjects S1 and S2 in Table 1).

Table 1 LSQ Scores

Subject	Activist	Reflector	Theorist	Pragmatist
1	10	16	9	10
2	7	16	9	10
3	17	16	17	16
4	13	13	12	12
5	15	9	13	12
6	12	9	5	7
7	7	11	11	16
8	11	4	7	6
9	12	9	10	15
10	4	7	17	9
11	9	7	7	6
12	8	12	16	10
13	5	14	17	6
14	13	12	9	19
15	10	12	10	15
16	12	15	9	10
17	12	15	11	13
18	3	14	8	4
19	6	2	14	4
20	7	4	15	9

Table 2 LSQ Scores and Classifications

	Classification	
Subject	Highest Score	Cluster Analysis
1	Hybrid	Hybrid
2	Hybrid	Hybrid
3	Reflector	Hybrid
4	Reflector	Hybrid
5	Activist	Hybrid
6	Activist	Activist
7	Pragmatist	Pragmatist
8	Activist	Activist
9	Pragmatist	Pragmatist
10	Theorist	Theorist
11	Activist	Activist
12	Theorist	Reflector/Theoris
13	Theorist	Reflector/Theoris
14	Pragmatist	Pragmatist
15	Pragmatist	Pragmatist
16	Reflector	Hybrid
17	Reflector	Hybrid
18	Reflector	Reflector
19	Theorist	Theorist
20	Theorist	Theorist

Hierarchical Cluster Analysis (HCA) approach was used in an attempt to take into account scores across all of the learning style categories rather than just one (refer to Table 2). Clustering helped to identify subjects who shared common values across the categories used in this study. It combines smaller clusters into larger ones according to their closeness in value. Learning styles derived from the HCA were used in the analysis is and discussions. Colours were used to identify the clustered learning styles.

Recorded Interaction

The tracking system records a unique identifier for the user and the start and end times of interaction with the system. It also records the time at which any salient events took place in terms of user interaction with multimedia elements of the system. It is possible to analyse this data with respect to a number of behavioural characteristics that are potential indicators of learning style. In our investigations, we have considered the relationship between dominant learning style and time spent on each category of media, the first element visited in the session, manner of navigation through text notes (linear vs ad hoc), and repeat of test questions. Results for students' navigational patterns are illustrated in Table 3. Here, "Not applicable" means that the subject did not navigate through that particular screen. The questions in the self-test were fixed and not random; regardless of the number of times the self-test was accessed, the same questions would be asked. Browsing patterns of the subjects varied and reflected how they behaved while using the system [Mullier, 2002].

Table 3 Behavioural Aspects of Students Interaction

Subject	First visit	Navigation through text notes	Repeat test
3	Text notes	Linear	Yes
4	Text notes	Linear	Yes
6	Live video	Linear	Yes
1	Live video	Linear	No
2	Live video	Linear	No
5	Live video	Linear	No
7	Live video	Linear	Not applicable
8	Live video	Non-linear, repetitive	No
9	Live video	Not applicable	Not applicable
10	Live video	Linear	Yes
13	Live video	Linear	No

15	Live video	Linear	Not applicable
16	Live video	Non-linear	Yes
17	Live video	Linear	Yes
11	Text notes	Non-linear	Yes
12	Live video	Linear	Yes
14	Live video	Non-linear	Not applicable
18	Self test	Non-linear	No
19	Text notes	Non-linear	No
20	Live video	Non-linear	Yes

Discussions

Some of the subjects did not display distinctively rigid learning styles as described by Honey Several showed a combination of learning styles. The LSQ used in this approach yielded a rathe interesting distribution of scores which represented single dominant as well as mixed learnin styles. The first classification was done according to the highest scores for the learning styles fo each subject. However, these results did not seem convincing enough. A second approach wa used utilizing Hierarchical Cluster Analysis. The dendrogram produced using this metho indicated a total of 7 Hybrid learners, 4 Pragmatists, 3 Activists, 3 Theorists, 2 Reflector/Theoris learners and 1 Reflector. The Hybrid learners carried scores of 2 or more learning styles. Th statistics displayed a mixture of at least 2 learning styles for the 9 subjects involved. The numbe of Hybrid learners was quite high. This lack of certainty is likely to be present whether or not th chosen learning styles test was appropriate. There are a number of models available; the use o other models could perhaps lead to a different categorisation.

Media Selection and Time Spent

Many of the Hybrid learners, Activists, Pragmatists and Reflectors spent their time viewing th complete video lecture. From the ASQs, a hybrid learner (S2), an active learner (S8) and a pragmatist (S14) who had completed the video clip rated the video lecture to be very useful i understanding the lesson. Most of those who rated the video lecture as useful had also complete the video clip. Interestingly, a hybrid learner rated the video lecture to be useless. It looked lik the choice of video lecture was not very much affected by the learning styles of a subject excep for theorists who carried unique favoritism over text and graphical notes. The subjects saw them as interesting learning material but did not necessarily accept them as a medium of learning.

The animated tutorial or animation was very popular as the media choice for hybrid learners an activists (based on the percentage of time spent, see Table 7.1). The ratings of usefulness give by these learners were at moderate level. One of the hybrid learners (S16) viewed the complet

animation but the rating given was "useless". He displayed incongruity in his navigational behaviour and written response in ASQ.

Navigation through the text and graphical notes was largely linear. A minority exhibited repetitive and non-linear behaviour where participants did not read through hierarchically from one page to the next. Linear navigation through text and graphical notes could be caused by traditional reading habits. The page number below the screen served as the best tool for page number indication and for the participant to move around the pages freely. Hybrid learners and Reflectors/Theorists spent the most time on text and graphical notes. In contrast those who spent less time with the notes appeared to find these more useful (according to the ASQ results), than those who spent more time on them. 2 Hybrid learners and 3 Pragmatists spent very little time on text and graphical notes but gave them the rating of "useful". Another Pragmatist even rated the text and graphical notes to be "useless". This Pragmatist did not browse through page-by-page; without starting with the first page, he jumped from second page to another and wandered across the pages.

75% of the participants attempted the self-test. Among them, 8 re-took the self-test and scored better than they did in the first trial. The first visit to the self-test may have served as a "tour" for some participants. The time spent on the second attempt was shorter than the first visit.

Table 4 Duration of Interaction with Elements of Multimedia Content

Subject No.	Learning Style (derived from HCA)	Text notes in:		Live video in:		Screen capture video in:		Total time on system (m:s)
		(m:s)	(%)	(m:s)	(%)	(m:s)	(%)	
S11	Activist	03:40	10	12:03	35	08:38	25	35:15
S6	Activist	06:03	39	12:36	19	09:50	31	32:15
S8	Activist	03:49	13	14:20	50	08:06	28	28:48
S5	Hybrid	10:03	31	12:51	24	13:12	32	41:43
S17	Hybrid	12:59	35	11:45	32	00:04	0.2	37:07
S4	Hybrid	13:55	43	06:02	19	05:15	16	32:12
S1	Hybrid	03:34	13	08:50	31	05:56	22	27:34
S16	Hybrid	01:38	6	06:42	25	10:00	37	26:54
S3	Hybrid	08:29	34	02:13	9	03:29	14	25:18
S2	Hybrid	04:50	55	12:24	22	1:45	8	21:47
S14	Pragmatist	00:18	2	14:07	93	00:18	2	15:10
S9	Pragmatist	00:08	1	12:08	85	01:41	12	14:18
S7	Pragmatist	00:09	1	10:29	79	00:32	4	13:12
S15	Pragmatist	00:38	5	04:44	36	03:10	24	13:03
S18	Reflector	01:12	6	15:25	71	00:13	1	21:36
S13	Reflector/Theorist	09:28	49	01:05	6	01:54	10	19:30

S12	Reflector/Theorist	09:59	68	00:24	3	00:36	4	14:40
S10	Theorist	04:57	44	00:02	0.3	00:10	2	11:10
S19	Theorist	05:53	68	00:03	0.6	00:12	2	08:42
S20	Theorist	04:02	56	00:13	3	00:06	1	07:13

Possible Improvements on Application Design

Most of the participants started MAL navigation with the live video lecture. This link is located at the top of the main menu and was the first item that the subjects saw when they entered the Main Screen of the MAL system. Most computer users view the computer screen from top left to bottom right. This could explain why most of the participants clicked on the "Watch video lecture" button first. It would be possible to test for this by re-running the experiment locating the Watch video lecture" button last on the menu. The tool tips of the video should indicate its length to the subjects and give a brief description about the content of the video clip. The pages of the notes are arranged in sequential order and attached with back and next buttons for more convenient access. The main focus of the notes is on the practical demonstration of Lesson 6 of Photoshop, which is written in text and embedded with print screen images. Judging from the reaction of the Theorists and Theorists/Reflectors, the emphasis of the notes was somehow different from what they were expecting. It would be good to improve these pages with an introduction page which explains all of the underlying theories of the lesson. Besides, it would also be pleasant to improve the system with an interactive tutorial such as a drag-and-drop-object quiz or mix-and-match exercise. It is also good to embed an interactive video where the users can click on the video and the system will provide response mirroring the interaction in a classroom. These may attract the pragmatists as the mentioned improvements require high level of interactivity. The self-test consists of a set of fixed questions. Regardless of the number of attempts, the questions remain the same. This directly influences the marks of the test when a subject retakes the test. A set of randomly generated questions would be a better tool to evaluate the performance of the students.

Conclusion

It is inappropriate, given the limited extent of the work, to draw many conclusions from the results or to propose any theories based on its outcome. Rather, this paper seeks to highlight issues that need to be addressed if we are to further our understanding of the complex relationship between user interaction and the content presented in various modalities in e-learning packages.

However, the study of students' learning styles may act as a reference in the context of designing an intelligent tutoring system. This study suggests that students with different learning styles may prefer to use different types of media. If we can detect these preferences, the materials may be adapted to accommodate them. This study may serve as a framework for Intelligent Tutoring System, where it is able to track, record and characterise the user's learning behaviour and navigation pattern. The pattern could then be kept and used display content in a format that matches the user's preferences. However more studies are needed before such a system could be developed.

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References

Dillon, A. and Gabbard, R. (1998). "Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control and style", *Review of Educational Research*, 68(3), pp. 322-349

Du H.C.D. et al. (1985). "Video-Based Hypermedia for Education-on-Demand". *IEEE Multimedia*. US, 5(1), pp.72-83.

Fleming, N. (2001). VARK- Multimodal Study Strategies.[Online] Available: http://www.vark-learn.com/questionnaire.htm [Accessed: 2003]

Honey, P. and Mumford. A. (1982) Manual of Learning Styles. London:. P Honey.

Kolb, D.A. (1984). Experimental Learning. New Jersey, USA. Prentice Hall.

Kushniruk et al. (2001). 'Televalution' of Clinical Information Systems: An Integrative Approach to Assessing Web-based Systems. *International Journal of Medical Informatics*.

Mullier, D. et al. (2002). "Identifying and Using Hypermedia Browsing Patterns", *Journal of Educational Multimedia and Hypermedia*, AACE, USA, 11(1), pp. 31-50.

Reuther, A. I. and Meyer D.G. (2002). "The Effect of Personality Type on the Usage of a Multimedia Engineering Education System". *32nd ASEE/IEEE Frontiers in Education Conference*, Boston, MA.

Sieber, V. et al. (2003). Learning Technologies and Learning Theories. *Usability Evaluation of Online Learning Programs.* Information Science Publishing. Liverpool: UK. 218-232

Thampuran S. et al (2001). "Multimedia Distance Learning Without the Wait" *31st Annual Frontiers in Education Conference*, Stipes Publishing, Nevada, Illinois,

Ulvund, F. (1997) "*Hyperlectures: Teaching on Demand*", XIIth International Conference of the AHC, Glasgow, UK, June 30 - July 3 1997