ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 8(14), IPL024, July 2015* ISSN (Online) : 0974-5645

# Quantification of Learner Characteristics for Collaborative Agent based e-Learning Automation

**S. Jawahar[1*] and K. Nirmala[2]**

[1]Quaid-E-Milleth Government College for Women, University of Madras, Chennai-600002, India; rsjawahar@gmail.com

[2]Department of Computer Science, Quaid-E-Milleth Government College for Women, Chennai-600002, India; nimimca@gmail.com

## Abstract

**Objectives:** The objective of this research work is to analyze on learner characteristics like active, reflective, group or solo learning qualities called 'learner portfolios' that are to be analyzed by a collaborative agent in an e-learning environment. **Methods:** This research work proposes a methodology that can determine e-learner characteristics from respective user profiles and interact with any adaptive e-learning system in an asynchronous mode. Since most of the learner characteristics are subjective, with literature support, this research work presents social survey results. This research work also introduces a collaborative agent based model for correlating learner characteristics. **Findings:** Adaptive e-learning systems employ software agents in asynchronous modes for various non-dependent process activities. As software agents act independently, such integrated approaches are expected to increase the efficiency. Literatures on collaborative agents that deal with learner portfolios of subjective attributes are very rare to be seen. **Application/Improvement:** These portfolios, if documented as learner profiles, can help e-learning systems to understand e-learners' behavior better and respond appropriately back to them.

**Keywords:** Adaptive e-Learning, Collaborative Agents, Learner Characteristics, Software Agents

## 1. Introduction

Software agents of educational automation procedures consist of pieces of software that deal with human characteristics, so as to facilitate efficiency and increased effectiveness in social learning. When software agents are integrated with learning processes (in adaptive e-learning environments) then they are known as interface agents. When learning processes are integrated with learner requirements (or e-learner characteristics) then such agents are known as collaborative (learning) agents. Collaborative agents are the ones that deal with user requirement variances, while instructional system agents deal with the instructional models; the resources system agents deal with quality of assets like scripts and content organizations, and the infrastructure system agents deal with internet infrastructures like bandwidth, computer systems in the internet, e-content packaging etc. When all these components are integrated together, then such agents are known as smart agents.

This research work, which is part of a whole research program that deals with smart agents, is however is limited to collaborative agent based adaptive e-learning process. The characteristics of the users (e-learners) that the collaborative agent can be able to understand, could be in the form of texts, graphs, icons, animation, multimedia and virtual reality that are documented in files as databases. Advances in technology have facilitated

* *Author for correspondence*

the development of such educational agents: A significant advance in developing active pedagogical agents[1]. Agents can be analogous to instructor's assistants that can provide the instructor with the learning portfolio or profiles of the students, which includes learning performances, understandings and misunderstandings, levels of efforts, and motivations of the students. But the term 'instructor' and 'students' referred in this research work, operationally means the adaptive e-learning system and the e-learner profiles and the portfolios are delimited to active/reflective and group/solo learning. These portfolios, if documented as learner profiles, it can then help the e-learning system to understand the learners' behavior better and respond appropriately back to them, the e-learning users, while the agents actually hide themselves from the learners. One of the drawbacks of such agent based systems is that the work is rarely sharable and reusable[2], because they have to deal with many learner characteristic factors, which are subjective and not logically definable. But intelligent automatic procedures on agents can be made to support the sharing and reusing of such works. However, sharing the work in different environments is difficult because no relevant standards do exists. Hence an ontology-based architecture may be tried out through research, with appropriate ontology that could overcome these drawbacks. Depending upon the requirements of pedagogical ontology or domain specific ontology, appropriate applications are needed to be developed. The design and ontological presentations of terms are beyond the scope of this research work.

This research work concentrates mainly on the methodology that can determine the learner characteristics from the user profiles and interact with the adaptive e-learning system in an asynchronous mode. Since most of the learner characteristics are subjective, social survey on South Indian e-learners have been proposed and administered, and the experimental results are presented in this research work. This research work also briefly presents the proposed model, which has been developed in Java, tested and validated (as the validation involves separate social survey, the results are not presented in this research work). The conclusions which have been drawn from the experiments will be of immense use to e-learning system researchers and designers. Even though many published works on agents and e-learner characteristics are seen in isolation, integrated works on these two is rarely seen. Under this above background this research work presents the problem formulation and explains the proposed model substantiated with experimental results.

E-learning resource models on adaptive learning could incorporate ontology for learner characteristics and instructional roles, in addition to ontology for domain. Even ontology on instructional structure and goal can also be adopted[3]. It is a well known fact that any domain content, which is based on a model, would represent only the domain specific subject content. But the important aspect of adaptive course models is in their ability to identify the relationships between the course elements (domain specific contents) and the learner behaviors[4]. Learner characteristics include pedagogical aspects such as learning style and nature of learner preferences, according to educational psychologists and theorists like Felder and hence such characteristics need to be looked at from an instructional strategy point of view[5]. The learning styles broadly include active learning, reflective learning, group learning, solo learning, global learning and sequential learning apart from other characteristics such as visual or verbal, inductive or deductive etc. An important observation made on pedagogical interface is on the specificity of instructional approaches for specific learning styles[6]. Different course settings, such as user preferences, content details and the delivery depending on learner backgrounds etc., must be designed for different learner characteristics. Learner behavior can also be documented and referred for preferred options through profiling that includes navigational logs of users over a period of time[7]. Such an attempt has improved the learning processes. The documented dynamic learner profiles considered both the personalized behavior of users as well as the changes that happened during the learning process. The need for knowing users' learning capabilities and their learning performances, and also knowledge level, is stressed. It is thus evidenced from the above surveys that subjective learner characteristics are extremely important for effective learning, particularly in adaptive e-learning environments. Such characteristics, if quantified will be of great use for selecting appropriate learning objects in an automated e-learning environment.

Various perspectives of learning processes (particularly in e-learning environments and in automated learning processes), when adopted in multiple software agents, would play a vital role in solving complex and user related problems[8]. The various perspectives could be the subjective learner characteristics as explained earlier.

These agents by virtue of their definition and nature would autonomously deal with the required tasks for related user needs, while hiding themselves (the presence of agents in the system) from the users. A learner system assisted software agent, on the other hand would help in providing relevant and aptly needed information of the subject content from instructional documents such as books, library materials, database etc., so as to encourage learners, who are interacting with the learner system, to effectively participate in the learning process[9]. This is adopted particularly for strengthening the attention of the learners.

A research work carried out by "McKay, Elspeth, and John Izard" in[10] titled us "eLearning Programme Design: Customized for user-centered participation". This research relies on continual employee reskilling through cost effective eLearning programmes using advanced Information Communications Technology (ICT) tools to enhance work-place training with assured predictable outcomes. Determining the nation's training costs appears to be hidden from public gaze. The answer is buried within highly competitive non-government organizations. Research reveals the most desirable approach is to personalize an employee's knowledge development through flexible online learning. Maintaining well skilled and knowledgeable employees is key to sustaining our competitive advantage through smarter information use of digital technologies.

"A novel justice-based linear model for optimal learner group formation in computer-supported collaborative learning environments" is discussed by "Sadeghi, Hamid, and Ahmad A. Kardan"[11] in the benefits of computer-supported collaborative learning are well established. To apply this learning strategy, at the initial step learners must be assigned to best collaborative groups. It is a crucial task, because group-mates of each student have major impacts on his/her learning during the collaboration period. How the problem and all of its requirements can be efficaciously formulated through a binary integer programming approach to construct a linear model which is optimally solvable in a reasonable time. The concept of justice in the context of learner group formation is also introduced and we expose how it can be quantified and applied to the model.

A research work explored by "Moise, Gabriela, Monica Vladoiu, and Zoran Constantinescu" in[12] titled us "MASECO: A Multi-Agent System for Evaluation and Classification of OERs and OCW Based on Quality Criteria". Finding effectively open educational resources and open courseware that are the most relevant and that have the best quality for a specific user's need, in a particular context, becomes more and more demanding. Hence, even though teachers and learners (enrolled students or self-learners as well) get to a greater extent support in finding the right educational resources, they still cannot rely on support for evaluating their quality and relevance, and, therefore, there is a stringent need for effective search and discovery tools that are able to locate high quality educational resources. The use of animated pedagogical agents[13] with emotional capabilities in an interactive learning environment has been found to have a positive impact on learners. The Greek philosopher Aristotle contended that three elements; emotion, logic, and character.

With these limited, but important literature works, it is evidenced that adaptive e-learning system can be tried out with a collaborative agent, that may be designed to scan and analyze documented learner profiles and select appropriate e-content objects for effective learning process. Thus with these literature support the objective of this research is to propose a collaborative agent based e-learning model and validate through learner characteristics. For the purpose of building learner characteristics of delimited features, social survey methodology is suggested for South Indian samples.

## 2. Proposed Method

The methodology that can determine e-learner characteristics from respective user profiles and interact with any adaptive e-learning system in an asynchronous mode, also introduces a collaborative agent based model for correlating learner characteristics. The sampling used for social survey is based on 'purposive sampling' and the feedbacks were fed in a statistical package SPSS 17.0. Normalized values on four selective variables namely, 'Act First', 'Think First', 'Global Learning' and 'Solo Learning' have been computed for active and reflective learner preferences have been documented. Inferences from the survey and conclusions on agent based approaches for subjective learner characteristics have been drawn.

### 2.1 Collaborative Agent based Model for Correlating Learner Characteristics

A simple and clearly spelt out e-learning system model that adopts an intelligent collaborative agent for the research objective specified earlier has been designed and shown in Figure 1.

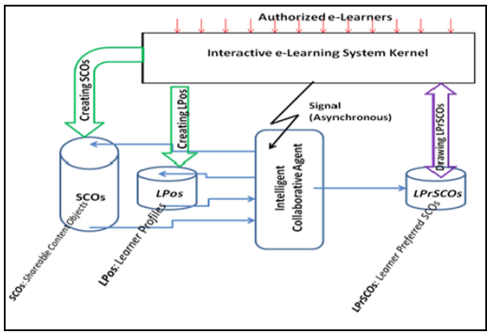


**Figure 1.** Collaborative Agent based Model.

The central component of the system is the kernel which has multithreaded programming concept. The fundamental design and operational philosophy of this proposed model is that of UNIX operating system. Similar to the 'cron' utility of UNIX, the agent is invoked in pre-specified time intervals (in other times it would 'sleep'). The operation of the intelligent collaborative agent is invisible to users, like any other agents, but effective at pre-specified intervals of time (invoked through asynchronous signals) as shown in Figure 1. Two databases are shown in the framework: (i) The Sharable (reusable) Content Objects (SCOs), which are small, reusable, independent instructional objects. One sample is shown in Figure 3, and (ii) The Learner Profiles (LPos) that consist of whether the particular authorized user is an 'active' or 'reflective' learner, who prefers 'group' or 'solo' learning etc. Benchmark values for learner characteristics specific to qualitative aspects have been determined through social studies (explained with a case study in section 3) are documented in this database. While the agent has liberty to use these databases at any time, the actual data are created/modified by the kernel only as seen from Figure 1. From these benchmark values, the interactively obtained values for specific user, the preferred SCOs are automatically selected by the agent and stored in another database called 'LPrSCOs'. This 'LPrSCOs' can be accessed by the kernel and appropriate SCO can be displayed for the particular user (e-learner). The social survey method for computing (subjective) learner characteristics is elaborated with a case study.

## 3. Experimental Results

The intended experiment consisted of survey that involved both control as well as experimental respondent groups. The control group need not be a random sample[14]. The members of the control group were exposed to all of the circumstances of the experiment but they were not involved in the experiment. The experimental group on the other hand got all of the circumstances of the experiment and the variables being tested by the experiment. A control group of 18 scrupulous e-learners were selected. The demography of this control group includes both teachers and students of computer application of the University of Madras, India, who were versatile in using e-contents and four of the control group respondents were professional technical teacher trainers, who have dealt with active and reflective learners. The experimental group of 58 selective e-learners of age group over 16 years has been selected. 42 of the group were the students of Master of Computer Application while 16 of them were students of Master of Computer Science; but all of these respondents were selected on the basis of specific usage of web based learning to about an average one hour per day. Both female and male demographists were considered, even though the experiments were not strictly social in nature. The purpose of the experiment was to determine and group active and reflective learners, through the scrutiny by the control group. The sample was based on purposive sampling[15]. A pilot study was conducted on the control group through interview questionnaire. The survey questions for the experiment were validated and administered on the experimental group. Out of nine validated questions, the first question was to determine a general liking of classroom sessions by the experimental group respondents. The hypothesis was that the disliking of classroom sessions by the active learners is significantly more than that of reflective learners. The second question was on vigorous engagement of learners on active learning components, such as group discussions and peer to peer consultations on contents outside the syllabus. The third question was on reflective learners who would quest for more theory for deeper understanding of the content. The fourth question was on a combined item of both active and reflective learning components, namely 'think first' or 'act

first'. Similarly the fifth question was also on a combined item, namely group discussions and solo learning. The idea behind the experiment is to correlate the results between active and reflective learner respondents. The measurement of the feedbacks was done on a four point scale, namely, 'very much', 'much', 'not much' and 'very little'. The responses received from the 58 experimental group respondents were fed in to SPSS 17.0 and the results were scrutinized by the control group and the active and reflective learners were segregated. The correlated results are tabulated in Table 1. A typical response bar diagram obtained for question three on active learners is shown in Figure 2. The normalized values of learning preferences were calculated from the percentage values of responses received from the feedbacks. An empirical value of 2.0 was assumed for the response 'very much' and 1.0 for 'much'. The averaged out values of the feedbacks of the respondents are presented in Table 1.

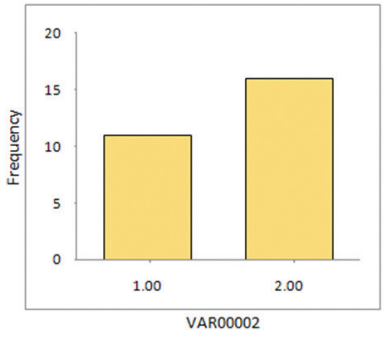


**Figure 2.** Typical Result of Active Learners.

Benchmark values can thus be empirically determined from such social studies. Depending upon these benchmark values, independent SCOs for different learner characteristics, such as: active learners or reflective learners or group learners or solo learners etc., can be designed and stored in SCOs database. One sample SCO on 'device dependency' for group learners is shown in Figure 3.

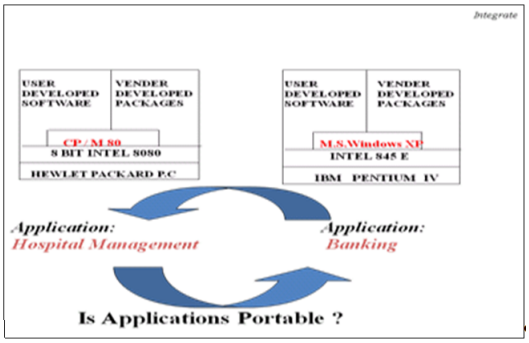


**Figure 3.** SCO for Group Learners of more than 0.50 Preferences.

The design of these SCOs for appropriate learner characteristics are done using problem centered instructional model known as 'First Principles of Instruction'[16].

## 4. Conclusion

An intelligent agent based e-learning system model has been proposed to correlate learner characteristics for

**Table 1.** Normalized Values of Learner Characteristics on Learning Preferences

| Learner Characteristic | No. of Respondents | Normalized Values of Learning Preferences | | | | Standard deviations of the five variables |
|---|---|---|---|---|---|---|
| | | Act First | Think First | Group Learning | Solo Learning | |
| Active Learner Respondents | 27 | 0.410 | 0.0 | 0.590 | 0.0 | 0.50071 |
| | | | | | | 0.64935 |
| | | | | | | 0.50071 |
| | | | | | | 0.42366 |
| | | | | | | 0.42366 |
| Reflective Learner Respondents | 31 | 0.054 | 0.39 | 0.161 | 0.14 | 0.00000* |
| | | | | | | 0.50800 |
| | | | | | | 0.47519 |
| | | | | | | 0.75491 |
| | | | | | | 1.01600** |

*All the reflective learners have expressed liking for classroom sessions.
**The deviation in the responses of the fifth question was slightly more than that of other variables.

appropriate selection of SCOs for appropriate learner characteristics. The benchmark values of selected learner characteristics for this model have been obtained through social survey. It is clearly demonstrated from Table 1 that a plain demarcation between active learners and reflective learners can be made through the four variables namely 'Act first', 'Think first', 'Group learning' and 'Solo learning' and these subjective learner characteristics can be quantified and measured. Certain learning preferences cannot strictly be considered as preferred only by certain learner characteristics, such as the group learning. Table 1 show that reflective learners too prefer for group learning. It is clearly demonstrated that such an agent based approach would increase the efficiency of the e-learning system and would create an effective learning atmosphere for preferred learning characteristics of the users.

## 5. References


1. Johnson WL, Rickel JW, Lester JC. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. International Journal of Artificial Intelligence in Education. 2000; 11(1):47–78.
2. Hayashi Y, Bourdeau J, Mizoguchi R. Using ontological engineering to organize learning/instructional theories and build a theory-aware authoring system. International Journal of Artificial Intelligence in Education. 2009; 19(2)211–52.
3. Hammami S, Qassem S, Al Muhaideb S. Adaptive e-learning using the semantic web: a comparative survey. International Journal of Information and Communication Technology Research. 2012; 2(4):366–72.
4. Brusilovsky P. Adaptive navigation support in educational hypermedia: the role of student knowledge level and the case for meta-adaptation. British Journal of Educational Technology. 34(4):487–97.
5. James WK. Learning Style: Cognitive and Thinking Skills, National Association of Secondary School Principals. Virginia, USA: Reston Publications; 1991.
6. Watson C, Li FWB, Lau RWH. A pedagogical interface for authoring adaptive e-learning courses. Proceedings of the Second ACM International Workshop on Multimedia Technologies for Distance Learning; NY, USA. 2014. p. 13–8.
7. Chiu H-Y. Profiling learner's behavior: A multi-agent approach to support diagnosis in learning management system. IEEE Third International Conference on Convergence and Hybrid Information Technology, ICCIT'08, Vol. 2; 2008. p. 1177–81.
8. Leman S, Giroux S, Marcenac P. A multi-agent approach to modeling student reasoning process. 7th word conference on Artificial Intelligence in Education; ED, Washington. 1995. p. 258–65.
9. Frasson C, Mengelle T, Aimeur E. Using pedagogical agents in a multi-strategic intelligent tutoring system. Workshop on Pedagogical Agents in Artificial Intelligence; Amsterdam. 1997. p. 40–7.
10. McKay E, Izard J. eLearning programme design: customized for user-centered participation. Proceedings of Global Learn. 2015(1):644–9.
11. Sadeghi H, Kardan AA. A novel justice-based linear model for optimal learner group formation in computer-supported collaborative learning environments. Computers in Human Behavior. 2015; 48:436–47.
12. Moise G, Vladoiu M, Constantinescu Z. MASECO: A Multi-Agent System for Evaluation and Classification of OERs and OCW based on Quality Criteria. E-Learning Paradigms and Applications. 2014; 528:185–227.
13. Chioma O, Vassileva J. Affective pedagogical agents and user persuasion. International Conference on Human-Computer Interaction; 2001. p. 397–401.
14. George T, Bremer J. A smarter way to select respondents for surveys. International Journal of Market Research. 2012; 54(6):751–80.
15. Sharma BAV. Research methods in Social Sciences. New Delhi, India: Sultan Chand publications; 1988.
16. Merrill MD. First Principles of Instruction. Englewood Cliffs, NJ: Educational Technology Publications; 2002.
17. Arunachalam AR. Bringing out the effective learning process by analyzing of e-learning methodologies. Indian Journal of Science and Technology. 2014; 7(S5):41–3.