IT-Based Solution to Foster Student Engagement

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Fostering Engagement for Enhanced Learning in Computer Science Courses[1]

Abstract

In this paper, we illustrate the use of an activity based teaching methodology by suggesting an increase in students' engagement through the use of specialized software tools in an introductory cybersecurity course. An activity based cybersecurity course enhancement is proposed to foster student engagement. The proposed activities have shown promising results indicating enhanced learning by the students. The methodology used in other Computer Science courses, is likely to enhance interest of students in other Computer Science (CS) and Information Technology (IT) program areas as well. We anticipate that enhanced learning in a cybersecurity course, in particular, and CS and IT courses, in general, is expected by increasing students' engagement through projects in network security software installation, testing and measurements. Students' learning is measured and assessed for the proposed activities in the course that could lead to development of similar teaching approaches and better understanding and effectiveness of most STEM related courses. In addition, students' survey showing general attitude towards research after the course is included. It was observed that although the proposed course activities did not significantly enhance the students' research interests, most continued their strong interests in CS or IT major with a strong possibility of conducting a supervised research.

Introduction

In general, many colleges and schools offering computer science and information technology programs face issue of low enrollment and even more serious problem of high dropout in both programs. Researchers of science, technology, engineering and math, also known as STEM, [1] propose that one of the problem for student's retention and recruitment in STEM program is that they are not able to associate themselves to this area. Institute of Electrical and Electronic Engineers (IEEE) and the Association for Computing Machinery (ACM) support engagement among school and university students [8]. A pilot study reported in [9] of beginner students indicates that students in Computer Science and other related fields reason, engage and relate to the knowledge content of the discipline.

In [2] authors present a model named Supporting Collaboration and Adaptation in a Learning Environment (SCALE) that uses web-based and activity-oriented learning environment to help and improve student learning for courses at introductory level. Generally, the purpose of the introductory courses is to establish sound understanding of the fundamentals [10]. This prepares students for success in advance courses later in the program [2]. Lectures, assignments and exams are more traditional methods of teaching that at time may not work because of larger number of students and limited class times. These traditional approaches encourage students to memorize course contents rather than understanding main concepts. In literature we can find number of

[1] This project was supported in part by a LIFE (Learning Innovations that Foster Student Engagement) minigrant to acquire the software at CSIT Department, Clayton State University.

additional approaches used for teaching such approaches. Tablet PC are reported in [11] to be used to enhance student engagement for programming courses. Use of computer games is another approach reported in [12] for teaching algorithm and programming concepts and [13] reports use of Web-Based laboratories for courses covering digital circuits, data representations, computer architecture, operating systems and networking to name a few.

Computer programming fundamentals has always been challenging to teach for faculty, and learning these concepts for students who are beginning in the computer science program. Traditional teaching is not effective in achieving course goal in such a course because of lack of active student engagement. In order to help students in these beginning courses we need to integrate and use techniques and technology that will help them to develop and improve programming skills through dynamic teamwork [3]. In addition, in most of the cases the class sizes are bigger, students are unprepared and have diverse level of understanding thus putting extra burden on the faculty. In some cases traditional face to face teaching along with tutorial and lab exercise may work but with the change in the way today's student communicate and learn, we may require a different approach to achieve our goals [14]. Advances in the field of technology have proven their usefulness in the context of learning and teaching in the approach named Information and Communication Technology (ICT) [15]. The authors in [3] present a different approach that utilizes the agile principles of pair programming.

Teacher and student both realize that learning in CS and IT related courses is often challenging because not only that the concepts are difficult but, it is also hard to visualize interrelation among these concepts and their operation. System of Teaching Intelligent Interventions (STII) is presented in [4] for use in teaching Web-Based computer science courses. Another problem is that because of difficulty in grasping these difficult concepts student tend to not engage in learning process. However, students can be be more active and engaged in learning if we are successful in generating some of kind of interest in the subject matter and make lessons more enjoyable [5]. Relationship between educational outcomes and student learning and its connection with student engagement makes educators worried how to achieve all these goals. Authors [7] propose use of Web 2.0 interaction tool to achieve student engagement. The results reported show that synchronous learning can bring not only higher student engagement but also academic output.

Study Description

The study reported in this paper shows that fostering of engagement in a cybersecurity course improves the learning outcomes. Although this course is not a gateway course but due to importance of cybersecurity nationally and internationally, it is certainly an important course to be considered for this study. Moreover, network security is an important STEM area and hence it is part of the required curriculum in Computer Science and Information Technology related programs. The course used for the study is a required course for BS in IT with networking concentration and is offered every spring with enrollments ranging from 20 to 30 students. This course addresses network and web-based security issues in general: network intruders (hackers), security policies and procedures, firewall, encryption, authentication and access control, and viruses. In addition, security issues unique to e-commerce systems are covered: electronic payments, secure transactions, secure sockets layer, digital signatures and auditing. Traditionally this course has been a part of E-Commerce track in IT program. However, due to relevance of

topic to computer networks, and discontinuation of e-commerce track, the course replaced another networking track course years ago. Some new topics have been included and some older topics have been modified. The current learning objectives are as follows:

1. Explain and differentiate security architectures, security design, security management and security strategies
2. Demonstrate the mastery of cryptography, security and privacy concepts
3. Demonstrate the understanding of digital signatures and authentication
4. Demonstrate the understanding of mathematics of cryptography including symmetric and asymmetric key ciphers
5. Explain key management and distribution including Kerberos
6. Identify and compare various encryption and security standards such as DES, AES, RSA etc.
7. Explain network security architecture and concepts such as PGP, MIME, SSL, TLS and IPSec.
8. Demonstrate secure network design practices

The project to improve the course via proposed hands-on activities has the following goals:

i) Create active learning components to foster student engagement
ii) Provide security software practice (installation, testing and measurements) to students to enhance learning
iii) Assess students' learning for the created components
iv) Summarize the assessment outcomes in form of report and/or paper publication

Current learning activities in this course does not involve sufficient student engagement. As a result students always struggle to learn the concepts associated with mathematics of cryptography, symmetric and asymmetric key ciphers, and security architectures such as DES (Data Encryption Standards), AES (Advanced Encryption Standards), PGP (Pretty Good Privacy) etc. New course projects and activities are proposed that will enhance learning by fostering engagement of students in the course. As a broad impact of the proposed learning activities, it is expected that students in this course in particular, and students in the program in general, will become aware of the network security challenges. It is also expected that these activities will strengthen the course and will help in anticipated departmental efforts to participate in development of cyber security program.

The new activities in the cybersecurity course are based upon acquired software. Following three activities are proposed:

Cain and Abel Program:

1. Practice network sniffer APR (ARP Poison Routing).
2. Perform password recovery.
3. Test of hash calculator for at least three type of hashes.
4. Hash cracking using dictionary attack.

PGP Program:

1. Creation of your own private key to be used in PGP and then setting up the personal keyring.
2. Creation of a word file with secret message and encrypting the file with different types of keys.

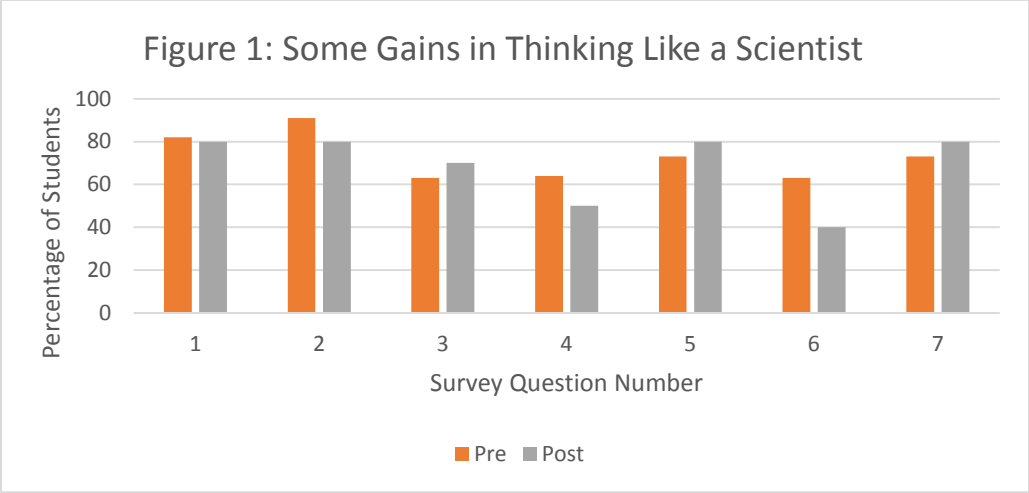
PGP Program:

Email send/receive using built-in encryption/decryption in PGP.

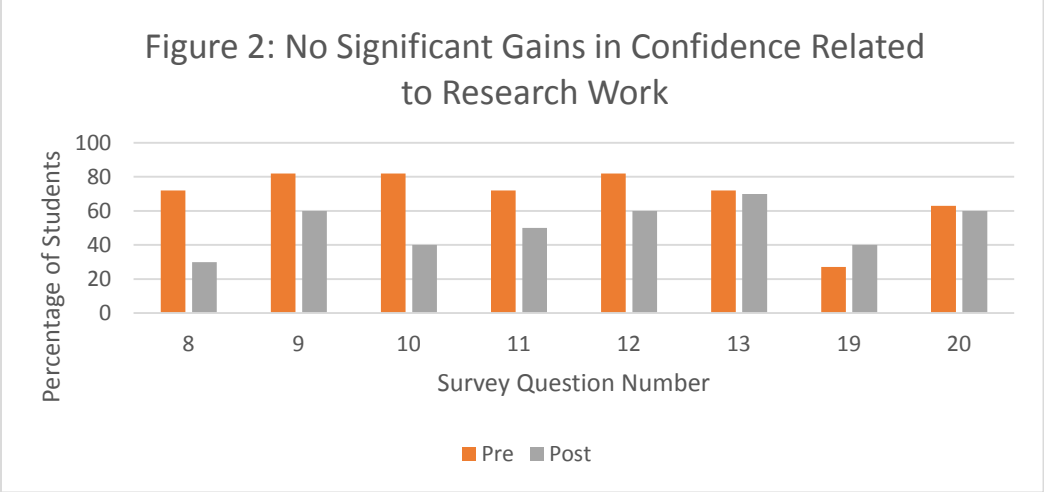
Results/Data Analysis

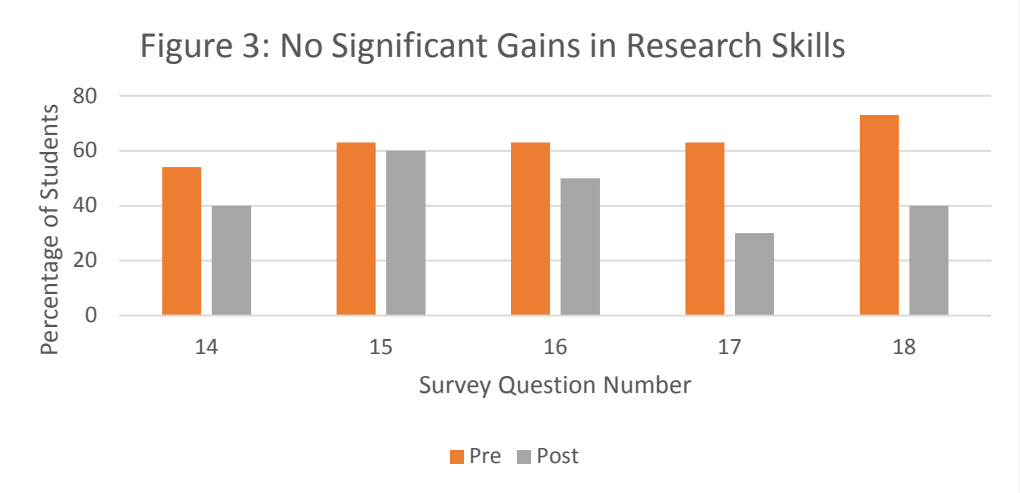
The assessment data consists of two categories: a SALG (Student Assessment of Learning Gains) category focusing on learning gains in general, and a category based upon1-5 Likert scale scores obtained by students' self-assessment of their activities for completed steps in the proposed enhanced course. Within the second category, the results are divided into two groups: first for software usage, installation, testing and demonstration, and the learning associated with it. The second group consists of other learning outcomes related to the course as a results of proposed software based activities. The result is tabulated and overall effectiveness of activity based learning is observed in both categories.

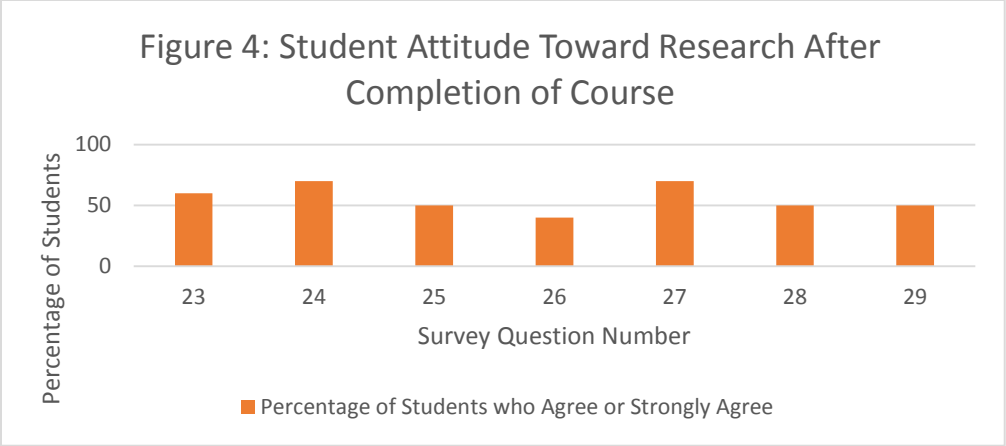
Finally, the obtained project results are presented in form of tables and graphs. The graphs indicate the learning gains in general with overall STEM focus. There were 29 questions in the survey ranging from questions on scientific understanding to various types of research abilities. We present here the results in four groups. The survey questions are included in the Appendix. Pre and post SALG surveys graphs are shown in Figures 1-4.



The activities in project resulted positively in most students thinking process as shown in Figure 1. Most students think like a scientist. However, most students do not believe that they gained any research skills or acquired confidence in research work (Figures 2 and 3). Also, it was observed that the proposed course activities did not significantly enhance the students' research interests. It is mainly because of the activities designed to focus on course learning outcomes. This gives rise to a future course enhancement where a research activity may be included in the course outcome. In Figure 4, survey results showing general attitude towards research after taking the course was included. It was observed that most students continued their strong interests in CS or IT major with a strong possibility of conducting a supervised research.







Outcomes	Before (12 students' average)	After (12 students' average)
Group 1a Overall: Demonstrate an understanding of Cain & Able software via illustrating the:	**2.33**	**3.38**
Use of network sniffer APR (ARP Poison Routing)	1.92	3.25
Password recovery process	3.42	3.42
Test of hash calculator for different types of hashes	1.67	2.83
Hash cracking using dictionary attack	2.33	4.00
Group 1b Overall: Demonstrate the understanding of PGP Program via illustrating the:	**2.81**	**3.83**
Creation of private key to be used in PGP and then setting up the personal keyring	3.58	4.08
Creation of a word file with secret message and encrypting the file with different types of keys	2.17	3.75
Email sending/receiving using built-in encryption/decryption in PGP	2.17	3.42
Group 2 Overall: CLO 2 - Demonstrate the mastery of cryptography, security and privacy concepts	**2.17**	**3.15**
Block cipher design concepts	1.67	2.75
Substitution cipher concepts	2.5	3.5
Symmetric encryption/cipher concepts	2.17	3.33
Transposition cipher design and concepts	2.33	3.0

The major accomplishments of this research are now presented. Students' learning for various course outcomes listed above are measured by self-assessment on a Likert 1-5 scale. As mentioned above, the results are divided into two groups: first for software based learning including software installation, testing and demonstration. The second group consists of other learning outcomes related to the course as a results of proposed software based activities. The result is tabulated and presented in above Table 1.

The findings and projects designed for the course are kept for anyone teaching this course or a similar course in future. Therefore anyone teaching this course can benefit from it and hence that ensures the sustainability of the project not just for this course but also for any similar course in future.

Conclusion

The work presented in this paper is aimed to promote and support student learning process through fostering student engagement using IT based solution. We designed, developed and illustrated the use of a new active learning based methodology to increase student activities that is expected to enhance interest in CS and IT related courses. Based upon the collected and analyzed data above we make the following conclusions:

1. According to SALG survey, in general students were more confident about their research skills before the study. Most students perhaps realized their lack of understanding about research resulting in lower overall post survey results. This result may also be due to lack of research related activities in the course. A future course enhancement may include such an activity as part of the course learning outcomes.
2. For the current course learning outcomes, it is evident that the use of software enhanced their understanding of the subject matter and their learning did improve as a result of using two acquired software.

Lessons Learned from the pilot study:

As expected, use of software enhanced the learning of students in the course. In the past learning activities in this course did not involve sufficient student engagement. As a result students always struggled to learn the concepts. New course projects and activities that were proposed enhanced learning by fostering engagement of students in the course. It is expected that similar activities and additional software will further enhance the student learning in this course.

Reference:

1. Peters, A. and Pears, A., "Engagement in Computer Science and IT – What! A matter of Identity?", In proceedings of 1st International Conference on Learning and Teaching in Computing and Engineering, pp. 114-121, Los Alamitos, USA, 2013.
2. Verginis, I., Gogoulou, A., Gouli, E., Boubouka, M. and Grigoriadou, M., "Enhancing Learning in Introductory Computer Science Courses Through SCALE: An Empirical Study",

IEEE Transactions on Education, VOL. 54(1), February 2011.
3. Isong, B. “A Methodology for Teaching Computer Programming: first year students’ perspective”, International Journal of Modern Education and Computer Science, Vol. 9, pp. 15-21, 2014.
4. Kanellopoulos, D., Sakkopoulos, E., Lytras, M. and Tsakalidis, A. “Using Web-Based Teaching Interventions in Computer Science Courses”, IEEE Transactions on Education, VOL. 50(4), November 2007.
5. Atech, C. and Alicia Charpentier, A., “Sustaining Student Engagement in Learning Science”, The Clearing House: A Journal of Educational Strategies, Issues and Ideas, Vol. 87(6), pp. 259-263, 2014.
6. Reyes, M., Brackett, M., Rivers, S., White, M., and Salovey, P., “Classroom Emotional Climate, Student Engagement, and Academic Achievement”, Journal of Educational Psychology, pp. 700-712, Vol. 104(3), 2012.
7. Gavin Northey, G., Bucic, T., Chylinski, M., and Govind, R., “Increasing Student Engagement Using Asynchronous Learning”, Journal of Marketing Education, pp. 171-180, Vol. 37(3), 2015.
8. Entwistle, N. “Conceptions of Learning and the Experience of Understanding: Thresholds, Contextual Influences, and Knowledge Objects,” in Re-framing the conceptual change approach in learning and instruction, S. Vosniadou, A. Baltas, and X. Vamvakoussi, Eds. Amsterdam, The Netherlands: Elsevier, 2007, ch. 11.
9. Perry, W., “Different worlds in the same classroom,” Improving Learning: New Perspectives, pp. 145–161, 1988.
10. “Computing curricula 2001, computer science,” ACM/IEEE-Curriculum 2001 Task Force, Dec. 2001 [Online]. Available: http:// www.computer.org/curriculum or http://www.acm.org/education/curricula.
11. Koile, K. and Singer, D. “Improving learning in CS1 via Tablet-PCbased in-class assessment,” in *Proc. ICER*, Canterbury, U.K., Sep. 9–10, 2006, pp. 119–126.
12. Clua, E. “A game oriented approach for teaching computer science,” in *Proc. WEI*, Belém, Brazil, 2008, Anais do XXVIII Congressoda Sociedade Brasileira da Computação, pp. 10–19.
13. L.-K. Soh, N. Khandaker, X. Liu, and H. Jiang, “A computer-supported cooperative learning system with multiagent intelligence,” in *Proc. AAMAS*, Hakodate, Japan, May 8–12, 2006, pp. 1556–1563.
14. Biggs, J. What the Student Does: teaching for enhanced learning, Higher Education Research & Development, 18:1, 57-75, 1999.
15. Jones, G. and Knezek, G. Non-commercial radio-satellite telecommunications: affrordable options for technology educators. Cited in S. Romi (2000) Distance Learning and Non-formal Education: Existing Trends and New Possibilities of Distance Learning Experiences. Educational Media International. 37 (1), 39-44, 1993.

Appendix: Sample SALG Survey (29 Questions)

THINKING AND WORKING LIKE A SCIENTIST: APPLICATION OF KNOWLEDGE TO RESEARCH WORK.

Presently, I understand the following concepts that will be explored in this course…	not at all	just a little	somewhat	a lot	not applicable
1. Analyzing data for patterns.	A	B	C	D	E
2. Problem-solving in general.	A	B	C	D	E
3. Formulating a research question that could be answered with data.	A	B	C	D	E
4. Identifying limitations of research methods and designs.	A	B	C	D	E
5. Understanding the theory and concepts guiding my research project.	A	B	C	D	E
6. Understanding the connections among scientific disciplines.	A	B	C	D	E
7. Understanding the relevance of research to my coursework.	A	B	C	D	E

PERSONAL CONFIDENCE RELATED TO RESEARCH WORK

Presently, I…	not at all	just a little	somewhat	a lot	not applicable
8. Have confidence in my ability to contribute to science.	A	B	C	D	E
9. Feel Comfortable discussing scientific concepts with others.	A	B	C	D	E
10. Feel Comfortable working collaboratively with others.	A	B	C	D	E
11. Have confidence in my ability to do well in future science courses.	A	B	C	D	E
12. Am able to work independently.	A	B	C	D	E
13. Understand what everyday research work is like.	A	B	C	D	E

SKILLS

Presently, I am able to…	not at all	just a little	somewhat	a lot	not applicable
14. Write detailed and thorough scientific lab reports or project reports and/or make poster or oral presentations.	A	B	C	D	E
15. Explain my scientific projects and lab activities to people outside my field.	A	B	C	D	E
16. Keep detailed and thorough records of lab or course project tests and/or results.	A	B	C	D	E
17. Conduct accurate observations, experiments and/or tests in the lab or field.	A	B	C	D	E
18. Effectively use statistics to analyze data.	A	B	C	D	E

The following questions ask about your overall research experience and about your attitudes or behaviors as a researcher.

Presently, I…	not at all	just a little	somewhat	a lot	not applicable
19. Feel like a scientist.	A	B	C	D	E
20. Feel that I think creatively about my course work.	A	B	C	D	E

Research experience

Questions related to past experiences.	yes	no
21. I have presented or a talk or poster related to STEM to other students or faculty.	A	B
22. I have previously written a laboratory report and/or project report.	A	B

Questions related to your current major.

Rate how much you agree with the following statements.	Strongly disagree	Disagree	Agree	Strongly agree
23. I feel satisfied with my current field of study or major.	A	B	C	D
24. I am thinking about changing my major.	A	B	C	D
25. I feel prepared to take part in conducting scientific research.	A	B	C	D
26. I have conducted independent research before.	A	B	C	D
27. I want to take part in an independent research project	A	B	C	D
28. What is your current major? (please answer on comments section of scoring form; indicate question #28)				

Demographics.

What year are you in college?	Freshman/rising sophomore	Sophomore/rising junior	Junior/rising senior.	Senior	Other
29. I am a:	A	B	C	D	E