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Attitude, Gender and Achievement in Computer Programming

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Abstract: The aim of this research was to explore the relationship among students' attitudes toward programming, gender and academic achievement in programming. The scale used for measuring students' attitudes toward programming was developed by the researcher and consisted of 35 five-point Likert type items in four subscales. The scale was administered to 179 students who enrolled in introductory computer programming course. Overall reliability of the scale was found as 0.96. The mean score of students' attitudes was 3.59 that lead us hard to say that students had positive attitude toward computer programming. It was found that there was a significant positive correlation between students' attitudes and their achievements in programming. The results showed that male students had more positive attitudes toward programming than female students.

Key words: Computer programming · Programming attitude scale · Gender difference · Achievement

INTRODUCTION

Research indicated that, for more than a decade, there has been a consistent decline in number of students choosing computer science program at the undergraduate level [1, 2, 3]. We need to increase the participation of students in computer science programs since the employment demand for qualified computer scientists and programmers is continue to increase, resulting in a shortage of good quality professionals in the field [3]. One of the reasons for students not choosing computer science may be the perception of undergraduate computer science students that computing, especially programming, is too difficult, boring and unsocial [4]. Accordingly students tend to develop negative attitudes toward programming. On the other hand, attitudes influence how we process information and how we behave [5, p. 4], consequently students' performance in programming is affected by their attitudes toward programming [6-8]. Thus, identifying students' attitude toward computer programming is an important issue in computer science education, since attitude effects students' performance on computer programming and attitude may differ between genders.

Review of Literature

Attitude Scales Toward Computer Programming: Attitude is defined as an overall evaluation of an object that is based on cognitive, affective and behavioral information [5, p. 4]. Since attitudes are not directly observable, social psychologists developed various methodologies for assessing attitudes. One of them is to use a Likert scale which provides a range of responses to a given question or statement. Likert type scales are very useful tools for the researcher, as they build in a degree of sensitivity and differentiate responses while still generating numbers and they are commonly used in educational research [9, pp. 325-326]. As opposed to other areas of educational research, there is no standardized scale for measuring attitudes toward computer programming [2, 10], so most authors developed their own scales.

There is a consensus among science education researchers that attitude and achievement are positively correlated [e.g. 17, 18] since attitudes play important roles on the perception of information and affect the degree of their retention [19]. On the other hand, there is a disagreement among researchers whether attitudes influence achievement or achievement influences attitude

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[20]. However, in the case of computing education research, contribution of attitude to academic achievement is still need to be investigated since there is not a clear relation between attitude and performance. Golding, Facey-Shaw and Tennant [6] found that attitudes toward programming does not affect academic performance, but according to Erodogan, Aydin and Kabaca [21] only personal confidence (a subscale of attitude) contributes significantly to academic performance. Erdogan, Aydin and Kabaca [21] found that there was no significant correlation between programming achievement and computer attitude. Furthermore, Hongwarittorrn and Krairit [15] was found that there was no statistically significant correlation between students' attitudes and students' exam scores. Tai *et al*. [22] reported that students with more positive attitudes towards learning environment attained significantly high learning achievements in computer programming.

Computer science students generally take their introductory programming course in the first semester of their study. First impression matters like many things in life and computer programming is no exception [23]. Since programming is an essential skill required for computer programmers, the negative impact on basic introductory courses may have harmful consequences in the learners' attitudes toward the field [24]. Thus, researchers try to find ways to improve students' attitudes toward programming. In general, students in paired learning environment developed positive attitudes toward programming [e.g., 8, 25, 26]. On the contrary, Williams *et al*. [43] and Weibe *et al*. [13] found that students in paired labs did have a more positive attitude towards computer science. Thomas, Ratcliffe and Robertson [27] indicated that strong programmers were less satisfied with pair programming[1] and more likely to feel they were being "slowed" down by their partner. Some researchers try to improve students' attitudes toward programming by using learning tools. For example, Hongwarittorrn and Krairit [15] expected that using Jeliot (Java program visualization tool, http:// cs.joensuu.fi/ jeliot/) would increase students' attitudes toward programming. Their results indicated that although Jeliot improved students learning performance in Java programming, it did not affect students' attitudes toward Java programming. However, the use of Alice (3-D interactive programming environment, http://www.alice.org/) increases student enjoyment and promotes positive attitudes toward programming [11, 28, 29]. This result is not consistent with Hutchinson et. al.'s study [3] which revealed that students' attitudes with respect to computer science did not appear to be impacted either positively or negatively by the use of the Alice curriculum. Thus, the correlation between attitudes toward programming and achievement needs to be further researched.

Programming Attitude and Gender: Although Ada Lovelace who was the daughter of the famed British poet Lord Byron was the first programmer, women are severely underrepresented in the field of computer science [2]. Attitude of women toward computing is one of among several factors that might explain the low participation of women in computing [30]. The result of computing education research showed that attitudes of woman toward programming are more negative than that of man. Generally, researchers found that attitudes of females toward computers were more negative than that of males [e.g.,10, 31, 32], but some others either found no difference [33, 34], or females has more positive attitudes toward computers compared to males [35].

Programming is not alluring for females [36]. This could be attributed to females' low confidence and programming abilities [37]. Therefore, their attitudes toward programming are more negative than males as found by Korkmaz and Altun [16]. Pair programming could be a chance to dissipate gender differences in attitudes toward programming [38]. For example in the study of Facey-Shaw and Golding [7] man and women had similar attitudes toward computing in peer tutoring curriculum. Similarly, educators may use Alice curriculum in introductory programming to eliminate gender differences in programming attitudes [3]. Lastly, once women have the confidence to problem-solve, see social aspects of computing and see a value to computing, they are more likely to pursue and persist in computer science [38].

MATERIALS AND METHOD

Purpose: The purpose of this research was to explore the relationship among students' attitudes toward programming, gender and academic achievement in programming. The specific questions that were answered by this study were:

[1] Pair programming is a style of programming in which two programmers work side-by-side at one computer, continuously collaborating on the same design, algorithm, code, or test [13].

- Is there a significant difference between male and female students' attitudes toward programming?
- Is there a significant correlation between students' attitudes toward programming and their achievements in computer programming?

Participants: The sample involved in this study was composed of 179 sophomore students in introductory programming course in the Department of Computer Education and Instructional Technology (CEIT) at a state university located at northern region of Turkiye, in 2012. Students graduated from CEIT are employed as Information and Computer Technology (ICT) teachers. The aim of introductory programming course is to teach basics of programming by using a programming language. The instructor chose Python to teach programming, since it is decided to be the one of the suitable first programming language [39, 40].

Development of Programming Attitude Scale: While we started this study Google Scholar did not returned any computer programming attitude research in Turkish. At the time of writing this report, a computer programming scale was developed by Korkmaz and Altun [16]. Since there is no Programming Attitude Scale in Turkish as the time we started to this study, we developed a valid and reliable scale which measures students' attitudes toward programming. Based on prior research, we decided to translate the scale developed by Wiebe *et al*. [14] to Turkish. Some of the items of this scale are not directly related to programming rather associated with computer science in general. We take this survey as a base for our programming attitude scale. Since our aim was to develop programming attitude scale, we either omit items in Wiebe's *et al*. survey or changed to reflect programming rather than computer science. We also changed most items to reflect feelings of students related to programming. Finally, we constructed 47 items for our survey which has little similarity with the original scale. Turkish version of the survey is available through requests from the author. Items were designed using a five point Likert type scale with students responding to each item by selecting from the following options: "Strongly Agree", "Agree", "Neither Agree nor Disagree", "Disagree" and "Strongly Disagree".

The survey was checked by two professors, good at English, from the Department of Educational Sciences and Department of Computer Education and Instructional Technology. As a pilot study the survey was administered to 11 students (4 females, 5 males) under the supervision of the author of this manuscript to check if students understand the intended meanings of each item and to get feedback about the survey. Finally, the questionnaire was administered using online survey software.

179 students answered the survey (85 females, 94 males). For analysis purposes, the selected response items were re-coded to a numerical scale which ranged from 1 to 5. Negatively phrased items were reversed coded such that a high score reflected a positive attitude. For the gender related items, a gender neutral attitude reflected a higher numerical score.

Exploratory Factor Analysis (Principal Component) was done for the validation of programming attitude scale. The Scree Plot yielded 4 factors to be retained. Items that did not load enough on a factor or load significantly more than one factor there were removed from the survey. Finally there were 35 items left in four factors which accounted for 65.0% of the variance in attitudes toward computer programming. This is a moderate amount of explanatory power and is considered satisfactory in terms of social sciences [41, p.120]. Factors are named as "Confidence in learning computer programming", "Usefulness of computer programming", "Attitudes toward success in computer programming", "Effective motivation in computer programming". The reliability of the survey was found as 0.958. Reliability ranged from 0.87 and 0.93 for the four subscales.

RESULTS

Programming Attitude and Gender: Students' mean scores of attitudes toward programming was calculated as 3.59 (X_{min}=1.66, X_{max}=4.94, σ =0.645). Therefore, it can be concluded that while students did not have a negative attitude towards programming, the attitude was not very positive. Independent samples t-test was performed to check if there was a significant difference between male and female students' attitudes toward programming. The measures obtained are given in Table 1.

Analysis revealed that males' attitude toward programming was significantly higher than females'.

Furthermore, gender difference in four subscales was also checked by independent samples t-test. The result was shown in Table 2.

Table 1: Independent samples t-test comparing gender difference in attitude

Gender	N	X	σ	df	t-value	P
Female	85	3.40	0.65	177	3.86	0.00
Male	94	3.76	0.59			

Table 2: Independent samples t-test comparing gender difference in subscales of attitude

Subscale	Gender	X	N	σ	df	t-value	P
Confidence in learning computer programming	Female	2.89	85	0.768	177	4.88	0.00
	Male	3.46	94	0.782			
Usefulness of computer programming	Female	3.64	85	0.814	177	2.73	0.00
	Male	3.94	94	0.689			
Attitudes toward success in computer programming	Female	4.14	85	0.822	177	0.57	0.57
	Male	4.20	94	0.649			
Effective motivation in computer programming	Female	3.00	85	0.818	177	3.59	0.00
	Male	3.44	94	0.808			

Table 3: Pearson correlation among achievement in programming with mean scores of PAS and its subscales.

Scale/Subscale	Achievement
Attitude toward programming (scale)	*0.409***
Confidence in learning computer programming	0.542**
Usefulness of computer programming	0.253**
Attitudes toward success in computer programming	0.059
Effective motivation in computer programming	0.378**

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

As shown from Table 2, there was no significant difference between male and female students in terms of their attitudes toward success in computer programming. In all other subscales of programming attitude, male students had more positive attitude.

Programming Attitude and Achievement: The degree of correlation between programming attitude and achievement in programming is a crucial question. In order to answer this question, Pearson correlation analysis was done between mean scores of students' attitudes toward programming and their passing grades in introductory programming course. In addition, correlation between subscales of attitudes and passing grades were also computed. The result is displayed in Table 3.

As shown in Table 3, a statistically significant correlation was found between students' programming attitudes and their introductory programming course performance. The highest correlation was found between Confidence in learning computer programming and achievement. On the other hand, there was no significant correlation between attitude toward success in computer programming and achievement. The lowest and insignificant correlation was found between usefulness of computer programming and their achievement in programming. It can be interpreted that 16.7% (r^2=0.409 ^{2}) of the variation in students' programming achievement can be attributed to their confidence, motivation and perception of usefulness of computer programming.

DISCUSSIONS AND CONCLUSIONS

The purpose of this study was to explore the relationship among students' attitudes toward programming, gender and performance in programming. Attitudinal research are still an important issue in education since it plays an important role in understanding how opinions are formed, changed and measured [5]. Thus, students' attitudes towards subject are a crucial factor to consider when deciding teaching methods and material design [36].

There were some instruments for measuring students' attitudes toward programming in the literature. One of the prominent of them was developed by Wiebe *et al*. [14] who derived their scale from the Fennema-Sherman [12] mathematics attitudes scales. Weibe's and other instruments intended to measure attitudes toward programming and computer science in general. In this study, we were obligated to develop a scale for only measuring programming attitude since there was no Turkish one while we started to this study. We take items on Weibe's survey as a base and include items that were

only related to programming attitude. Some items remained the same but majority of them were altered as to reflect students feelings and perceptions related to computer programming. At the end, we had only minor similarity with the Weibe's survey. Validation of the scale was performed through exploratory factor analysis and there were 35 items left on the survey out of 47 items.

It was reported in many computer education studies that female enrollment in computer science was remarkably low [2]. This may be attributed to the more negative attitude of females towards computers than males [e.g, 31, 32]. The result of this study showed that females' mean scores of programming attitude were significantly lower than males as opposed to the result of the studies done by Yildirim and Kaban [33] and Bakr [34]. Our result was completely agree with the study of Korkmaz and Altun [16] who found that attitude of the male students towards computer programming learning is meaningfully higher than that of the female students. One interesting result of this study was that although we included gender related items in our original survey, these items were excluded due to factor analysis.

Students' attitudes toward a subject affected their achievement in that subject. It was one of our purposes that if there exists any correlation between students' attitudes toward computer programming and their achievement in programming. The correlation between students' mean attitude score and passing grades in introductory programming course were significant ($r=0.443$, $P<0.01$). It can be concluded that 16.7% of the variation in achievement attributed to attitude. Although the correlation is significant, we can only predict group success in introductory programming but not predict individual success [9, p.536]. Since contribution of programming attitude to performance is considerably low, it can be concluded that programming attitude is not the only predictive factor of performance. This is in conjunction with the conclusions of Palaigeorgiou *et al*. [10]. The correlation between confidence in learning programming and performance is the highest among the subscales. This result is in conjunction with the studies of Facey-Shaw and Golding [7] who found that a strong relationship between confidence and programming ability. On the contrary, Thomas, Ratcliffe and Robertson [27] emphasized that students with less self-confidence seem to enjoy pair programming the most. The results of this study enabled us to conclude that CEIT students did not see the computer programming would be useful in their business life. This is somehow meaningful if we considered the CEIT students would become computer teachers and would have little work with computer programming. This may be different for computer science students and needs to be further researched. According to the results of this study, among the four subscales of the attitude toward programming, confidence in programming has the highest correlation with performance in programming. This result is completely agreed with the study of Golding *et al*. [6].

Since students' attitude towards programming may yield increased performance and appreciation of the underlining concepts in programming [6], we need to increase students' attitude towards programming. There are some suggestions in the literature. For example, Dagiene and Futschek [42] proposed that if we introduce informatics concepts through contest students will have more positive attitude. Using Alice seems to improve attitudes toward programming [28]. Research on pair programming generally resulted increase in students attitudes toward programming [e.g., 8, 43].

Limitations and Further Research: The results of this research have some limitations. One of the main limitations of this research was the number of subjects. The survey developed in this research was tested on a relatively small sample. Costello and Osborne [44] reviewed articles related to exploratory factor analysis. There is no general rule for determining the subject size for factor analysis, but researchers generally accept that sample size should be greater than 100 and suggested subject to item ratio as at least 5:1. However, according to Costello and Osborne's review more than 40% of the examined articles used less than 5:1. So we decided to use statistical methods (KMO and Sphericity) to test whether our sample is suitable for exploratory factor analysis and the data is factorable. Although statistical analysis showed that our sample was adequate, the research should be repeated with a larger sample size for more accurate results. Another main limitation was that all the subjects were CEIT students. For a generalizable result, even though it is hard to accomplish, students from various departments who were taught with same programming language and received same exams should be included in the further research.

Since we constructed our items by using the survey developed by Wiebe *et al*. [14], some items may not appropriate for measuring students' attitudes toward programming. Future research should be done with qualitative methods to see if the items in sour scale are representatives of students' feelings and perceptions of computer programming. A qualitative research may yield additional items.

REFERENCES

1. Heersink, D. and B.M. Moskal, 2010. Measuring high school students' attitudes toward computing. In Proceedings of the 41st ACM technical symposium on Computer science education (SIGCSE '10). ACM, New York, NY, USA, pp: 446-450.
2. Hoegh, A. and B.M. Moskal, 2009. Examining science and engineering students' attitudes toward computer science. In Proceedings of the 39th IEEE international conference on Frontiers in education conference (FIE'09). IEEE Press, Piscataway, NJ, USA, 1306-1311.
3. Hutchinson, A., B. Moskal, S. Cooper and W. Dann, 2008. Impact of the Alice curriculum on community college students' attitudes and learning with respect to computer science. Paper appears in the proceedings of the annual meeting of the American Society for Engineering Education, Pittsburgh, PA
4. Farkas, D. and N. Murthy, 2005. Attitudes toward computers, the introductory course and recruiting new majors: Preliminary results. In 17th Workshop of the Psychology of Programming Interest Group, Sussex University, pp: 268-277.
5. Maio, G.R. and G. Haddock, 2010. The psychology of attitudes and attitude change. London: SAGE Publications Ltd. doi: 10.4135/9781446214299
6. Golding, P., L. Facey-Shaw and V. Tennant, 2006. October. Effects of peer tutoring, attitude and personality on academic performance of first year introductory programming students. In Frontiers in Education Conference, 36th Annual (pp: 7-12). IEEE.
7. Facey-Shaw, L. and P. Golding, 2005. Effects of peer tutoring and attitude on academic performance of first year introductory programming students. In Frontiers in Education, 2005. FIE'05. Proceedings 35th Annual Conference (pp: S1E-S1E). IEEE.
8. Nagappan, N., L. Williams, E. Wiebe, C. Miller, S. Balik, M. Ferzli and J. Petlick, 2003b. Pair learning: With an eye toward future success. Extreme Programming and Agile Methods-XP/Agile Universe, pp: 185-198.
9. Cohen, L., L. Manion and K. Morrison, 2007. Research Methods in Education. 6th edn. Oxon: Routledge.
10. Palaigeorgiou, G.E., P.D. Siozos, N.I. Konstantakis and I.A. Tsoukalas, 2005. A computer attitude scale for computer science freshmen and its educational implications. Journal of Computer Assisted Learning, 21: 330–342. doi: 10.1111/j.1365-2729.2005.00137.x
11. Bishop-Clark, C., J. Courte, D. Evans and E.V. Howard, 2007. A quantitative and qualitative investigation of using Alice programming to improve confidence, enjoyment and achievement among non-majors. Journal of Educational Computing Research, 37(2): 193-207.
12. Fennema, E. and J.A. Sherman, 1976. Fennema-Sherman mathematics attitudes scales. Instruments designed to measure attitudes toward the learning of mathematics by females and males. JSAS: Catalog of Selected Documents in Psychology, 6(31)Ms. 1225.
13. Wiebe, E., L. Williams, J. Petlick, N. Nagappan, S. Balik, C. Miller and M. Ferzli, 2003a. Pair programming in introductory programming labs. In Proceedings of the 2003 American Society for Engineering Education Annual Conference and Exposition.
14. Wiebe E., L. Williams, K. Yang and C. Miller, 2003b. Computer Science Attitude Survey, TR-2003-01, Department of Computer Science, NC State University, 2003. Retrieved Feb 6, 2013, from http://www4.ncsu.edu/~wiebe/www/articles/prl-tr-2003-1.pdf
15. Hongwarittorrn, N. and D. Krairit, 2010. Effects of program visualization (jeliot3) on students' performance and attitudes towards java programming. In The spring 8th International conference on Computing, Communication and Control Technologies, 2010.
16. Korkmaz, Ö. and H. Altun, 2013. Engineering and CEIT student's attitude towards learning computer programming. International Journal of Social Science, 6(2): 1169-1185.
17. Tüysüz, C., 2010. The Effect of the Virtual Laboratory on Students' Achievement and Attitude in Chemistry. International Online Journal of Educational Sciences, 2(1): 37-53
18. Prokop, P., G. Tuncer and J. Chudá, 2007. Slovakian Students' Attitudes toward Biology. Eurasia Journal of Mathematics, Science and Technology Education, 3(4): 287-295.
19. Festus, C. and O.A. Ekpete, 2012. Improving Students' Performance and Attitude towards Chemistry through Problem-Based-Solving Techniques. International Journal of Academic Research in Progressive Education and Development, 1(1): 167-174.

20. Zacharia, Z., 2003. Beliefs, attitudes and intentions of science teachers regarding the educational use of computer simulations and inquiry based experiments in physics. Journal of Research in Science Teaching, 40(8): 792-823.
21. Erodogan, Y., E. Aydin and T. Kabaca, 2008. Exploring the psychological predictors of programming achievement. Journal of Instructional Psychology, 35(3): 264.
22. Tai, D.W.S., C.H. Yu, L.C. Lai and S.J. Lin, 2003. A study on the effects of spatial ability in promoting the logical thinking abilities of students with regard to programming language. World Transactions on Engineering and Technology Education, 2(2): 251-254.
23. Pendergast, M.O., 2006. Teaching Introductory Programming to IS Students: Java Problems and Pitfalls. Journal of Information Technology Education, 5: 491-515.
24. Ismail, M.N., N.A. Ngah and I.N. Umar, 2010 Instructional strategy in the teaching of computer programming: a need assessment analyses. The Turkish Online Journal of Educational Technology, 9(2): 125-131.
25. Williams, L., C. McDowell, N. Nagappan, J. Fernald and L. Werner, 2003. September. Building pair programming knowledge through a family of experiments. In Empirical Software Engineering, 2003. ISESE 2003. Proceedings. 2003 International Symposium, (pp: 143-152). IEEE.
26. Nagappan, N., L. Williams, M. Ferzli, E. Wiebe, K. Yang, C. Miller and S. Balik, 2003a. February. Improving the CS1 experience with pair programming. In ACM SIGCSE Bulletin, 35(1): 359-362.
27. Thomas, L., M. Ratcliffe and A. Robertson, 2003. Code warriors and code-a-phobes: a study in attitude and pair programming. ACM SIGCSE Bulletin, 35(1): 363-367.
28. Courte, J., E.V. Howard and C. Bishop-Clark, 2006. Using Alice in a Computer Science Survey Course. Information Systems Education Journal, 4(87): 1-7.
29. Moskal, B., D. Lurie and S. Cooper, 2004. Evaluating the effectiveness of a new instructional approach. In ACM SIGCSE Bulletin, 36(1): 75-79.
30. Gürer, D. and T. Camp, 2002. An ACM-W literature review on women in computing. ACM SIGCSE Bulletin, 34(2): 121-127.
31. Chang, S.L., R.S. Shieh, E.Z.F. Liu and P.T. Yu, 2012. Factors influencing women's attitudes towards computers in a computer literacy training program. The Turkish Online Journal of Educational Technology, 11(4): 177-187.
32. Bebetsos, E. and P. Antoniou, 2009. Gender differences on attitudes, computer use and physical activity among Greek university students. The Turkish Online Journal of Educational Technology, 8(2): 63-67.
33. Yıldırım, S. and A. Kaban, 2010. Attitudes of pre-service teachers about computer supported education. International Journal of Human Sciences, 7(2): 158-168.
34. Bakr, S.M., 2011. Attitudes of Egyptian teachers towards computers. Contemporary Education Technology, 2(4): 308-318.
35. Khatoon, T. and S. Mahmood, 2011. Computer Attitude as a Function of Gender, Type of School Mathematics Anxiety and Mathematics Achievement. European Journal of Social Sciences, 18(3): 434-443.
36. Grandell, L., M. Peltomäki, R.J. Back and T. Salakoski, 2006. January. Why complicate things?: introducing programming in high school using Python. In Proceedings of the 8th Australasian Conference on Computing Education, 52: 71-80.
37. Milto, E., C. Rogers and M. Portsmore, 2002. Gender differences in confidence levels, group interactions and feelings about competition in an introductory robotics course. In Frontiers in Education, 2002. FIE 2002. 32nd Annual (Vol. 2, pp. F4C-7). IEEE.
38. Werner, L.L., J. Denner and S. Bean, 2004. Pair programming strategies for middle school girls. In Proceedings of the Seventh IASTED International Conference on Computers and Advanced Technology in Education (2004), pp: 161-166. Retrieved Feb 20, 2013, from http:// users.soe.ucsc.edu/ ~charlie/ projects/ pairprogramming/CATE.pdf
39. Sanders, I. and S. Langford, 2008. Students' perceptions of Python as a first programming language at Wits. In proceeding of: Proceedings of the 13th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education, ITiCSE 2008, Madrid, Spain, June 30 - July 2, 2008
40. Borcherds, P.H., 2007. Python: a language for computational physics. Computer Physics Communications, 177(1-2): 199-201.

41. Hair, J.F., W.C. Black, B.J. Babin R.E. Anderson and R.L. Tatham, 2006. Multivariate Data Analysis. 6th ed., Pearson Internation Edition, Upper Saddle, New Jersey, USA.
42. Dagiene, V. and G. Futschek, 2010. Introducing informatics concepts through a contest. In IFIP Working Conference: New Developments in ICT and Education. Universite de Picardie Jules Verne, Amiens.
43. Williams, L., E. Wiebe, K. Yang, M. Ferzli and C. Miller, 2002. In support of pair programming in the introductory computer science course. Computer Science Education, 12(3): 197-212.
44. Costello, A.B. and J.W. Osborne, 2005. Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis. Practical Assessment, Research and Evaluation, 10(7): 1-9. Available online: http://pareonline.net/getvn.asp?v=10&n=7