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Meta-Cognitive Tool Development for History Teaching: Investigating how Software Usability Affects Student Achievements

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Abstract: This paper presents a Meta-Cognitive Tool (MCT) development for history teaching. It was developed to support teaching history of civilization courses at the engineering faculty. It covers hierarchically arranged concept maps which are presented dynamically by using Extensible Markup Language (XML) files. MCTs are integrated in e-learning portals to support self-learning. MCTs were investigated in terms of the Human Computer Interaction (HCI) discipline to evaluate their usability in online courses. For this purpose, relationships between learners' cognitive abilities, individual differences, and usability of e-learning portal were considered in order to create a model between individual differences and software usability. The usability of MCT was evaluated by 116 (70 male, 46 female) subjects who were registered for the HUM1005 History of Civilization I, a general elective course at the faculty of engineering. They completed four different surveys: an IQ survey, a personality survey, a motivation survey, and a software usability measurement inventory (SUMI). This research compares intelligence, personal factors, and motivation factors with the personal software usability results in order to determine the correlations and associations between the usability of the software and learners' individual differences. In the study, results show that the usability of any education tool has effect on achievement of the learner. Noteworthy, a correlation was found between Grade Point Average (GPA) and usability scores.

Keywords: Computer systems organization**,** information systems, software
Categories: C.0, H.2, D.1.7

1 Introduction

University students have difficulties creating relations between ideas and knowledge and then integrating the information with their prior information [Novak and Gowin 1984]. History teaching to engineering students involves some of these difficulties. To solve these problems in history education, concept maps help learning by serving as a kind of template to organize and structure knowledge ([Novak and Cañas, 2007]; [Turan, 2010]). A concept map is a diagram that shows the relationships among different related concepts. A well designed concept map shows the structure of the content in detail by using visual objects. So, it fosters the learning of complex information more easily than complex and heavy information loaded presentations using words and verbal contexts. Concept maps are useful and vital in project-based educational activities [Novak and Iuli, 1991]. [Plotnick, 1997] suggests that concept maps are helpful in fields that require creativity, complex structure design, learning assessment, brainstorming, and the communication of complex ideas which are important issues in the project [Plotnick, 1997]. The use of concept map approach can also help learners to understand the thought processes of subject matter experts (SME) who design the concept maps. There is also the possibility of employing concept maps as advance organizers [Novak and Gowin 1984]. An advance organizer is a global view of the material that is to be learned ([Ausubel, 1968]; [Ausubel, 1978]). Concept maps can be used to create a course description in the spirit of an advance organizer. This approach is essentially different from the traditional linear sequencing of topics [Coffey, 2007]. A well-designed concept map can also help to improve and systemize the learning processes and can help to overcome difficulties in unfamiliar knowledge domains. Presenting these concepts in a single view may not be a good solution [Novak and Cañas, 2007]. Concept maps organize the concepts so that they are accessible to learners who have different learning styles. A learning style is a technique for acquiring knowledge that is the most suitable way to learn for the individual concerned. However, there is not a single perfect theory that is accepted by researchers with regard to learning styles. Implementing a learning style model can be useful in teaching and learning if it matches the learning modes of the students [Brumby, 1982]. Felder and Silverman explained that there are mismatches between the learning styles of engineering students and the traditional teaching styles of engineering professors [Felder, 1988]. For instance, engineering students are generally required to use their learning skills to create a thought process and to communicate ideas using learning media which are not appropriate for them [Felder, 1988]. In these situations, students get bored and become inattentive in class. They may obtain lower scores in exams and become discouraged with regard to the course. The types of different learning styles are as follows; *sensing and intuitive, visual and auditory, inductive and deductive, active and reflective,* and *sequential and global*. Recently researchers discarded the deductive dimension and changed the visual/auditory category to *visual/verbal*. [Felder, 1988; 1989; 1994] states that active learners retain and understand information best by doing something active with it – discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly to begin with; sensing learners like learning facts; intuitive learners often prefer discovering possibilities and relationships; visual learners remember what they see—pictures, diagrams, flow charts, time lines, films, and demonstrations; sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly “getting it”.

MCT design and development strategies are based on the use of concept maps and taking into consideration learners’ learning styles. MCT was designed to help verbal and sequential learners in the engineering faculty. Meta-cognitive maps include a hierarchical concept sequence, rather than historical chronology. Concept sequences are related in terms of reasons and the results of specific conceptual keywords. As we know, the cognitive capacities of learners vary. Thus, meta-cognitive maps help learners to increase their cognitive capacity and their learning successes. As shown in [Fig. 1], instructors can create meta-cognitive maps and students can follow them to enhance their learning. With this tool, global learners who have non-linear logical thinking patterns can learn concepts by studying non-linear maps and thinking about the relationships between the concepts within the cognitive maps. The MCT help students to obtain a better understanding of the concepts visually, and attracts students to the history courses.

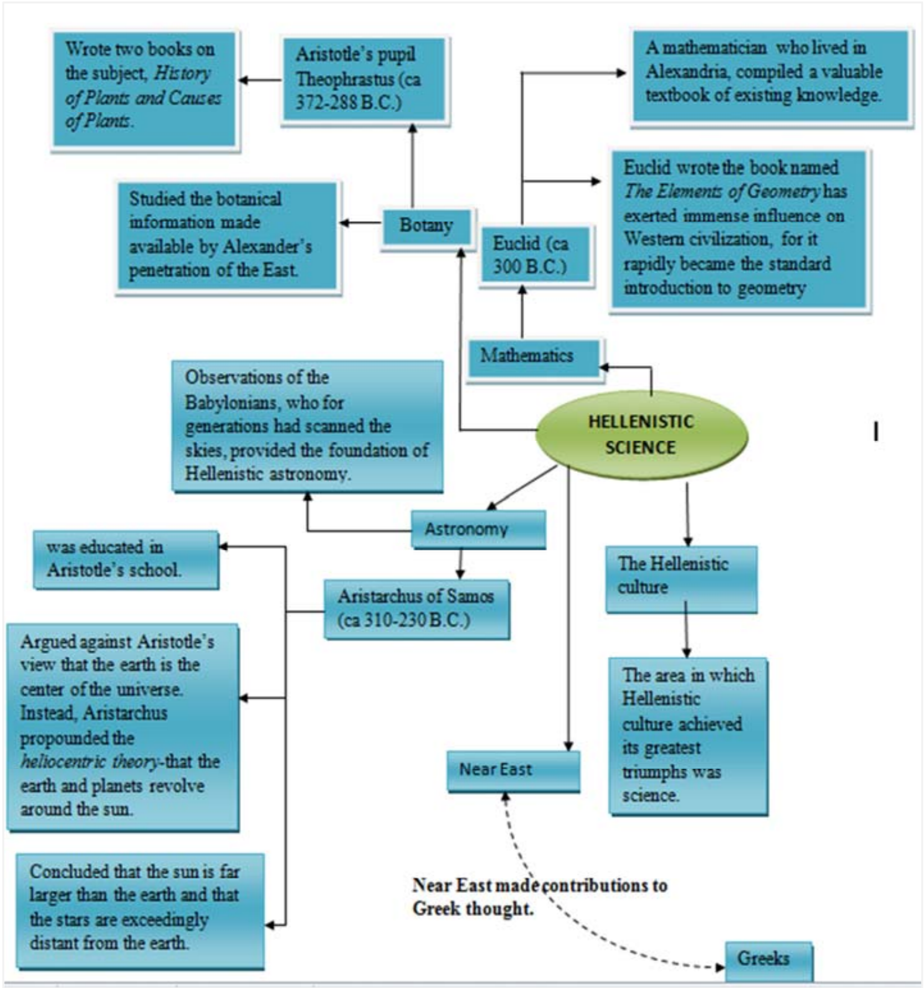

Figure 1: Concept map for Hellenistic Science

The main objective of this study was to investigate the usability of MCTs from the learners' perspective. The MCT creates interaction with learners and allows them to choose different interfaces according to the learners' preferred learning style. In particular, MCT was developed as part of the History of Civilization course delivered during the fall semester of 2009 in the faculty of engineering at the University of Bahcesehir. The following aspects were considered: a) evaluating the usability problems associated with the developed prototypes [Fig. 2], b) evaluation of learning using the MCT [Karahoca et al. 2010]. Following sections include specification and usability analysis of the meta-cognitive tool; results and conclusions of the study.

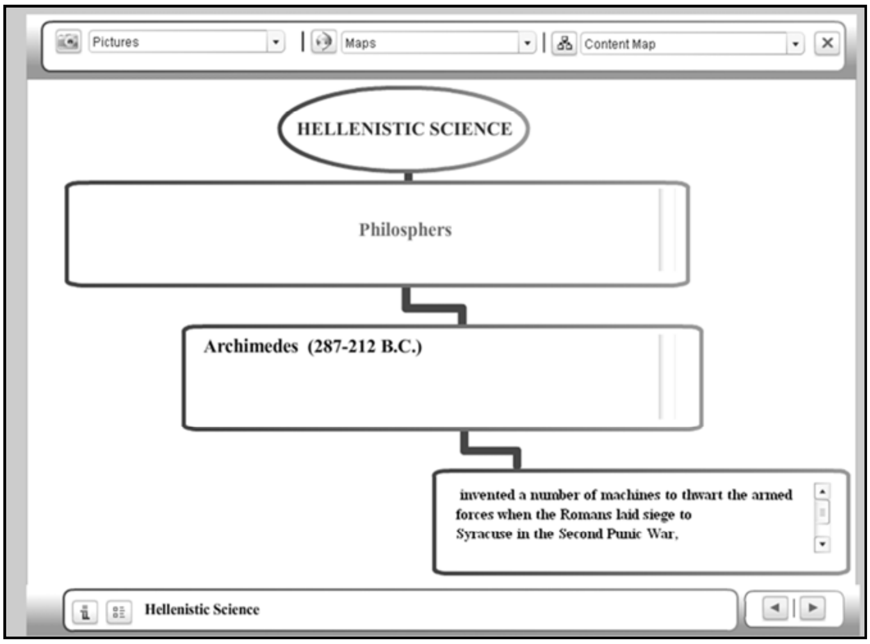

Figure 2: Main interface of the second prototype

2 The Specification of the Meta-Cognitive Tool

In this section, technical specification of the meta-cognitive tool is given. The learning tool has been developed to allow the contents to fit exactly within concept maps so that the learners have the chance to examine the lessons for the course in an organized way as was indicated in the concept maps. When developing such a tool we had to take some educational requirements into consideration.

1. The tool should provide lessons and related materials in a way that matches with the concept maps.
2. The tool should present the contents in both sequential and global layouts.
3. The tool should present the contents both verbally and visually.
4. The tool should incorporate navigational tools that are easy to learn and to use.

The tool was designed to meet the requirements stated above. When developing this kind of learning tool, it was essential for students to be able to access it both in class lectures and as online lectures for future use [Fig. 3].

Figure 3: Use case diagram of system integration

The portability of the learning tool was also an important issue. Because of all these requirements, the Adobe Flash developing environment was selected. A Flash based tool was easy to develop because Flash was designed to be used in an internet environment. In addition, the possibility of converting Flash applications in an (.EXE) format for PC usage and an (.HQX) format for Macintosh use made it a good candidate for using in class lectures without the need of having to connect to the internet. Flash also has the capability to support XML files internally. While developing the learning tool, there was a crucial requirement to provide lessons and related materials in a way that matched with the concept maps. To meet this requirement, the presentation contents were created to exactly match the concept maps while using XML, which included the data of the visual representation of the concept maps that were exported outside of the program. The learning tool just loads XML automatically, and it is programmed to analyze loaded data to present related materials in visual and verbal forms that were indicated by the SMEs within the concept maps. The following section focuses on the usability of the MCT.

3 Usability Analysis of the Meta-Cognitive Tool

Software quality metrics can be used to investigate any software tool's effectiveness and efficiency. The measurement of software usability in terms of quantifiable means is realized through the use of extension metric concepts. Also, the analysis shows that it is not enough to implement software design steps successfully. In software development life cycle, the learners' psychometric test results should be taken into account to develop usable interfaces. Recently, software quality concepts have tended to specialize and focus on a web site's usability issues. Within this context, the most heavily demanded software quality factors are functionality, reliability, usability, efficiency, maintainability, and portability as considered in ISO/IEC 9126 [ISO 1998]. However, the most critical stage in the software development life cycle is the requirements analysis phase, due to the customer's needs and expectations [Marisco and Levialdi, 2004]. At this stage, inputs are obtained from the requirement analysis work. The user interface design gives shape to the usability of the software. Therefore, the early design stages in the rapid application of development projects contain some usability handicaps (Folmer and Bosch, 2004]).

The rapidly growing internet contains a plethora of information in websites. However, problematic usability issues prevent this information from being effectively used. Nielsen defines usability in terms of five quality indicators - learnability, efficiency, memorability, errors, and satisfaction ([Nielsen, 2002]; [Nielsen, 2003]). In addition to this, Jones defines usability as the total effort required to learn, operate, and use software or hardware [Jones, 1997].Users' cognitive abilities and personal traits based on behavioural aspects affect software usage performance. User satisfaction is the key parameter in software and website usage. Different academic studies have been implemented to sort out the different works that are related to usability and user satisfaction ([Johnson et al. 2004]; [Lavie and Tractinsky, 2004]).

HCI (human computer interaction) is an interdisciplinary field of science that focuses on the interaction of people and systems, and the ways they influence each other. We can use HCI methods to determine ways to design a system in tune with the needs of the learners, including their abilities, limitations, and work environment. Within the HCI approach, we employed the Cognitive Walkthrough methodology to observe the learner's reactions to the software using a detailed task list scenario [Chan, 2002].

Software usability evaluations can be made via Kirakowski's SUMI survey [Kirakowski and Corbett, 1993]. As mentioned in [Dix et al. 2004], Whiteside and colleagues have proposed 21 usability metrics which are related to ISO 9241[ISO, 1997]. In this study, these usability metrics were observed for cross-checked with the SUMI results.

One of the important software quality factors is usability which might relate to cognitive abilities and individual factors. For the evaluation of these metrics, both IQ [Serebriakoff 1996a] and personality tests [Serebriakoff, 1996b] were applied to the subjects ([Serebriakoff, 1994a]; [Serebriakoff, 1996b]). The motivation of the learners was also surveyed. In this section, research aim, method, participants and the conducted questionnaires are described.

3.1 The Aim

The aim of the survey was to determine correlations between values obtained from behavioural and IQ tests and results obtained from software usability tests. The following relationships were tested and analyzed:

1. Individual differences –academic success,
2. Academic performance, IQ – usability,
3. Individual differences – usability,

4. Gender, individual differences – usability,
5. Individual differences, academic performance, and five factors in SUMI (efficiency, affect, helpfulness, control, and learnability).

3.2 Method

Cognitive walkthrough (CW) was used to observe the learner's reactions to the MCT using a detailed task scenario within the HCI approach. Cognitive Walkthrough methodology can be performed at all stages of the design including using the prototype, the conceptual design document, and the final product. This is a more specific version of a design walkthrough that focuses on cognitive principles ([Blackmon et al. 2002]; [Dix et al. 2004]).

Based on the learner's goals, a group of evaluators move through the tasks evaluating each step to find how difficult it is for the learner to identify and operate the interface elements. This way, it is more appropriate to understand their current sub-goals and how clearly the system provides feedback with regard to that action. Cognitive walkthroughs take into consideration the learner's thinking processes that contribute to his/her decision making, such as memory load and ability to reason [Wharton et al. 1992].

The cognitive walkthrough is a technique for evaluating the design of a learner interface, with special attention paid to how well the interface supports "exploratory learning" for first-time use without formal training. The system's designers can perform the evaluation in the early stages of the design prior to any possible empirical learner testing. Early versions of the walkthrough methods relied on a detailed series of questions, to be answered on paper or in electronic form. The strengths and limitations of the walkthrough methods are considered, and it is placed into the context of a more complete design approach [Chan, 2002].

Cognitive Walkthrough for the Web (CWW) is a specialized version of the CW, and has three properties: 1. CWW uses detailed scenarios for the learners; 2. Clicking on a link, button or some other method; 3. CWW evaluation is adapted for websites [Blackmon et al. 2002]. CW can be used particularly in early design steps in the software development life cycle. However, CWW has the advantage of being able to use it in each cycle of a rapid development methodology. This approach is specifically intended to help estimate the usability of a website for first time or infrequent learners, for those who are in an exploratory learning mode.

3.3 Participants

This study was performed with 116 students (70 male and 46 female), aged between 20 and 22 years (M=21.01, SD=0.89) who were registered for the HUM1005 History of Civilization I course. SUMI, IQ and personality tests were applied to all students. There were 488 items in total with regard to all inventories in IQ tests, personality-factor tests, and software-usability questionnaires. Motivating potential scores (MPS) surveys were also completed by the students. MPS was developed by Hackman and Oldham in order to determine the job characteristics model [Hackman & Oldham 1980].

3.4 Questionnaires

There are several different software usability questionnaires which can be used to determine learner satisfaction with regard to software, such as SUMI (software usability measuring inventory) developed by [Kirakowski and Corbett, 1993], MUMMS (measuring the usability of multi-media), and WAMMI (website analysis and measurement inventory) prepared by [Levi and Conrad, 2001] for the evaluation of web-based software solutions. SUMI was selected to evaluate the usability of MCT because it incorporates three-answer Likert type scales and good grouping features for the ISO 9241 usability metrics. The software usability questionnaire includes 50 statements which are evaluated using a 3-point Likert scale (agree, undecided, disagree) and are easy for generating a response in five minutes. The personality factor survey is divided into four different stages: Personality Factor 1 helped us to determine the extraverted as opposed to the introverted personality type. Personality Factor 2 was used to measure neuroticism as opposed to stability. Personality Factor 3 determined the creativity levels of the students. This section of the survey included uncompleted geometrical shapes for completion. Personality Factor 4 tried to reveal the carefulness of the sample group [Serebriakoff, 1996b]. IQ inventory is divided into three sub-sections: numerical, verbal, and geometrical. There are fifty questions in each of the three sections of the IQ inventory [Serebriakoff, 1996a].

The research involves two observations which were conducted in parallel; one focusing on the learner and the other on the usability of the software. The aim of the observations of the learners was to investigate the cognitive abilities and the individual differences of the subjects, and chart the learner profiles in terms of the software usability. Certain correlations among these data sets were investigated to identify the unified means of metrics for HCI studies. The early design stage involved evaluation of the cognitive abilities of the students and evaluation of the usability of the software prototype. A relationship between cognitive abilities and software usability indicators was investigated. Usability conditions were handled in the analysis and design steps through the development phase of the software development life cycle. According to [Calcaterra et al. 2005], hypermedia navigation behaviour is related to computer skills rather than to cognitive styles. Alternatively, we assumed that cognitive abilities were directly related to the success ratio of software usage. We tried to prove that not only the cognitive abilities of the learners' but also their individual differences were key points with regard to the software usability.

4 Results and Discussion

Survey results can be categorized into two different groups: a) IQ, motivation, and personality surveys; b) software usability surveys: b1) The ISO 9241 and b2) SUMI. IQ survey factors including verbal, numerical, and geometrical tests were used to evaluate the students, and a personal factors survey was used to determine the individual differences between students.

4.1 ISO 9241 Usability Metrics

CWW was performed and twenty-one criteria were established to measure the usability attributes and the possible ways to set the worst/best case and planned/now-level targets. These measurements are referred to as usability metrics. The following list shows the results acquired for each metric by observing the students:

1- Time of task completion: The procedure was tested among 116 students. Average completion time for the procedure was 3 minutes. The minimum completion time was one minute and 20 seconds, and the maximum completion time was 6 minutes and 33 seconds.

2- Percent of task completed: All students completed the test procedure, with the exception of three students, who could not connect to the website due to network problems. Procedure applicability is measured as 97.41%.

3- Percent of task completed per unit time**:** The job completion time was 3 minutes on the average. If a minute is taken as the unit time, the job completion amount per unit of time ratio is nearly one-third.

4- Ratio of successes and failures**:** All students completed the procedure successfully except for three students who were unsuccessful due to network or hardware problems.

5- Time spent on errors: The average time spent on error was one minute and 30 seconds.

6- Percent or number of errors: Students completed the procedure without encountering any errors.

7- Percent or number of competitors who completed the procedure best of all: 42 students out of 116 students completed the procedure without making any mistakes. The ratio for perfect procedure completion was 36.21%. According to this value, 36.21% is the percentage of students who completed the procedure without getting any error messages.

8- The number of commands used: Eight commands were used to complete the procedure.

   E-Learning portal usage scenario

   1- Access to the http://eng.elearning.bahcesehir.edu.tr,
   2- Click the link HUM1005 History of Civilization I to access portal,
   3- Use the student id and password to login to the system,
   4- Click the fourth chapter which covers Hellenistic Civilization,
   5- Follow the interactive slides,
   6- Access the cognitive maps to learn the keywords,
   7- Click the quiz engine to match the descriptors and the keywords.
   8- Log out from the e-learning system.

9- Frequency of help and documentation use: Usage frequency for help and documentation was 81%. Help and documentation that was provided on the website was satisfactory.

10- Percent of favourable/unfavourable learner comments: Fifty five percent of the students involved commented in favour of the website while the remainder commented unfavourably. Twenty three learners evaluated the website as being useless.

11- Number of repetitions of failed commands: The average number of repetitions of failed commands was three.

12- Number of executed commands in terms of successes and failures: All commands were effectively performed without the users encountering any problems.
13- Number of times the interface mislead the learner: No interface misleading was encountered by the learners during the procedure activities.
14- Number of good and bad features recalled by the learners: The number of good features was 9 while 6 bad features were recalled by the learners in the scenario.
15- Number of available commands not invoked: Twenty-four unused commands (links) were detected on the home page.
16- Number of regressive behaviours: There were 9 observed regressive behaviours.
17- Number of learners preferring the system: 80% of the students who took the tests reported that they would continue using the website after the tests.
18- Number of times or average number of learners needed to solve a problem: Few problems were encountered with regard to the process. During the test that was performed by the students, the average problem solving time was reported as between 45 seconds and 1 minute.
19- Number of times the learner was disrupted from carrying out a task: The average number of times that learners were disrupted while carrying out a task was five. These problems generally arose because of hardware performance and were solved in less than a minute.
20- Number of times the learner lost control of the system: In the website usability testing stage, no software control problems were reported.
21- Number of times the learners expressed frustration: 80% of the learners were satisfied with the website.

However, there are critical comments from the users about MCT. For example, complexity, insufficient categorization, low speed of the web server, and network problems were basic categories in terms of frustrations. The students' familiarity with computer applications has positive impact on implementing scenario successfully. The usability results are given in Table 1.

4.2 Software Usability Measurement Inventory Results

SUMI (Software Usability Measurement Inventory) was developed by the Human Factors Research Group (HFRG) at University College Cork, Ireland. SUMI is a 50-item questionnaire for assessing software-system-usability. It has five indicators (the descriptions of the subscales are based on [Kirakowski and Corbett 1993]):

1) Efficiency: the degree to which learners feel the software assists them in their work;
2) Affect: learners' general emotional response to the software;
3) Helpfulness: assistance level of the software;
4) Control: the degree to which learners feel they, and not the software, are in control;
5) Learnability: the ease with which learners feel they managed to get started using the software and to learn new features.

Each sub-group has 10 items and each item is rated on a 3-point Likert response scale using the points: "agree," "don't know", and "disagree". By comparing the items of each scale with the descriptions of the seven dialog principles in ISO 9241 Part 10, Kirakowski found that four of the five subscales seemed to correspond directly to dialog principles in ISO 9241 Part 10. The fifth subscale seems to be related to another dialog principle (Table 2).

Usability Objective	**Effectiveness Measures**	**Efficiency Measures**	**Satisfaction Measures**
Suitability for the Task	Percentage of goals achieved: 100%	Time to complete a task: 3 minutes in average	Rating scale for satisfaction: 80% in average
Appropriate for trained learners	Number of “power features” used: 5	Relative efficiency compared with an expert learner: 33%	Rating scale for satisfaction with “power features”: 80% in average
Learnability	Percentage of functions learned: 100% in average	Time to learn criterion: 1 minutes in average	Rating scale for “ease of learning”: 80% in average
Error Tolerance	Percentage of errors corrected successfully: 72%	Time spent on correcting errors: 50 seconds in average	Rating scale for error handling: 72%

Table 1: Results of the usability metrics

ISO 9241 Part 10	**SUMI**
suitability for the task	Efficiency
self-descriptiveness	Helpfulness
controllability	Control
conformity with learner expectations	Affect, efficiency
error tolerance	
suitability for individualization	
suitability for learning	Learnability

Table 2: ISO 9241 vs SUMI

The SUMI survey results show that the suitability for learning the procedure is 63%. MCT provides high controllability for users. Learners agreed that MCT assists them in the procedure, and 55% of them believed that MCT was easy enough to use and was helpful. Learners have enough emotional response to MCT with 48% as given in Table 3.

	Sucessfull(%)	**Don't know(%)**	**Unsucessfull(%)**
Affect	48	28	24
Control	51	32	17
Efficiency	50	25	25
Helpfulness	55	30	15
Learnability	63	24	13

Table 3: SUMI survey results

4.3 IQ Survey Results

Cognitive abilities were evaluated using IQ tests. In our case, 116 students filled the geometrical, numerical, and verbal sections of Serebriakoff's IQ survey [Serebriakoff 1996a]. The survey is composed of three sections - qualitative (verbal), quantitative (numerical), and geometrical (pattern). IQ scores of the group and the number of correct answers given for each section is represented in [Fig. 4-5].

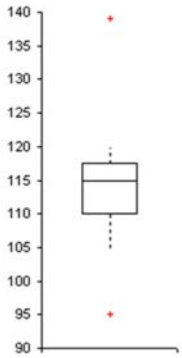

Figure 4: IQ scores for sample group

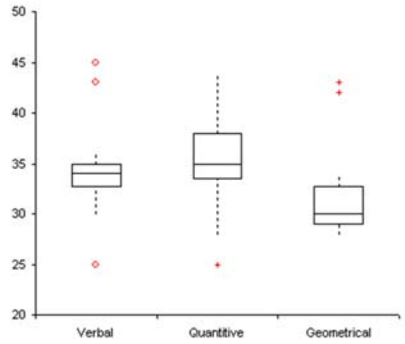

Figure 5: Right answers for verbal, quantitive and geometrical sections

The purpose of using an IQ test was to identify the possible effects of cognitive abilities on software-usability. Success in verbal abilities, along with higher creative abilities, has a significant effect in terms of the rapid cognition of the software procedures. It was also observed that students who could not manage to apply procedures or complete the tasks in an average time tended to be the ones with lower levels of verbal ability.

The IQ scores of each student who took part in the test have been calculated using Serebriakoff's formula and the average IQ level was 116.81 (SD=17.03). The students' usability assessments are investigated by means of dividing the group into two parts: students with high IQ and students with low IQ. The following results were obtained from the surveys for the quantitative, qualitative and geometrical sections. The percentages of correctly answered verbal and numerical questions were slightly greater than that for the geometrical section, but the difference is not significant.

As displayed in [Fig. 5], students had most difficulty with the geometrical section. However, differences between sections were not too great. The survey results also showed that the overall performance for the quantitative section was relatively poor. When each section of the survey was evaluated individually, it became possible to see what type of questions the wrong answers were concentrated around and what type of questions were answered correctly. On the basis of these findings we can come to a certain conclusion: for the qualitative section, the fill-in-the-gaps of a given paragraph part was answered most easily. Most of the mistakes were made in the part where the student had to find the meaning of a word for a given synonym. In the quantitative section, equation-solving questions stood out as being the most successfully answered category. Most of the wrong answers were given in the geometry section. Here, reconfiguring a shape type questions were found to be the most successfully answered, while block-stacks were the least successfully answered.

The survey results of the IQ and personality characteristics prove that behavioural and psychometric parameters of the learners have to be evaluated when the requirements analysis stage is implemented in web portal development. In this way, software usability handicaps may be considered at the software design stage.

Success in terms of verbal ability, along with higher creative ability, has a significant effect on the rapid cognition of software procedures. It was also observed that students that could not manage to apply procedures or who completed the tasks in or less than average time tended to be the ones with lower levels of verbal ability.

4.4 Personality Type Survey Results

The personality factors of the students involved in this study were evaluated under the criteria of extravertedness, stability, creativity, and neuroticism.

The extravertedness score for male students averaged 11 and was 10.7 for females. These values indicate that our students fall into the social segment between extraverted and introverted. In other words, it is seems possible that these students will become more extraverted in the future. Because of this tendency, students will exhibit stable personality characteristics, confidence in group activities, and good communication skills in parallel.

The results obtained from the personality factors test show us that, within the frequency interval of evaluation, the values for emotional stability were 18 on average. These values indicate that students turn out to be relatively confident, emotionally stable and coherent.

When creativity as a personality factor was evaluated, respondents had an average score of 14. Students received an average score of 269 in the leadership factors survey. According to these results, students have leadership and entrepreneurial characteristics. When the lower and upper limits for the evaluation are considered as 50 and 400 respectively, male students fall into the average category. Female students tend to exhibit stable and political characteristics. All students of both genders are socially sensitive, confident, determined to achieve goals (i.e. they are goal-oriented), and good team workers.

The first group in terms of the personality factor test is extraverted versus introverted personality types. There was no significant difference in extravertedness levels seen amongst male and female students ($F_{(1,114)} = 2.081$). Students were observed to exhibit common personality features, while they exhibited stable personality features due to the emotional stability in the first group tests. The majority of students were found to have coherent type personalities, while only 13% of males had sensitive personalities as shown in [Fig. 6-7].

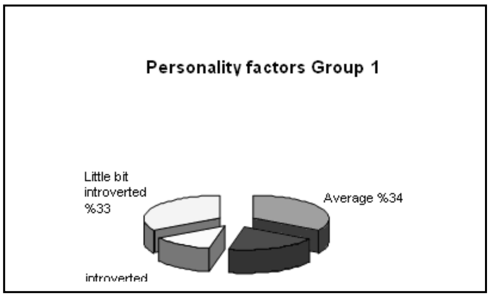

Figure 6: Extraverted versus introverted

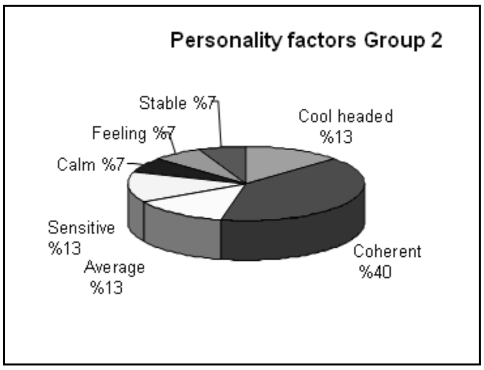

Figure 7: Coherent versus sensitive

Students were observed to be extremely creative, while a majority of them tended to exhibit stable-political (60%) personality features. The level of creativity may increase the usability of the software design. 33% of the males and 25% of the females demonstrated enterprising personality features compared as shown in [Fig. 8-9].

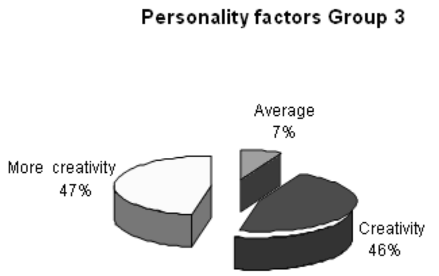

Figure 8: Creativity

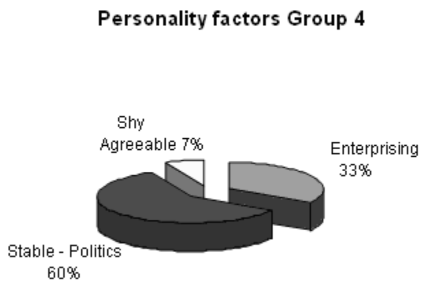

Figure 9: Stable and politics

4.5 Motivation Survey Results

A simple description of "motivation" is the capability to adjust behaviour. Motivated students are those students who are directed towards some goal. Motivation comes from personal interests, desires, and the need for fulfilment. However, external factors such as rewards, admiration, and promotion also influence motivation. As stated in Motivating Potential Scores (MPS) developed using Hackman and Oldham's job characteristics model, motivation refers to "…the forces either within or external to a person that arouse enthusiasm and persistence to pursue a certain course of action" [Daft 1997, 526]. Their model suggests that every job has five core characteristics that identify its motivating potential. These five characteristics are skill variety, task identity, task significance, autonomy, and feedback. Relying on the MPS equation, the job's motivating potential was computed. A motivating job is denoted by a high MPS score and has all five job characteristics. The highest possible score for a motivation survey is 65. Students had an average score of 34.31 (SD = 6.31). People who are committed to achieving organizational objectives generally outperform those who are not committed. Various factors, including the influence of cultural differences, affect what people value and what is needed to be done to motivate them (see [Fig. 10]).

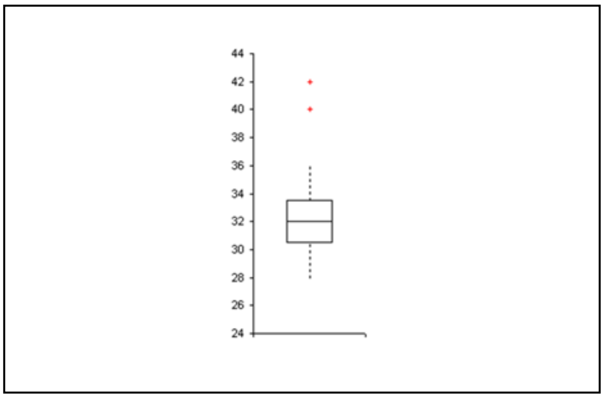

Figure 10: Motivation scores for the subjects

4.6 Relationships between Individual Differences and Academic Success

With the help of the t-test, a significant association ($F_{(1,114)}$) = 4.787, sig. level = 0.005, p<0.05) was found between IQ (M=119.43,SD=10.93) and GPA(M=2.85,SD=0.59). In addition, correlations were found between IQ and GPA (Rho= 0.488) and motivation (M=33.81, SD=6.48) and GPA (Rho = 0.458). Thus, the following relationship emerged: high motivation – high GPA, low motivation – low GPA). There were no significant correlations (Spearman's Rho) between motivation and IQ scores.

4.7 Relationships between Academic Performance, IQ and Usability Scores

GPA (M=2.85, SD=0.59) and usability (M=16.67,SD=4.70) were found to have coherent patterns of relationships ($F_{(1,114)}$=2.377, significance level = 0.032, p<0.05). The association level was higher when IQ was used as a covariate ($F_{(2,113)}$ = 3.021, significance level = 0.006). Two way ANOVA (p<0.05) results indicated that students having both higher IQ (>120) and higher GPA(>3.00) outperformed others in terms of the usability test ($F_{(1,114)}$ =4.305, sig. level = 0.07). Students classified as having higher IQ and higher GPA tended to give higher usability ratings in the SUMI assessment.

4.8 Relationships between Individual Differences and Usability

Usability scores and IQ levels have shown significance at the 0.122 level ($F_{(1,114)}$ =1.119). Motivation and usability were also found to be strongly correlated ($F_{(1,114)}$ =

7.686, significance level = 0.02). Another comparison was made between introverted (personality test scores; M=6.37, SD=2.31) and extraverted student groups. However, no significant association ($F_{(1,114)}$ = 0.394)) with that factor was observed.

			GPA	IQ	motivation	usability	personality
Spearman's rho	GPA	Correlation Coefficient	1.000	.488(*)	.458(*)	.570(**)	-.254
		Sig. (2-tailed)	.	.025	.037	.007	.267
		N	116	116	116	116	116
	IQ	Correlation Coefficient	.488(*)	1.000	.137	.412	.202
		Sig. (2-tailed)	.025	.	.554	.064	.379
		N	116	116	116	.116	116
	motivation	Correlation Coefficient	.458(*)	.137	1.000	.312	-.262
		Sig. (2-tailed)	.037	.554	.	.168	.251
		N	116	116	116	116	116
	Usability	Correlation Coefficient	.570(**)	.412	.312	1.000	.164
		Sig. (2-tailed)	.007	.064	.168		.477
		N	116	116	116	116	116
	personality	Correlation Coefficient	-.254	.202	-.262	.164	1.000
		Sig. (2-tailed)	.267	.379	.251	.477	
		N	116	116	116	116	116

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)

Table 4: Correlations matrix

4.9 Relationships between Gender, individual Differences and Usability

Testing the relationship between gender and motivation ($F_{(1,114)}$=0.193), between gender and GPA($F_{(1,114)}$=0.023), and between gender and personality score ($F_{(1,114)}$ = 1.081) using one way ANOVA ($p<0.05$) resulted in no associations. However, male students had an average usability score of 17.81, compared with 13.00 for female students. Females achieved scores significantly lower than male students. Association was found through ANOVA ($p<0.05$) between gender and usability scores (F = 2.703, significance level = 0.043). Male students with higher GPA also achieved higher usability scores ($F_{(1,114)}$ = 2.407, significance level = 0.33).

4.10 Relationships between Individual Differences, Academic Performance, and Five Factors in SUMI Assessment (Efficiency, Affect, Helpfulness, Control, Learnability)

According to the ANOVA test ($p<0.05$), students with higher GPA(>3.00) found the software to be more helpful ($F_{(1,114)} = 1.103$, significance level = 0.094) and to have a higher degree of learnability ($_{F(1,114)}$ = 2.597, significance level = 0.045). Students having higher IQ level (>120) indicated that the software was learnable ($F_{(1,114)}$ = 1.998, significance level = 0.038). The difference between usability score assessments of males and females mainly came from efficiency ($p<0.05$, $F_{(1,114)}$=2.327, sig. level=0.084) and helpfulness ($p<0.05$,$F_{(1,114)}$ =3.291, sig. level = 0.085) scores (Two way ANOVA $p<0.05$, IQ as fixed factor). No important difference in affect ($F_{(1, 114)}$ = 0.943, sig. level = 0.344) and learnability ($F_{(1,114)}$ = 0.789, sig. level = 0.385) was found among males and females.

5 Conclusions

In this study, software usability was examined in terms of a series of factors: GPA, IQ level, gender, and motivation in Table 4. Significant relations were found between academic performance, IQ, and software usability scores. [Fig. 11] gives a summary of the results and conclusions drawn from the analysis.

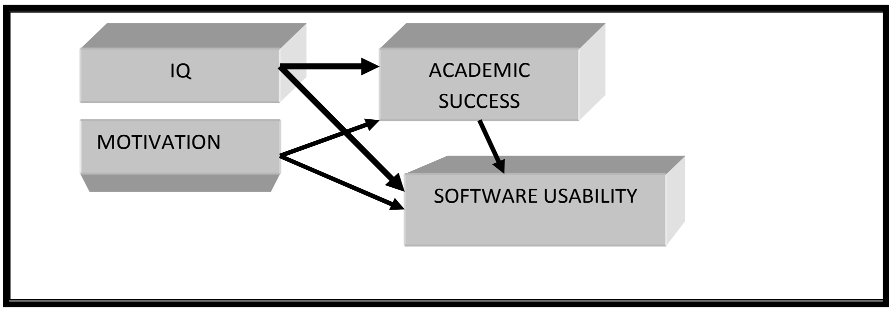

Figure 11: Framework of relevant relationships among factors involved in usability assessments

In addition, noteworthy correlations (Rho=0.57, $p<0.01$) were found between GPA and usability scores. Factors correlated with GPA (motivation, IQ level) tested against usability scores and strong association were found for both females and males. Students having the same IQ level but higher GPA scores achieved higher usability scores. The motivation factor was found to highly affect the usability scores, as were GPA scores and IQ levels. Usability scores were investigated at the sub-score level to determine the causes of inequality of usability scores between high IQ – low IQ, high GPA – low GPA groups. The following results were obtained:

- Students with higher IQ had higher learnability scores;
- Students with higher GPA had higher learnability and helpfulness scores.

Differences between male and female students in terms of usability scores were noted, while males with IQ scores equal to that of females had better usability scores. Differences in overall usability scores were due to dissimilar helpfulness and effectiveness sub-scores of female and male students. Further work can be performed with an integration of cognitive abilities, individual differences, cognitive styles, and software usability measured in a single inventory. For this purpose, the validation and confidence levels of the inventory need to be proven by sample testing.

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