Assessing effectiveness of the cognitive abilities and individual differences on e-learning portal usability evaluation

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Abstract

In this paper, we are investigating relationships between end users’ cognitive abilities, individual differences, and e-learning portal usability to create an indicator between individual differences and software usability. The usability of http://e-learning.bahcesehir.edu.tr that has intellectual content including a web portal is evaluated in design and development phases by 116 (72 male, 46 female) subjects who are registered to “HUM1005 History of Civilization I” general elective course. They completed four different surveys respectively: an IQ survey, a personality survey, motivation survey and software usability measurement inventory (SUMI). SUMI is used to assess the evaluations of the subjects to the web site. This research compares intelligence, personal factors, and motivation factors against the personal software usability results, in order to determine the correlations and associations between the usability of software and end users’ individual differences. Finally, the assumption, “the usability of any software does not only depend on the requirements of the users, but also, cognitive abilities and personality factors of the end users”, is overlapped with our findings. Noteworthy correlation (Rho=0.57, p<0.01) found between GPA and usability score.

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Keywords: Human-computer interface; Cognitive Abilities; Personal Factors; SUMI; Hypermedia; IQ Tests, cognitive style tests.

1. Introduction

Individual differences include psychological traits, cognitive skills and individual preferences. Individual differences have an effect on the level of software usage performance of users [9]. As mentioned in (Marchionini, 1995), cognitive abilities are defined in personal information infrastructure with domain, system and searching expertise[17]. Sometimes there are misunderstandings between cognitive abilities and styles. Cognitive styles are independent of intelligence and personality. They should relate to observable behaviours such as learning performance and learning preferences. Cognitive styles are a person’s perceiving, remembering, thinking, and problem solving patterns[]. Thus, this study considers cognitive abilities and individual differences rather than cognitive styles for the software usability issues.

Software quality metrics provided for software usage effectiveness, and efficiency. As proposed from this viewpoint, we aimed to find starting point of the behavioural metrics and psychometrics in the ISO standards to

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support each other. Measurement of software usability in terms of quantifiable means is realized with extension metric concepts. In addition, according to our analysis, it is not only enough to implement software designing steps successfully, but also, we need to take into account, end users’ psychometric test results into the software designing steps for the usability purposes. Recently, software quality concept tends to specialize and focus around the web site usability issues. Within this context, mostly demanded software quality factors are functionality, reliability, usability, efficiency, maintainability and portability as considered in ISO/IEC 9126 (1998). However, the most critical stage in software development life cycle is requirements analysis phase due to the customer needs and expectations. At this stage, inputs for software-design come from the requirement analysis. Actually, user interface design gives shape to the usability of the software. Therefore, early design stages in the rapid application development projects, contains some usability handicaps [8].

Rapidly growing Internet contains plethora of information in the web sites. However, problematic usability issues prevent this information from being effectively used. Nielsen defines usability by giving five quality components; learnability, efficiency, memorability, errors and satisfaction [18-21]. In addition to these, Jones (1997) defines usability as the total effort required to learn, operate, and use software or hardware. Other usability parameters are compared in Folmer&Bosch. Also, end users’ cognitive abilities, and personal properties based on the behavioural aspects, and interaction between personal properties, effects software usage performance with equivalent importance as software quality level. User satisfaction is the key parameter in software and web site usage. From this viewpoint, different academic studies implement sort of different works that are related with usability and user satisfaction [1,12-13,15-16].

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 due to the needs of users, including their abilities, limitations, and work environment settings. Within the HCI approach, we employed “Cognitive Walkthrough” methodology to observe the end user reactions to the software in a detailed task list scenario [5].

Web site usability evaluations are determined via Kirakowski’s SUMI survey. As mentioned in [7], Whiteside, Bennett, & Holtzblatt (1988) has proposed 21 usability metrics which are related with ISO 9241 [21]. These usability metrics are observed for the cross checking with SUMI results.

One of the important software quality factor is usability that is directly interested with cognitive abilities and individual factors. For the evaluation of these metrics, both IQ and personality tests are applied to the subjects [23-24]. In this paper organized respectively as; research aims, methods, participants, and questionnaires, the results of the surveys and discussions, conclusions and future works.

2. Methods

Our research involves two observations conducted in parallel, one focusing around the user and the other around the software usability. The aim of the observations around the user was to investigate cognitive abilities and individual differences of the subjects, and chart the user profile of the software usability. Certain correlations among these data sets were sought to identify unified means of metrics for HCI studies.

The early design stage involves determination of the cognitive abilities of the students in project study and then surveying them in the context steps of the web usability to gain thinking about the correlations between cognitive abilities and software usability indicators. Web site usability conditions can be handled in the analysis and design steps through the development phase of the software development life cycle. According to the (Calcaterra et al., 2005) hypermedia navigation behaviour is linked to computer skills rather than to the cognitive styles [4]. Alternatively, we assumed that, cognitive abilities are directly related with the success ratio of software usage. We tried to prove in concept about not only the cognitive abilities of the end users’ but also individual differences as a key point of the software usability.

2.1. The aim

The aim of the survey was to determine correlations among values obtained from behavioural and IQ tests, with results obtained from software usability tests to derive new metrics or indicators to define web usability values. Following relationships were tested and analyzed:

1-Relationships between individual differences and academic success,
2-Relationships between academic performance, IQ, and usability scores,
3-Relationships between individual differences and usability,
4-Relationships between gender, individual differences, and usability,
5-Relationships between individual differences, academic performance, and five factors in SUMI assessment (efficiency, affect, helpfulness, control, and learnability).

2.2. Method

We used cognitive walkthrough (CW) methodology to observe the end user reactions to the software in a detailed task list scenario within the HCI approach. “Cognitive Walkthrough” methodology was performed at all stages of design steps including: using the prototype, the conceptual design document, and the final product. This is a more specific version of a design walkthrough, focusing on cognitive principles [4].

Cognitive walkthrough involves the designers acting and trying to think as users. “Cognitive walkthrough” methodology, involves the designers’ contribution to think and act as a user throughout the whole design and development process. The team tries to anticipate the user’s actions and thoughts, while trying to accomplish a particular task. Then the team moves through tasks like a user would look for problems. This was particularly important at the beginning of the testing because many of our screens were still in paper format. We had to ensure that we had a screen for every possible path.

Based on user’s goals, a group of evaluators steps through tasks, evaluating each step to find how difficult it is for the user to identify and operate the interface elements that are more appropriate for their current sub-goals and how clearly the system provides feedback to that action. Cognitive walkthroughs take into consideration the user’s thinking processes that contribute to decision making, such as memory load and ability to reason [24].

The cognitive walkthrough is a technique for evaluating the design of a user interface, with special attention to how well the interface supports “exploratory learning” for the first-time user without formal training. The system’s designers can perform the evaluation in the early stages of the design; prior to any empirical user testing that is possible. Early versions of the walkthrough methods relied on a detailed series of questions, to be answered on paper or electronic forms. The strengths and limitations of the walkthrough methods are considered, and it is placed into the context of a more complete design approach [5].

Cognitive Walkthrough for the Web (CWW) is specialized version of the CW and has three properties: 1. CWW uses detailed scenarios for the users, 2. Clicking on a link, button or another thing; 3. CWW evaluation is adapted for the web sites [2]. Actually, we can use CW especially in early design steps in the software development life cycle. However, CWW has advantage to use it in each cycle at rapid development methodology.

This approach specifically intends to help understand the usability of a web site for first time or infrequent users, for those who are in an exploratory learning mode. We additionally applied personality factors tests, IQ and software usability tests to users with this approach.

2.3. Participants

This work is performed with 116 students, 72 male and 46 female, aged between 20-22 years (M=21.01, SD=0.89) who are registered for the “CSE3807 Cognitive Science and Cultural Perception in Software Engineering” course. Software-usability tests, IQ and personal-factor tests are applied to all students. There are totally 488 items in all inventories in IQ, personality-factor tests, and software-usability questionnaires.

2.4. Questionnaires

There are several different software usability questionnaires to determine user satisfactions about the software such as SUMI(software usability measuring inventory) developed by (Kirakowski,1996), MUMMS (measuring the usability of multi-media) and WAMMI (website analysis and measurement inventory) prepared by (Levi&Conrad, 2001) for the evaluation of web based software solutions.

We had chosen SUMI, because of its three-answer type Likert scale and good grouping features for the ISO 9241 usability criteria within. Software usability questionnaire includes 50 rules, which are identified by 3-point scale (agree, undecided, disagree) and easy to get response in five minutes. Personality factor survey, divided into four different stages [22].

Personality Factor 1 helped us to determine the extraverted as opposed to the introverted person type. Personality Factor 2 is used to measure the neuroticism as opposed to stability personality type. Personality Factor 3 determined
creativity level of the students. This section of the survey includes geometrical shapes for completion. Personality Factor 4 tries to reveal carefulness of the sample group. In addition, personality factors are considered according to the gender as detailed in results. IQ inventory is divided into three sub section: a) Numerical, b) Verbal, c) Geometrical. Fifty questions reside in each three section in the IQ inventory [23].

2.5. Usability measurement scenarios

Following scenario is given as a procedure to the students to test the web site. Each student has followed the sequence below to accomplish the given task.
1. Access to the http://e-learning.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 Indian Civilization,
5. Follow the interactive slides,
6. Access the cognitive maps to learn keywords,
7. Click the quiz engine to match the descriptors and keywords.
8. Log out from the e-learning system.

3. Results

We evaluated survey results into two groups: a) IQ, motivation, and personality factors b) Software usability factors with respect to the ISO 9241 and the SUMI. IQ survey factors include verbal, numerical, and geometrical tests to evaluate the students (Serebriakoff, 1994) and personal factors survey is evaluated for determining the individual differences between students.

3.1. Usability metrics based on ISO 9241

Twenty-one criteria are used to measuring the usability attribute and the possible ways to set the worst/best case and planned/now-level targets. These measurements are named as usability metrics. Following section shows the results acquired for each criterion.

1) Time to complete a task

E-card sending procedure tested among 116 students. Average completion time of the procedure is 3 minutes, minimum completion time is one minutes and 20 seconds, and maximum completion time is 6 minute and 33 seconds.

2) Percent of task completed

All students have completed the test procedure, except for three students, which could not have connected to the web site due to the network problems. Procedure applicability 85.71% is measured.
3) Percent of task completed per unit time
   A job completion time is 3 minutes in average and if a minute is taken as unit time, job completion amount per unit time ratio is near one-third.

4) Ratio of successes to failures
   Fifteen students have completed procedure successfully and three students were unsuccessful by the reason of the network or hardware problems.

5) Time spent in errors
   The average time spent for error is one minutes and 30 seconds.

6) Percent or number of errors
   Students completed the E-card sending procedure without encountering any errors.

7) Percent or number of competitors better than it
   42 students over 116 students have completed the procedure without making any mistakes. Ratio for perfect procedure completion is 36.21%. According to this value, 36.21% is procedure completion percentage without getting any error messages.

8) The number of commands used
   Five commands were used to complete the e-card sending procedure.
   1. Go to the web page,
   2. Click the link,
   3. Click for e-card image sending,
   4. Filling the information for the e-card,
   5. Click the send e-card button.

9) Frequency of help and documentation use
   Usage frequency for help and documentation was observed as 81. Help and documentation provided in the web site was satisfactory for the attendants.

10) Percent of favorable/unfavorable user comments
    Fifty five percent of the test attendants commended in the favor of and other half comments are unfavorable.

Twenty three users evaluated the web site as useless.

11) Number of repetitions of failed commands
    Average number of repetitions of failed commands was measured as three.

12) Number of runs of successes and of failures
    All commands are effectively performed in this work by e-card sending scenario. All commands performed the user requests depends on the hardware performance.

13) Number of times interface misleads the user
    No interface misleads were encountered by the user during the e-card sending procedure activities.

14) Number of good and bad features recalled by users
    Number of good features are 9 and bad features are six recalled by users in the scenario.

15) Number of available commands not invoked
    Sixty-four unused commands (links) were detected on the home page.

16) Number of regressive behaviors
    Regressive behaviors number is observed as nine.

17) Number of users preferring your system
    Fourteen students (80.95%) those who took the tests, reported they would continue using the web site after the tests. Following the completion of the work, the web site is published and results in the Table 2 are obtained that demonstrates number of visitors and their nationalities in a six months period of time.

18) Number of times or average number of users need to work around a problem
    Few problems were encountered through the process, during the test was performed by the students and average problem solving times is reported between 45 seconds and 1 minute.

19) Number of times the user is disrupted from a work task
    Average number of times the user is disrupted from a work task is five. These problems were generally because of the hardware performance and solved in less than in a minute.

20) Number of times user loses control of the system
    In the website usability testing stage, there were not any software control problems that have been reported.

21) Number of times user expresses frustration of satisfaction
80.95 percent of the users are satisfied from the website. However, there are critical unsatisfied properties in the website. For example, complexity, insufficient categorization, low speed of the web server and insufficient sources are main categories of the frustrations.

Personality characteristics factors, those that indicate person’s ability towards adaptation and success values for new tasks are also effective upon usability parameters. Results obtained from the study regarding the ISO 9241 parameters such as completion of the task are relevant with the personality characteristics factors test results. In other words, there exists a significant direct relationship between parameters oriented towards success and persons abilities towards success. In addition, students’ familiarity with computer applications and usage supports the success ratios positively.

Table 1. Usability Metrics’ Results

<table>
<thead>
<tr>
<th>Usability Objective</th>
<th>Effectiveness Measures</th>
<th>Efficiency Measures</th>
<th>Satisfaction Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitability for the Task</td>
<td>Percentage of goals achieved: 100%</td>
<td>Time to complete a task: 3 minutes in average</td>
<td>Rating scale for satisfaction: 80.95% in average</td>
</tr>
<tr>
<td>Appropriate for trained users</td>
<td>Number of “power features” used: 5</td>
<td>Relative efficiency compared with an expert user: 33.34%</td>
<td>Rating scale for satisfaction with “power features”: 80.95% in average</td>
</tr>
<tr>
<td>Learnability</td>
<td>Percentage of functions learned: 10% in average</td>
<td>Time to learn criterion: 1 minutes in average</td>
<td>Rating scale for “ease of learning”: 80.95% in average</td>
</tr>
<tr>
<td>Error Tolerance</td>
<td>Percentage of errors corrected successfully: 72.23%</td>
<td>Time spent on correcting errors: 50 seconds in average</td>
<td>Rating scale for error handling: 72.23%</td>
</tr>
</tbody>
</table>

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 subscales (the descriptions of the subscales are based on Kirakowski, 1993):

1. Efficiency: the degree to which users feel the software assists them in their work,
2. Affect: users’ general emotional response to the software,
3. Helpfulness: the degree to which users feel the software assists them in using it,
4. Control: the degree to which users feel they, and not the software, are in control,
5. Learnability: the ease with which users feel they have been able to get started using the software and learn new features.

Each subscale has 10 items. Each item is rated on a 3-point Likert response scale with the points “agree,” “don’t know” and “disagree”. Comparing the items of each scale with the descriptions of the seven dialog principles in ISO 9241 Part 10, Kirakowski (1993) found that four of the five subscales seem to correspond directly to dialog principles in ISO 9241 Part 10. The fifth subscale seems to be related to another dialog principle.

SUMI survey results show that suitability for learning of the procedure is 63%. Web site has proposed controllability to the users with near to 51%. 55% of the users agreed that web site assists them in the procedure and
55% of them believed that web site has enough easy to use and helpfulness. General emotional thinking for the web site is good with 48%.

**IQ Survey Results**

Cognitive abilities can be evaluated by IQ tests and in our study 116 students filled the geometrical, numerical, and verbal sections of the (Serebriakoff’s IQ Survey, 1996). The survey is composed of three sections as qualitative (verbal), quantitative (numerical) and geometrical (pattern). Number of right answers given for each section is represented in the Fig 2.

The purpose to apply an IQ test was to identify possible effects of cognitive abilities on software-usability. Success in verbal abilities along with higher creative abilities has significant effect towards 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 average time or in less than the average time tends to be the ones with lower levels of verbal abilities.

IQ scores of each student attended to the test have been calculated with Serebriakoff’s formula and figured in Fig.1. Mean IQ level is 116.81 (SD=17.03). In latter sections, students’ usability assessments are researched by means of dividing the body into two parts; students with high IQ level and students with low IQ level and comparing the differences in SUMI responds.

![Fig. 1 IQ scores for sample group](image)

It is possible to make assumptions for sections that were easily answered and that were difficultly answered by the data that obtained from the surveys. Following results were obtained from the surveys for the quantitative, qualitative and geometrical sections. Percentage of correctly answered verbal and numerical questions are slightly more than the geometrical section, though the difference is not significant.

As it is apparent in the Fig.2, students had most difficulty with the geometrical section however; differences between sections are not too large. Survey results also show us that even if the overall performances for quantitative section was poorly successful, when evaluated for individual performance the higher score of all the sections stands out to be this one.
When each section of the survey was evaluated individually, we can see around what type of questions to the wrong answers were concentrated and what type of questions were answered correctly. Depending on these remarks we can come to certain conclusions; for the qualitative section, fill-in-the-gaps of a given paragraph part was answered the easiest. Most of the mistakes were made in the part where the student has to find the meaning of a word for a given synonym.

For the case of the quantitative section, equation-solving questions stand out to be the most successfully answered part. Most of the wrong answers were given to the geometrical section, reconfiguring a shape type questions are found to be the most successfully answered while block-stacks were the least successful.

Survey results of the IQ and personality characteristics prove that behavioral and psychometrics parameters of the end users have to be evaluating when requirement analysis stage implemented in the web portal development. By this way, software usability handicaps can be considering in the design stage of the software. Both software development costs minimize and ISO9241-11 usability standards are guaranteed for the software.

Success in verbal abilities along with higher creative abilities has significant effect towards the rapid cognition of software procedures. It was also observed that students that could not manage to apply procedures or complete the tasks in or less the average time tends to be the ones with lower levels of verbal abilities.

3.4. **Personality type survey results**

Personality factors of the students involved in this study were evaluated under the criteria's; extravertedness, stability, creativity and neuroticism.

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

Results of obtained from the personality factors test shows us that, within the frequency interval of evaluation, values for emotional stability are 18 on average. These values indicate that students turn out to be more confident, emotionally stable and concrete.

When creativity as a personality factor is evaluated, respondents have average score of 14. Students received an average score of 269 from the leadership factors suvey. According to these results, personality types for students' turns out are exhibiting leading and entrepreneurial characteristics. When the upper and lower limits for the evaluation are considered as 400 and 50, male students fall into the average intervals. Female students tend to
exhibit stable and political characteristics. All students of both genders are socially sensitive, confident, determined for achievement of goals (goal oriented) and team worker.

The first group of the personality factor test is queries extraverted versus introverted personality types. No significant difference in extravertedness level seen among male and female students ($F(1,114) = 2.081$). Students are observed exhibiting average personality features, while they exhibit stable personality features due to the emotional stability in first group tests. Majority of students have been found to have coherent type personality, while only 13% of males have sensitive personality.

Students were observed as extremely creative while a majority of them tends to exhibit stable-political (60%) personality features. Level of creativity may increase usability of software design [3]. The 33% of the males demonstrate enterprising personality features compared with 25% of the females.
3.5. Motivation Survey Results

Motivation factors presented in this study were evaluated through questionnaire answered by students. The questionnaire had 13 questions to determine the school motivation and answers were in Likert scale format.

A simple description of “motivation” is the capability to adjust behavior. Motivated students are the students, who are directed toward some goal. Motivation comes from personal interests, desires, and need for fulfillment. However, external factors such as rewards, admiration, and promotions also influence motivation. As characterized by Daft, motivation refers to “the forces either within or external to a person that arouse enthusiasm and persistence to pursue a certain course of action” [6].

![Motivation Scores for the sample group](image)

According to Daft, people who are committed to achieving organizational objectives generally outperform those who are not committed. Various factors, including the influences of different cultures, affect what people value and what is needed to be done to motivate them.

3.5. Test Results

The comparison test results for the studies defined in section 2.1 are given and discussed in this section.

3.6.1. Relationships between individual differences and academic success

Significant association (F(1,114) = 4.787, sig. level = 0.005, p<0.05) found between IQ (M=119.43,SD=10.93) and GPA(M=2.85,SD=0.59). In addition, correlations found between IQ and GPA (Rho= 0.488), 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). No significant correlations (Spearman’s Rho) found between motivation and IQ scores.

3.6.2. Relationships between academic performance, IQ and usability scores

GPA (M=2.85, SD=0.59) and usability (M=16.67,SD=4.72) found to have coherent patterns of relationship (F(1,114)=2.377, significance level = 0.032,p<0.05). The association level was higher when IQ used as covariate.
Two way ANOVA (p<0.05) results has shown that students having both higher IQ (>120) and higher GPA(>3.00) outperformed others in 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.

3.6.3. Relationships between individual differences and usability

Usability scores and IQ level has shown significance in 0.122 level (F(1,114) = 1.119). Motivation and usability also found to be strongly correlated (F(1,114) = 7.686, significance level = 0.02). Another comparison 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) observed for that factor.

3.6.4. Relationships between gender, individual differences and usability

Testing the relationship using one way ANOVA(p<0.05), between gender and motivation (F(1,114)=0.193), between gender and GPA(F(1,114)=0.023), between gender and personality score (F(1,114) = 1.081) resulted in no association.

However, male students had an average usability score of 17.81, whereas female students had 13.00. Females achieved scores significantly lower than male students. Association found through ANOVA (p<0.05) between gender and usability scores (F = 2.703, significance level = 0.043). Also male students with higher GPA achieved higher usability scores (F(1,114) = 2.407, significance level = 0.33).

3.6.5. Relationships between individual differences, academic performance and five factors in SUMI assessment (Efficiency, Affect, Helpfulness, Control, Learnability)

According to ANOVA test (p<0.05) Students with higher GPA(>3.00) have found the software having more helpfulness (F(1,114) = 1.103, significance level = 0.094) and more learnability (F(1,114) = 2.597, significance level = 0.045). Students having higher IQ level (>120) answered that the software is learnable (F(1,114) = 1.998, significance level = 0.038).

The difference between usability score assessments of males and females mainly comes from; efficiency(p<0.05,F(1,114) = 2.327, significance level = 0.084) and helpfulness (p<0.05,F(1,114) = 3.291, significance level = 0.085) scores (Two way ANOVA p<0.05, IQ as fixed factor). No important difference in affect (F(1, 114) = 0.943, significance level = 0.344) and learnability(F(1,114) = 0.789, significance level = 0.385) found among males and females.

Table 4. Spearman's rho Correlations Matrix

<table>
<thead>
<tr>
<th></th>
<th>gpa</th>
<th>iq</th>
<th>motivation</th>
<th>usability</th>
<th>personality</th>
</tr>
</thead>
<tbody>
<tr>
<td>gpa</td>
<td>1.000</td>
<td>.488(*)</td>
<td>.58(*)</td>
<td>.70(**)</td>
<td>-.25(*)</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.025</td>
<td>.037</td>
<td>.007</td>
<td>.267</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>116</td>
<td>116</td>
<td>116</td>
<td>116</td>
<td>116</td>
</tr>
</tbody>
</table>

| iq    | .488(*)  | 1.000    | .137       | .312      | .262        |
| Sig. (2-tailed) | .025    | .554     | .664       | .379      |             |
| N     | 116      | 116      | 116        | 116       | 116         |

| motivation | .458(*)  | .137      | 1.000      | .312      | .262        |
| Sig. (2-tailed) | .037    | .554     | .168       | .251      |             |
| N         | 116      | 116      | 116        | 116       | 116         |

| usability | .570(**) | .412      | .312       | 1.000     | .164        |
| Sig. (2-tailed) | .007    | .064     | .168       | .477      |             |
| N         | 116      | 116      | 116        | 116       | 116         |
4. Conclusions

In this study, software usability examined to a series of factors; GPA, IQ level, gender and motivation. Significant relations have been found between academic performance, IQ and software usability scores. Figure 8 gives a summarization of results and conclusions drawn from the analysis.

Fig. 8 Framework of relevant relationships among factors involved in usability assessments

In addition, noteworthy correlations (Rho=0.57, p<0.01) found between GPA and usability score. Factors correlated with GPA (motivation, IQ level) tested against usability scores and strong association found for both females and males. Students having the same IQ level but higher GPA scores achieved higher usability scores. Motivation factor found to be highly affecting the usability scores as well as GPA and IQ level.

Usability scores investigated in sub score level to determine the cause of inequality of usability scores between, high IQ-low IQ, high GPA-low GPA groups and following results are reached:
1. Students with higher IQ have higher learnability scores (which are reside in SUMI survey)
2. Students with higher GPA have higher learnability and helpfulness scores.

Difference between male and female students in usability scores have seen, males with equal IQ level had better usability scores compared to females. Difference in overall usability scores was due to unlike helpfulness and effectiveness sub scores of female and male students.

Further work can be performed with integration of the cognitive abilities, individual differences, cognitive styles, and software usability measuring in a single inventory. For this purpose, validation and confidence of the inventory needs to be proven by sample testing.

References