Evaluating the Learner Styles of Computer Science Students

As part of a wider scope on student learning styles to develop a eLearning UI

Donnchadh Coffey
Department of Computer Science
University College Cork
Cork, Ireland
Email: dpwc1@cs.ucc.ie

Tracey Mehigan
Department of Computer Science
University College Cork
Cork, Ireland

Sabin Tabirca
Department of Computer Science
University College Cork
Cork, Ireland

Abstract— **Learning styles refer to the theory that people differ in respect to what type of teaching or study is most effective for them. Supporters of learning-style assessment argue that the best training requires identifying peoples' learning style and modifying teaching accurately. This study was conducted to investigate differences in learning styles in a close net group of Computer Science students. The study is based on the learning style work by Richard M. Felder and Barbara A. Soloman. A survey that included the Learning Style Index, 44 Educational Analytical questions was administered to forty-three subjects from various computer science orientated groups. The study related to types of learners in a group under four distinct learning styles, including the active and reflective, visual and verbal learners etc. An important consideration in the design of educational programs is the learning style of students in the field of management education. The study was conducted under a broad in-house project involving an interactive educational application, with emphasis on interface development and the reliance on learning preference. The results of the study show comparisons and slight contrasts in the findings in gender participants and types of learner.**

Keywords- Learning styles, eLearning, online, education, resource.

I. INTRODUCTION

There has been a recent emphasis across educational institutions to harness the potential of technology for the delivery of core programs to a wider student population. This can be achieved through content delivery through educational websites and eLearning tools. In order to create a successful eLearning platform program, educators need to assess their traditional courses to consider their approach when transfer them into eLearning systems. Assessing the learning styles of the students taking part is one of the steps necessary to facilitate the needs of a wider and more diverse student population. With the diversity of learning style tools in use, it is imperative to choose one according to the inimitable necessities of the eLearning environment. The most relevant factors to consider when picking a learning style tool are defining the proposed use of the data to be composed, connecting the tool to the designed usage, and then finally, choosing the best applicable resource. A questionnaire has the potential to harness this information, accumulate the data with ease and present this information in understandable formats. Questionnaires are research orientated resources that consist of a series of questions and reminders for the purpose of collecting data from those taking part. They are aimed for statistical analysis of the answers but harbor greater advantages in quick and easy data recall. An online questionnaire provides an easier way of quick recall time and mass recipients having access for completion. Cross-sectional approaches to survey development entail a rapid response to data collection and survey participants. Online questionnaires or surveys offer greater scope to tailor the results for personal documentation, being one of the factors involved in the creation of the survey and subsequent database for this current study.

The FSLSM (Felder & Silverman, 1988) is a widely employed model for inferring learner characteristics in students. The model has been widely used in the field of eLearning and is particularly associated with adaptive learning systems. A clear example of this model is represented by Graf and Kinshuk (2006) in their adaptive Learner Management System.

The model was formulated by Felder and Silverman to provide instructors with the best basis for the delivery of educational content within the field of engineering. When developing the model, Felder and Silverman's aim was to capture the most important learning-style differences among students to enable the delivery of content in a manner that suits all students. Felder and Silverman's work was based on the belief that the matching of a student's learning-style with the teaching-style of the instructor would lead to better learning-outcomes and motivation for students. Where a mismatch occurs, Felder & Spurlin (2005) suggest that students are likely to lose interest, leading to an inferior educational outcome.

II. DISCUSSION

The FSLSM distinguishes between learning-styles based on four dimensions. The 1988 version of the FSLSM indicated thirty two learning-styles, however, they later (2002) dropped the Inductive / Deductive dimension. Consequently the model now allows for sixteen learning-styles. "Learners are characterised by values on the four dimensions. These dimensions are based on major dimensions in the field of

learning-styles and can be viewed independently from each other" (Graf et al. 2007). The measurement instrument associated FSILS, develops the preference profile of a student on four of the learning-style dimensions. The four dimensions, which focus on how students process, perceive, understand and stress information are, Active/Reflective, Sensitive/Intuitive, Visual/Verbal, and Sequential/Global. Students are measured as high or moderate preference on either side of each dimension scale or can reflect a balance within a single dimension. Where a student is balanced on a dimension scale they are considered to have no preference for either side of that dimension scale.

To enable teachers to reach all students in a single session, Felder & Silverman also propose a teaching model for use in parallel with the learning-style model. The model aims to classify instructional methods according to their corresponding learning-style.

As indicated, the FSLSM is concerned with the measurement of how students process, perceive, understand and stress information. These Active/Reflective, Sensitive/Intuitive, Visual/Verbal, and Sequential/Global dimensions make up the overall model. The dimensions are explained below.

The Active / Reflective Dimension of the FSLSM is associated with information processing. Active learners are experimentalist; they feel more comfortable with active experimentation. They retain and understand information predominantly when doing something active with it. This is apparent when doing something in the external world with the information given. They like to discuss or apply information to a task and explain information to others. Reflective learners generally prefer theory, and prefer reflective observation; these learners prefer to think about information before applying it to the external world (Felder & Silverman 1988).

The Sensitive / Intuitive Dimension is representative of how students perceive information. Sensitive learners like learning facts and data and they also like experimentation. They like problem solvers and like to employ standard methods. These learners are careful and do not tend to do well in timed situations. Intuitive learners prefer principles and theories and like discovering possibilities and relationships that may exist between information. These learners are favourable to repetition and can become bored by detail and challenged by complications. (Felder & Silverman 1988).

The Visual / Verbal Dimension the student's preference in relation to how they receive information. Visual learners remember best what they see. Therefore they tend to learn best through images and diagrams. Pictures, diagrams and flowcharts, timelines, films and demonstrations are most suitable for this category of learner. Verbal learners learn best through text and auditory explanations. They also benefit from discussion and favour verbal explanations (Felder & Silverman 1988).

The Sequential/Global Dimension differs from the other three model dimensions in that it focuses on how learners progress toward an overall under-standing of a topic or subject area. Sequential learners usually follow a line of reasoning. They achieve a more effective learning-outcome where learning topics are presented in small incremental steps of complexity. Global learners are usually unable to explain how they arrive at solutions, achieving a learning-outcome in large leaps and bounds, absorbing the learning materials almost randomly without seeing the connections and then suddenly seeing the whole picture (Felder & Silverman 1988).

a) The Felder-Soloman ILS Questionnaire (FSILS)

The FSILS is the main measurement instrument associated with the FSLSM. The FSILS is a non-commercial instrument initially published in 1991. The index was updated in 1994 after further analysis based on responses. An online version became available for use as a non-commercial use in 1997 (Felder & Spurlin 2005).

The FSILS comprises a total of 44 questions which are used to rate a student on each of the four dimensions of the FSLSM. A total of 11 questions are posed for each dimension. Each question offers two potential answers to the user. For example, each question is answered either with a value +1 (where answer 'A' is selected by the user) or -1 (where answer 'B' is selected). These values are totaled in respect of the dimension score. Preferences are expressed for students as between values +11 and -11 to indicate the total score achieved on either side of the dimension scale.

- A score of 1 or 3 represents a balance on that dimension.
- A score of 5 or 7 indicates a moderate leaning toward the relevant side of the dimension.
- A score of 9 or 11 is indicative of a high leaning toward the relevant side of the dimension.

The FSILS is currently the only validated instrument for the FSLSM (Graf and Kinshuk 2006). The validity and reliability of the FSILS has been tested by Felder and Spurlin (2005), Seery et al (2002), Livesay et al (2003) and Zywno (2003). Four different measures including test-retest, internal consistency, inter- scale reliability and construct validity were examined across a number of studies, and the results demonstrated the validity and reliability of the model.

To further tie in the FSILS a study was conducted to further understand the benefits of the data retrieved and usefulness of the resource. Ethical principles and considerations were taken into account seeking the approval of the research Ethics Committee. The study was approved and guidelines were met. All questions were coded to ensure that anonymity would be maintained and secured. Students and lecturers names will not be recorded on the questionnaires. All participants would maintain the right to withdraw from the

study at any time without penalty. Anonymity and confidentiality would be protected at all times.

In the creation of the survey resource, database fields, internal site maps, aesthetic and questions were planned before development. The survey was built on the foundations of the Felder-Soloman learning style index, this index is a tool used to assess four extent preferences mapped to a learning style model. The model was developed by Richard M. Felder and Barbara A. Soloman as a means of determining individuals learning style profile. To begin with, an initial database was created to house the participating student's registry information including username, nationality and college course. Other database entries included survey score entries and survey completion time; these entries were filled through the process of survey completion.

The online resource was created using a content management system format fitting the questions into a PHP created template where content was imported when called. The data was sent and received through the use of forms within the sites regarding logins for previous users, registry, or the learning style questions. The site establishes a connection to the related database, the student completes the given form, this is sent to the database which inserts the data into the corresponding field with the correlating "name" reference. The site connects to the database using MySQL, which ties in well if predominately using PHP.

After online registering, the student takes part in a forty four question survey and submits their answers. Once on the main survey area a session is commenced and the student's details have been called in from the database which is visible from a welcome message. On completion, the site presents the students with four scales measured from minus eleven to eleven associated with the learning style index's four aspects of style profiling. The method involved in calculating the scores of the survey uses the options pushed from the form entailing all survey questions. The process of pushing these answers involves the calling of the named attributes (in this case the questions) from the survey's form using the form control "post". Variables are created for each section (one to four) and their values are set to zero. Each survey question denotes the learning style index category it belongs to whether it is Active or Reflective (in terms of section one), verbal or visual (section three). The values associated with each sections variables increment or decrement according to the option selected by the student.

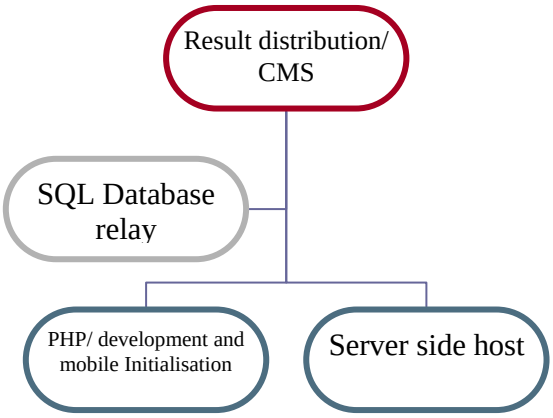

Figure 1.

Survey Development

Each sections value would then be redirected to the databases corresponding score field. Using MySQL the database is updated where the student's username matches that of their previous registry entry, so the scores are set alongside the students initial details.

III. Sample Population

For the learning style trial survey, two groups were taken from the department of Computer Science in University College Cork. The first group was comprised of undergraduate students from first year to second year Computer Science, the second group comprised of postgraduate students undertaking Masters in Computer Science and other subsidiary masters under the banner of computer science education. The population size in both groups reached beyond 150 which were all contacted after subsequent ethics committee sign offs and regulatory survey examinations. Out of each group a sample size of forty three (n = 43) was accumulated from the undergraduate group and a sample size of forty seven (n = 47) was acquired from the postgraduate group. The groups were asked via email to conduct the tests in their own time as the database accumulated the rising intake of participants. In some cases small groups from each sample group were asked to participate in the survey after a lecture and monitored during the process.

IV. Results

The study was conducted using students from University College Cork, contacting two hundred students with roughly a 50 percent response rate from the undergraduate (n = 43) and postgraduate (n = 47) computer science students. The results were analyzed using descriptive statistics; with a good response from participants the findings were clear and diverse within a specialized group. Each learning style attributes result were categorized under three separate groups in order of attribute leniency on a scale of fair to strong. Applicants who's score was highly positive or negative had a strong tendency toward that particular attribute (for example, Active is on the negative scale and Reflective on the positive) and as the score neared the

0 mark the applicants score was not as definitive. Overall after the collection of data, the undergraduate student results seemed to veer towards the highly fair outcome. The results showed inconsistent data which didn't enable a definitive allocation of learning style type due to the high number of participants deviating towards the fair and moderate distributions. The results from the postgraduate participants leaned more towards a more specialized approach with a visible decrease in volume of "fair" intake.

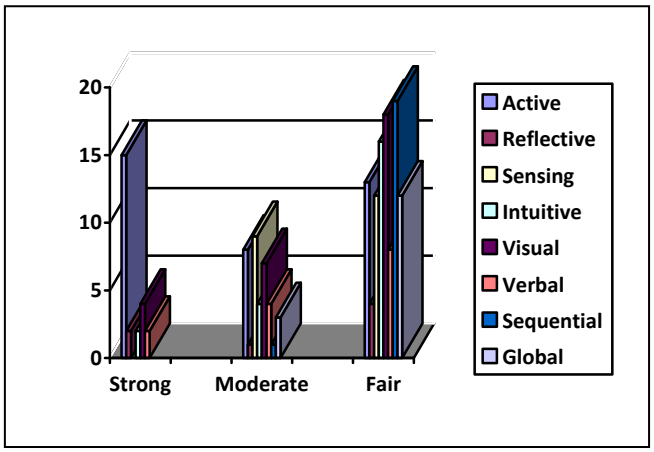

Figure 2.
Results for undergraduates learner types

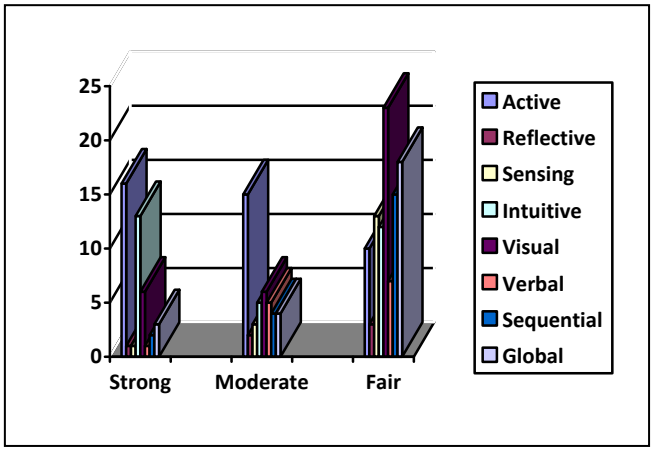

Figure 3.
Results for postgraduates learner types

Undergraduate result analysis

After collecting the data, results show out of a sample size of n=43 participants 37 Active learners. Reflective learners consist of 6. In terms of sensing and Intuitive learners the results were nearly matched at 21 sensing and 22 Intuitive. In regards to the Visual/Verbal dimension 12 were indicated as verbal, while 31 represented as visual. Sequential 23, Global 20. The majority of the participants have been established as Active, Intuitive, Visual and Sequential

In data retrieval and calibration the scores or results were sectioned into four unique groups' score1, score2, score3, score4 corresponding to the individual learning style outcomes. All the learning styles held the same pattern of recognition on a scale of minus eleven to eleven, negative values were connected to the first mentioned learning style attribute and the positive values were connected to the second mentioned attribute. For example for Active and Reflective learners the participants that achieved a score below zero will be under the banner of an Active learner vice versa if the participants were to achieve a positive score above zero they would garner a Reflective learner attribute. As previously mentioned a scale from fair to strong was also applied to the data to rectify the severity of each type. As seen in the results below the average score1 (μ= -3.85) suggests the great number of Active learners in the group having students' even achieving the minimum negative value but at a fair grade. The distribution of values is vast in the case students of Active or Reflective intake having a range of eighteen values of separation. The average for score2 (μ= -.51) is relatively close to zero making known that students who took part were not necessarily unaccustomed to Sensing in teaching practice and were not totally against most of its practice in favour of intuitive learning. The average in score3 (μ= -1.30) deviates more to the negative spectrum, having a very low min and relatively high max similar to score1. This ultimately causes the average to deviate as the students tended to point towards more visual based learning. Lastly score4 holds the only average (μ= -.26) out of the set that is a positive value making the majority of the students sequential learners.

In order to find and prove normality in each learning type, tests for normality alongside graphical representation were used. For all of the learning types their histograms had a bell-shaped curve which signifies normality, there was no deviation from the expected normal in the normality plots of each expect for a slight deviation in the sequential and global plot. The Kolmogorov-Smirnov normality test was used on each learning type to determine whether or not the data was normally distributed, if $P < 0.05$ this proves that the set is normally distributed. Active and Reflective ($P = 0.03$), Sensing and Intuitive ($P = 0.028$), Visual and Verbal ($P = 0.003$), Sequential and Global ($P = 0.001$). From the previous results both Active/Reflective and Sensing/Intuitive results are normally distributed. The Visual/Verbal and Sequential/Global results bare an inconsistent distribution and do not match the bell-shaped curves presented by both histograms and plots for each.

	N	Min	Max	Mean
score1 (Act/Ref)	43	-11	7	-3.85 **Fair** Active
score2 (Int/Sen)	43	-6	8	-.51 **Fair** Int
score3 (Vis/Ver)	43	-9	7	-1.30 **Fair** Visual
score4 (Seq/Glob)	43	-5	6	.26 **Fair** Seq

Figure 4.

Average of the undergraduate results

Postgraduate result analysis

From the data, results showed out of a sample size of n=47 participants 41 Active learners. Reflective learners consist of 6. In terms of sensing and Intuitive learners the results were nearly matched at 17 sensing and 30 Intuitive. In regards to the Visual/Verbal dimension 13 were indicated as verbal, while 35 represented as visual. Sequential 21, Global 26. The majority of the participants have been established as Active, Intuitive, Visual and Global. Already there was a significant departure from the previous undergraduate results having the majority of participants garnering a moderate to strong tendency toward a learning type with the exception of the Sequential and Global attributes.

Like in the previous undergraduate score tally, the scores or results were sectioned into four groups' score1, score2, score3, score4 which corresponded to the individual learning style outcomes. As seen in the results table the average score1 (μ= -5) suggests the great number of Active learners in the group having a students' even achieving a moderate negative value. The average for score2 (μ= -5) which is a great jump from the previous table that veered close to the 0 mark. The majority of students were labelled intuitive learners on a moderate scale. The average in score3 (μ= -6.5) is the most definitive attribute concluding a very visual group with a strong tendency on the scale. Score 4 holds the only average (μ= 5) out of the set that is a positive value making the majority of the students global learners. Like the other attributes the Sequential/Global types are mode

In order to find and prove normality in each learning type, tests for normality alongside graphical representation were used. Like the preceding example all of the learning types their histograms had a bell-shaped curve which signifies normality, there was no deviation from the expected normal in the normality plots of each. The Kolmogorov-Smirnov normality test was used on each learning type to control whether or not the data was normally distributed, if P < 0.05 this ascertains that the set is normally distributed. Active and Reflective (P = 0.02), Sensing and Intuitive (P = 0.04), Visual and Verbal (P = 0.183), Sequential and Global (P = 0.190). The results show all P values are greater than 0.05 and therefore are normally distributed. All results seem to swing towards a normally distributed dataset. Both the graphical representations including both histograms, plots and the KS normality tests prove normality within the set given which differs greatly from the last dataset for the undergraduate students.

	N	Min	Max	Mean
score1 (Act/Ref)	47	-11	5	-4.95 **Mod-**Active
score2 (sen/Int)	47	-7	8	-.4.61 **Mod-**Intuit
score3 (Vis/Ver)	47	-11	9	-6.48 **Strong-** Vis
score4 (Seq/Glob)	47	-7	7	4.85 **Mod-**Global

a

Figure 5.

Average of the postgraduate results

V. CONCLUSION

In the analysis of the learning styles model, the learning style information made an effort to develop the variety of learning style capabilities of the students by using a variability of learning activities and supporting the students as they attempted to become more proficient.

The use of learning style mechanisms should allow the students to deliberate more carefully the factors and activities that are favorable to more active and profounder learning.

Felder and Silverman (1988) propose a complementary teaching model to support their learning style model. Felder and Silverman indicate that the teaching model can be defined by the answers to specific questions, for example;

- What type of information does the instructor emphasize: concrete – factual, or abstract – conceptual or theoretical?
- What mode of presentation is stressed: visual – pictures, diagrams, films, demonstrations, or verbal – lectures, readings, and discussions?

What Type of perspective does the instructor provide on the information presented: sequential – step-by-step progression (the trees), or, global – context and relevance (the forest)?

These questions reflect the dimensions of the Learner Style model. In the preparation of learning objects for inclusion

within an eLearning environment, these questions should be answered in consideration of the results of the conducted study. The study indicated that the majority of the participants had been established as Active, Intuitive, Visual and Sequential, thus these dimensions should be the main focus when answering the teaching model questions. The content of the proposed eLearning system should target these specific groups. Students vary from each other; diversity is a key factor in a students' educational motive. Students can differ in the way they respond to learning and the way they approach work and perform. As the learning style index helps to establish a grounded style of learning for an individual student, content/material can be altered to fit their educational needs.

In comparison the results for each group differed greatly showing a more unified and uniformed approach from the postgraduate group in juxtaposition to the erratic non definitive results in the undergraduate group. This proves that the undergraduate group contains a mix of learners whose learning styles all differ greatly and haven't mixed as a unit or connected greatly as a group yet. The majority of the postgraduate group would have been subjected to four years or more of third level education before undergoing a postgraduate computer science degree and would be more aware what type of learning style they would lean towards. Furthermore the subject matter would be relatively new to undergraduate whereas postgraduates as a group would understand how to tackle the information and delegate a learning style to produce the required outcome. It is clear from the results that the postgraduate students have a more definitive idea of their learning style and undergraduate students need time in their learning environment to further establish their learning style.

The outcome of the survey and results were measured to be used for the optimisation and development of a students' application User Interface. A wider scaled project is linked to these UI development procedures and inherits the traits at which the final UI and teaching apparatus is presented to staff and students. From looking at the results the teaching method best suited to the application would be an active hands-on approach with haptic intuitive structures, lots of visual cues and sequenced assessment. Teaching lends itself to an array of inventive ways of instruction and training. UI's can be tailored to teaching methods and vice versa, the goal is to create and adapt with students and invent new constructive ways of informative learning.

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