Identifying and resolving disorientation in e-learning systems

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***Abstract*— Web-based learning has been one of the most researched areas for the past two decades. Among different problems encountered in e-learning research, an important phenomenon is disorientation. It is the event which results in learners losing their sense of direction in hyperspace or unknowingly deviating from their learning goal. In this paper we review some e-learning systems and their support for identifying or resolving disorientation. We then present architecture of proposed system with an embedded Disorientation Module (DM). DM consists of sub components namely Sensing Module, Resolution Module and Evaluation Module with subsequent techniques for identifying and resolving various types of disorientation. The paper concludes with suggestions regarding future research directions.**

Keywords*— *E-learning, Adaptive Hypermedia, disorientation, losing in hyperspace, high-level content

I. Introduction

Web-based learning environments are becoming very popular [1]. E-learning systems provide useful tools for computer supported learning. They aim to increase the knowledge gain of users by different recommendation and adaptation techniques Two increasingly popular approaches to e-learning are Educational Recommender systems (ERS) and Adaptive Hypermedia systems (AHS). Educational Recommendation Systems is a category of recommendation systems which uses various filtering techniques to generate content to meet a specific user's learning goal(s). Whereas Adaptive Hypermedia Systems can adapt to the needs of its user based on the user model [2]. Both of them provide personalized learning experience for each learner by creating a user profile, which takes the difference in their personality characteristics in account.

Among several factors which affect the learning process in a web-based environment, one factor is disorientation. Learners undertaking a course can sometimes deviate from the path assumed by the course designer. Factors such as external distractions and limited ability to grasp a concept for a long time also distracts a learner. Presenting content higher than the knowledge level of learner also produces a sense of disorientation for the learner. Further research in this direction accentuates the need of a model which distinctively identifies each kind of disorientation. In this paper we aim to submit the aforementioned disorientation model, followed by our proposed system architecture for resolving the occurrence of disorientation.

Remaining paper is divided into 4 sections. Section 2 contains review of related work. The subsequent section introduces the disorientation model, mentioning the categories of disorientation in e-learning systems and their impact on a student's learning. It is followed by section 4 which defines the architecture of our proposed system. Section 5 describes the future work and concludes the paper.

II. Related Work

Number of systems have been developed over the past two decades. Following list contains a mix of phenomenal as well as recent systems developed in the domain of AHS and ERS.

A. ELM-ART (1996)

ELM-ART (ELM Adaptive Remote Tutor) [3] is developed on the base of the system ELM-PE [4], which supports distance learning and problem solving for programming in LISP. It is an online version of the LISP textbook taught in courses in the past years. It is hierarchically divided into higher level units and their subunits, and has a separately maintained student model for each registered student. Student model comprises of student's way of solving a particular problem and his individual learning history.

This system is designed to include a network of concepts, plans and rules, for it to understand the pedagogical structure of the Lisp domain and the relationships between various concepts. This knowledge helps in determining the prerequisites of a concept and provides recommendations for similar concepts such as all the subunits with the related explanation or demonstration.

With more browsing opportunities, comes the risk of student being lost in hyperspace [5]. To cope up with this problem, system uses *adaptive annotation* and *adaptive sorting* of links [3] for aid student navigation. Using the information from student model, system adaptively generates pages and visually annotates each link with dynamic icon and font to help a student in understanding whether it is *known*, *ready to be learned* or *not ready to be learned* by using traffic lights metaphor. The links are then adaptively sorted, with the most similar ones preceding others.

It also deals with disorientation due to high content by warning a student about unlearned prerequisites when he enters a page which is not yet ready to be learned. In case the student fails to correct an error on his own, the system helps the student by messages with increasing level of detail.

B. AHA! (1998)

AHA stands for Adaptive Hypermedia Architecture [6]. It was initially developed as a means to deliver curriculum of courses related to computer science and related disciplines at six universities in the Netherlands and Belgium along with few other institutes, but is now available to be freely used in all kinds of applications other than education.

The core of the AHA system consists of an engine which maintains a user-model based on knowledge about concepts. [6]. It uses Boolean values to represent user's preference or prior knowledge about the concept/topic. It also maintains a log for recording the time user takes to read a page and the score for each test taken. Log entries help in determining the knowledge gain of user. This information from the user model can then be used to suggest appropriate content to the user.

AHA implements adaptive content called 'fragment variants' using HTML by means of a preprocessor, which filters content fragments by means of conditionals encoded in structured HTML comments [6]. It helps in making adaptive changes to the content (text, video or image) being displayed to the user. Filtering occurs in the form of *link annotation*, *link hiding, link removal* and *direct guidance*. Link annotation is marking color of the links provided to the user as 'desired', 'undesired', 'neutral', 'external links', etc. These respective color of the links can be chosen by the user in the 'setup' HTML page. Link hiding is implemented by either hiding, disabling or removing a link which is unrelated or the knowledge prerequisite for that content has not been achieved. Direct guidance is realized by directly redirecting the user to the appropriate next link according to their knowledge value [6].

C. SKILL (1998)

SKILL (Scalable Internet-Based Teaching and Learning System) [7] provides adaptive learning environment by taking diversity of student knowledge levels and learning preferences into account. The users of this system are categorized as *student, teacher* or *administrator*. It has a knowledge pool generated from the basic pool of concepts which consists of learning material in the form of HTML courses slides, handouts and additional references. While designing a course, an instructor groups similar concepts from the knowledge pool and defines a navigational path through the course. This navigational path is kept separate from the course content.

Beside the walk through the default navigation path students can drill down into each concept. Hence for every concept related materials are available as cross references to the actual concept. When a student follows a cross reference he/she leaves the default navigation path, but can resume at this point at some later time [7]. This generates a disorientation problem where the learner can find it difficult to head back to the original point of concept.

It provides adaptation by providing a start configuration in which a student identifies known topics, and answers subsequent control questions to validate the knowledge of concerned concept, after which the concept is hidden from the course. In case the student chooses to answer the control questions later, those concepts are marked especially until the questions are answered [7].

In addition to this personalization, a user can annotate course contents by adding both private annotations and concepts or by proposing course extensions which can be either private or shared, this additional information is added to the navigation path and develops a collaborative learning environment.

D. TANGOW (1999)

TANGOW stands for Taskbased Adaptive learNer Guidance On the WWW [8]. It is a tool which enables course designers to develop adaptive learning environments on the World Wide Web which consist of databases containing rules, tasks and course content. A student process is maintained for each learner interacting with the system, which stores their profile and learning behavior. This information is then sent to the two modules of the Student Process namely Task Manager and Page Generator. There is a different Task Manager for each course that a student is taking, which stores student's actions in Dynamic Workspace and passes them on to the Page Generator for generating dynamic HTML pages. In addition to this there is an always running Process Manager which accepts incoming requests and sends them to the corresponding Task Manager. Communication between client browser and the system is facilitated by the CGI program, which checks and sends the client parameters to Process Manager and waits for response from Page Generator for sending dynamically generated HTML pages to the learner [8]. All these modules store relevant information in databases namely User DB, Course Content DB and Teaching Tasks Repository [8]. Figure shows the architecture of TANGOW system.

E. ILASH (2003)

Incorporating LeArning Strategies in Hypermedia focuses on providing the most appropriate learning strategy to the learner [9]. It contains Physics courseware laid out in adaptive and non-adaptive form. In addition to providing adaptation in the form of adaptive layout presentation and adaptive navigational support [10], learning strategy is also adapted by means of dividing the course contents into S_type (Summarizing strategy) and Q_type (Questioning strategy) [9]. A student is required to browse both types respectively, and the learning strategy is adapted based on the results of post-test comparisons between both strategies.

F. PEL- IRT (2005)

Personalized E-Learning system using Item Response Theory focuses on providing adaptive learning to the users [11]. The main architecture consists of two main parts namely front-end and back-end. Front-end deals with recording user actions and managing communication, while back-end estimates learner's ability and analyses it to present appropriate course content to the user. The user needs to be registered to be provided with personalized services. The system assigns courses with moderate difficulty to learners logging in for the first time [11]. Once they click on course materials and answer predefined questionnaires, Course Recommendation Agent provides them with personalized services and Feedback Agent adjusts difficulty parameter of course materials based on explicit learner feedback.

Due to collaborative feedback approach, course materials are effectively adjusted after the difficulty level initially being determined by the course experts. It also adjusts learner abilities on the scale of -3 to 3 (poorest to best) based on the questionnaires answered by the learner after each level [11].

G. Genetic-based personalized e-learning system (2008)

Genetic-based personalized e-learning system adjusts learning paths based on incorrect responses to a test by an individual learner [12] It yields personalized curriculum sequencing by considering courseware difficulty on the basis of results obtained by pre- test attempted by the learner. It facilitates free browsing within the system by generating optimal learning path chosen by the system [12].

H. AEHS-LS (2011)

The architecture of Adaptive E-Learning Hypermedia System based on Learning Styles [13] is divided into Domain model, Student model and the Adaptation model. Once the student registers with the system, he/she selects the appropriate learning styles by either selecting one by their own choice, or by answering a set of questions. It then offers linear navigation in the form of direct guidance, hierarchical navigation through the tree-like structure of contents and relational navigation through link insertion and link disabling through prerequisite concepts relationship [13]. It is designed to be adapted to different learning styles and acquired knowledge of a student. [13].

I. E-Student Web-Based Adaptive Hypermedia System (2012)

E-student learning system is used for C and C++ programming language courses. It aims to provide effective learning paths to learner and to provide student feedback about the course structure [14]. It uses five recommendation strategies namely Number of visits, Evaluation, External sources, Comments and Navigation assistance. They are used to show a recommended path by counting the number of hits to a specific page, using rating stars to show user satisfaction about a topic, suggesting external resources and changing the color of links based on the number of visits, recording user comments and providing visually annotated resolved projects respectively. [14]

J. Realizeit (2013)

Realizeit provides flexible means to move any educational institute and any learning level's course contents online. The main idea is to separate curriculum and content, making several pieces of content available for the same topic for different learners. Content and curriculum in Realizeit can be imported or created locally using the system [15].

The system also logs user interaction and outcome data for generating student profile. This profile is used to evolve curriculum and content accordingly [15].

K. SITS (2016)

SITS is a solution-based intelligent tutoring system [16] which aims to improve learning outcomes and problem solving skills of students in computer programming by using multi-agent system. Multi-agent system takes user's knowledge level and target programming problem into account, and suggests appropriate options for flowchart development. The main idea is to use flow charts to enhance their problem solving skills and make fundamental programming session motivational. It provides adaptive guidance to user by providing navigational support, pre-requisite recommendations and adaptive flowchart development [16].

III. Disorientation model

The primary objective of an ERS is to maximize the knowledge gain of diverse learners. While interacting with an ERS, a learner tends to lose the sense of direction, especially when he doesn't have a clear learning goal or preference. As a result of this, there is no significant improvement in user's knowledge. By far, most of the literature uses disorientation and losing in hyperspace [11] as synonyms. However, we have identified certain distracting phenomenon experienced by the user while attempting to learn online, which have not yet been quoted, but fall under the category of disorientation.

Most of the existing learning systems fail to acknowledge or identify disorientation due to lack of proper categorization of the reasons which cause it. A good ERS should be able to discern the occurrence of a particular kind of disorientation, take measures to resolve it and evaluate user's learning in order to ratify its performance. Fig. 1 shows the disorientation model.

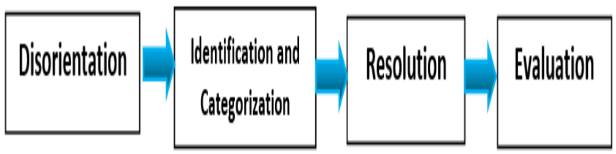

Fig 1: Disorientation model

A. *Categories of Disorientation*

Disorientation is of many kinds and occurs due to several factors, which are listed below.

1) Back to square one: Sometimes the learner tends to lose focus halfway through study. This loss of focus, if not detected, makes the user lose their orientation, and they have to start over again. This phenomenon can be termed as back to square one. It can occur due to any one of the following reasons.

a) External distraction: Web-based learning using happens in a browser, and with latest browsers having the option of opening multiple tab simultaneously, learners have a tendency to open multiple tabs in one window and can hop from the learning system to social media application upon getting any notification. The same happens when a learner experiences distraction from a phone call, doorbell or being interrupted by someone during the learning process.

b)Limited Attention Span: Learners with a limited attention span tend to randomly check for updates or aimlessly browse the internet or play games after a certain time. This limited attention span diverts their mind from their previous point of focus.

2) Losing in hyperspace: Traditional e-learning systems have a complex course structure and navigational path, whereas students differ in many aspects such as expert level, age, prior knowledge, concentration and IQ, due to which it is inadequate for them to follow the uniform instruction path assumed by the course designer. In ERS, recommendation is either implicit such as in TANGOW or AHA through *'direct guidance'* [2] [8] or explicit by leaving the choice of navigation to user by suggesting them appropriate content. In the latter case, there is a chance that the learner dismisses a proposed content recommendation way too many times. This can lead to him/her being eventually lost in the hyperspace [11].

3) High level content: Disorientation also occurs because of the inability of ERS to determine user's knowledge level or preferences correctly, as a result of which the learner tends to lose concentration due to difficulty of subject matter or hard to grasp concepts. Chen et. al. [11] also talk about learners finding the course content not challenging and a waste of time. Both these situations cause the learner's thoughts to deviate from the course content. This is similar to the phenomenon of student's thoughts wandering off in the traditional classroom due to inability of the instructor to grasp their attention or because of student not having prerequisite knowledge related to the subject.

B. *Comparative analysis*

As can be noted from the section 2 containing related work, a lot of work has been done in the domain of AHS and ERS for providing guided learning experience to the user. However, the identification criteria for disorientation hasn't been clearly defined, making it difficult for the existing e-learning systems to detect its occurrence. Table 1 gives an account of reviewed systems along with the evaluation parameters.

TABLE 1. SUPPORT FOR DISORIENTATION IN EXISTING SYSTEMS

Systems	**Back to square one**	**Losing in hyperspace**	**High level content**
ELM-ART	**N**	**Y**	**Y**
AHA!	**N**	**Y**	**Y**
TANGOW	**N**	**N**	**N**
SKILL	**N**	**N**	**N**
PEL-IRT	**N**	**Y**	**Y**
E-STUDENT	**N**	**N**	**N**
I-LASH	**N**	**Y**	**N**
Genetic-based personalized e-learning	**N**	**Y**	**Y**
AEHS-LS	**N**	**Y**	**N**
Realizeit	**N**	**N**	**Y**
SITS	**N**	**N**	**Y**

In the light of this summary table, it can be noted that none of these systems provides support for back to square one. The support for losing in hyperspace through direct guidance is provided in ELM-ART [3], AHA [6], I-LASH [9], PEL- IRT [11], Generic based personalized e- learning system [12] and AEHS-LS [13], whereas high level content is acknowledged in only ELM-ART [3], AHA! [6], PEL-IRT [11], Generic based personalized e-learning system [12], RealizeIt [15] and SITS [16]. This intensifies the need of an e-learning system which sees to these issues collectively.

IV. PROPOSED SYSTEM ARCHITECTURE

A. *Learner modelling*

Learners are different from each other in many aspects. Some are distracted easier than others. In order to detect the occurrence of a particular kind of disorientation, the system will first do some learner modeling. Once the learner logs into the system, he fills in his/her demographic information and takes tests including attention span test, Reading and comprehension speed test and learning style tests.

B. *Learner Module (LM)*

The results obtained by learning modeling constructs the Learner Module. It contains the following information about the logged in user:

- Learning style
- Reading/ Comprehension speed
- Attention span
- Demographics

C. Course Module (CM)

This component is the repository of course contents of the subject, along with its structure.

1) Course Content: All course contents of the specific course.

2) Navigational Path: The possible combination of paths of study for different kinds of students.

3) Module Division: Division of each module into submodules / components.

4) Maximum links (before deviation): The number of maximum links before which it is safe to assume that the learner hasn't wandered off or lost into hyperspace. This will act as the threshold for activating path deviation strategy.

5) Module tests: Tests designed for each module to determine learner's knowledge gain.

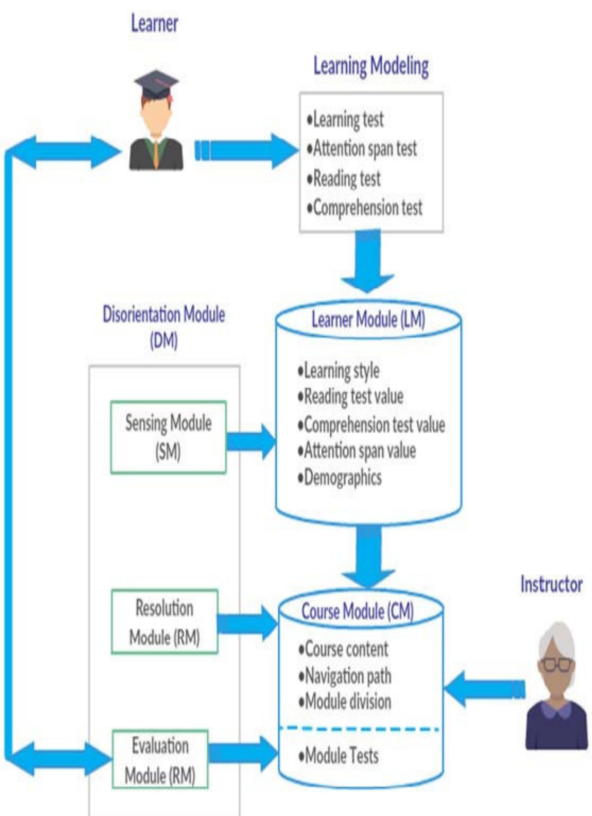

Fig 2: Proposed system architecture

D. Disorientation Module (DM)

The proposed system will have a dedicated disorientation module which performs the functions of sensing and resolving disorientation, and eventually evaluating the system. Fig. 3 shows interaction of different sub modules in DM.

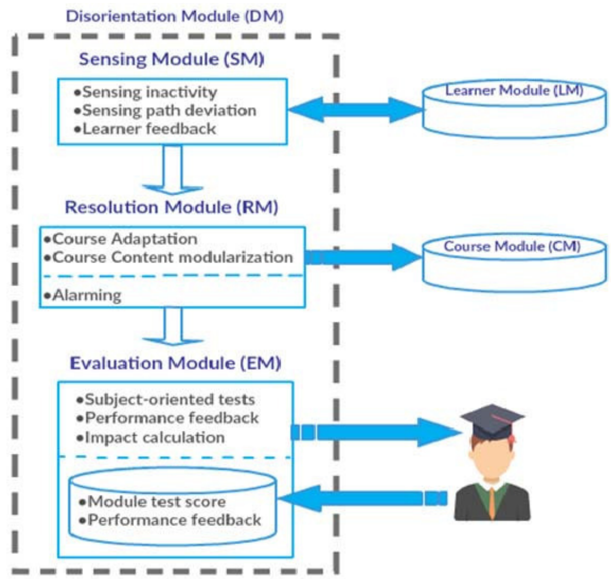

Fig 3. Disorientation module

1) Sensing Module (SM): First step of resolving problems resulting due to disorientation is to identify that it has occurred in the first place. Sensing module is the most important module in the system as it will be used for identification and categorization of disorientation and then activating the appropriate resolution strategies for the identified kind.

a) Sensing inactivity: System will perform period check for inactivity by subtracting the time elapsed since the last scroll/click from the time threshold (which can be obtained from attention span tests of learner). In case of a negative result, the learner will be notified of their absence by alarm and asked for feedback.

b) Sensing path deviation: System will perform period check for inactivity by subtracting the maximum links threshold (which can be obtained maintained by counting the number of links following the one clicked). In case of a negative result, path deviation strategy will be activated.

When a user has dismissed recommended links more than a given number of times, it can be assumed that the probability of him being lost in hyperspace has increased. System can keep a count of times user has dismissed the proposed links, which can then be compared with the dismissal limit. This limit is relative and can vary for different topics and systems. Longer the navigational path, smaller will be the limit. For example, ELM-ART provides recommendation for learning items which are not changeable [3], whereas in an Evolving E-Learning System, learning items are dynamically added, modified or even deleted [19]. A learner interacting with the latter has a higher chance of getting lost in hyperspace by link dismissal than that of the former, so the limit for the later should be smaller.

2) Resolution Module (RM): Once the sensing module indicates the occurrence of disorientation, RM will activate strategy for corresponding type.

In case of inactivity, the system will first determine type of disorientation occurred based on user feedback. For high level content, course contents will be adapted to revisit the perquisites first. For limited attention span, the course contents will be further modularized and then adapted. Whereas for external distraction, the user will simply be alarmed about his loss of focus.

3) Evaluation Module (EM): System performance will be evaluated by taking subject-oriented tests, followed by system performance feedback from the learner. Their results will determine overall impact on student's learning.

V. Conclusion and Future Work

Web based systems have attracted significant attraction of researchers in the recent past. A number of such systems devote themselves to address issues in different educational domains. One of these issues is disorientation, which renders a user clueless during the learning process. In this paper we present a disorientation model, and propose identification and resolution strategies against each of those categories.

This is a problem rich area which has a large margin of development. This work can be extended to provide support for identifying disorientation caused in open corpus and collaborative e-learning environments. It can also include support for neural networks to aid the identification of disorientation caused by physical and psychological impairments. We intend to present our working system and evaluation results in the future.

References

[1] Zaíane, Osmar R. "Building a recommender agent for e-learning systems."*Computers in Education, 2002. Proceedings. International Conference on*. IEEE, 2002.

[2] Brusilovsky, Peter. "Adaptive educational hypermedia." *International PEG Conference*. Vol. 10. 2001.

[3] Brusilovsky, Peter, Elmar Schwarz, and Gerhard Weber. "ELM-ART: An intelligent tutoring system on World Wide Web." *Intelligent tutoring systems*. Springer Berlin Heidelberg, 1996.

[4] Weber, Gerhard, and Antje Mollenberg. "ELM-PE: A Knowledge-based Programming Environment for Learning LISP." (1994).

[5] Liu, Xiao-Qiang, Min Wu, and Jia-Xun Chen. "Knowledge aggregation and navigation high-level Petri nets-based in e-learning." *Machine Learning and Cybernetics, 2002. Proceedings. 2002 International Conference on*. Vol. 1. IEEE, 2002.

[6] De Bra, Paul, and Licia Calvi. "AHA: a generic adaptive hypermedia system."*Proceedings of the 2nd Workshop on Adaptive Hypertext and Hypermedia*. sn, 1998.

[7] Neumann, Gustaf, and Jana Zirvas. "SKILL--A Scalable Internet-Based Teaching and Learning System." (1998).

[8] Carro, Rosa M., Estrella Pulido, and Pilar Rodríguez Marín. "Task-based Adaptive learNer Guidance On the WWW: the TANGOW System." (1999).

[9] Bajraktarevic, Namira, Wendy Hall, and Patrick Fullick. "ILASH: Incorporating learning strategies in hypermedia." *Proceedings of the Fourteenth Conference on Hypertext and Hypermedia*. 2003.

[10] Brusilovsky, P. (1996) Methods and techniques of adaptive hypermedia. *Journal of User modelling and User adaptive interaction*, **6**, 2-3, pp. 87-129.

[11] Chen, Chih-Ming, Hahn-Ming Lee, and Ya-Hui Chen. "Personalized e-learning system using item response theory." *Computers & Education* 44.3 (2005): 237-255.

[12] Chen, C.-M. (2008), 'Intelligent web-based learning system with personalized learning path guidance', *Com- puters & Education* **51**(2), 787–814.

[13] Mustafa, Yasir Eltigani Ali, and Sami Mohamed Sharif. "An approach to adaptive e-learning hypermedia system based on learning styles (AEHS-LS): Implementation and evaluation." *International Journal of Library and Information Science* 3.1 (2011): 15-28.

[14] Pinter, Robert, et al. "Recommender System in E-student web-based adaptive educational hypermedia system." *MIPRO, 2012 Proceedings of the 35th International Convention*. IEEE, 2012.

[15] Howlin, C. and Lynch, D. (2014), The realizeit adaptive learning platform, *in* 'E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education', Vol. 2014, pp. 873–873.

[16] Hooshyar, D., Ahmad, R.B., Yousefi, M., Fathi, M., Horng, S.J. and Lim, H., 2016. SITS: a solution-based intelligent tutoring system for students' acquisition of problem-solving skills in computer programming. *Innovations in Education and Teaching International*, pp.1-11.

[17] Towards the Next Generation of Recommender Systems: A Survey of the State-of-the-Art and Possible Extensions

[18] Lops, Pasquale, Marco De Gemmis, and Giovanni Semeraro. "Content-based recommender systems: State of the art and trends." *Recommender systems handbook*. Springer US, 2011. 73-105.

[19] Iaquinta, Leo, et al. "Introducing serendipity in a content-based recommender system." *Hybrid Intelligent Systems, 2008. HIS'08. Eighth International Conference on*. IEEE, 2008.

[20] Sheth, B. and Maes P. Evolving agents for personalized information filtering. In Proceedings of the 9th IEEE Conference on Artificial Intelligence for Applications, 1993.

[21] Konstan, J. A., Riedl, J., Borchers, A. and Herlocker, J. L.: 1998, 'Recommender Systems: A GroupLens Perspective.' In: Recommender Systems: Papers from the 1998 Workshop (AAAI Technical Report WS-98-08). Menlo Park, CA: AAAI Press, pp. 60-64

[22] Smart Recommendation for an Evolving E-Learning System, Tiffany Ya TANG and Gordon MCCALLA *Dept. of Computer Science, University of Saskatchewan 57 Campus Drive, Saskatoon, SK S7N 5A9, CANADA*