

28th Annual Conference of the Australasian Association for Engineering Education (AAEE 2017)

ORDER OF PROCEEDINGS

SYDNEY, 10-13 DECEMBER 2017



Publication Information

All full papers accepted for publication in the Proceedings of the 28th Annual Conference of the Australasian Association for Engineering Education were submitted as full papers and were blind peer reviewed. Authors were given the opportunity to amend their paper in light of these reviews before the decision to accept and publish the paper was made. This process of reviewing is in accordance with the criteria set for research papers by the Department of Education, Employment and Workplace Relations (DEEWR) and the Department of Innovation, Industry, Science and Research (DIISR) of the Australian Government.

This Publication Title: Proceedings of the 28th Annual Conference of the Australasian Association for Engineering Education (AAEE 2017)

Author: Australasian Association for Engineering Education Conference (28th: AAEE 2017)

Editors: Nazmul Huda, David Inglis, Nicholas Tse, Graham Town

Published in Australia by: School of Engineering, Macquarie University, Sydney, Australia

ISBN: 978-0-646-98026-3

© 2017 Australasian Association for Engineering Education

These proceedings are copyright. This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit

<http://creativecommons.org/licenses/by/4.0/>

Responsibility for the contents of the articles rests upon the authors and not the publisher. Data presented and conclusions drawn by the authors are for information only and not for use without independent substantiating investigations on the part of the potential user.

AAEE-2017 Proceedings

Paper #	Authors	Title	Page #
3	Cat Kutay and Elysebeth Leigh	Aboriginal Engineering - technologies for an enduring civilisation	6
7	Cat Kutay, Anthony Kadi and John Canning	Flipped learning not flopped learning	14
9	Eugene Tham and Lori Breslow	A Study on Integrating Case-Based Learning into Engineering Curriculum	22
10	Grace Panther and Devlin Montfort	Comparing Students and Practicing Engineers in Terms of How They Bound Their Knowledge	31
11	Kacey Beddoes and Grace Panther	Mapping the Integrated Research Landscape on Gender and Teamwork in Higher Education: 2000-2016	37
13	Kourosh Dini and Aaron Blicblau	An initial step towards developing techno-entrepreneurs in the engineering curriculum	45
15	Anna Lyza Felipe, Thanh Chi Pham, Minh Xuan Nguyen and Edouard Amouroux	Interdisciplinary Collaborative Teaching in Project-Based Learning Approach	54
16	Mohammad Al-Rawi and Annette Lazonby	A new strategy for active learning to maximise performance in intensive courses	62
17	William McBride and Bernadette Foley	Engineering Exposure to Professional Practice: Navigating the requirements	73
18	Chris Whittington, Tim Anderson and Andy Conner	Embedding Authentic Practice Based Learning in Engineering Undergraduate Courses	85
20	Sasha Nikolic and Raad Raad	Designing and Using Self-Paced Tutorials: Lessons from the Pilot	96
21	Bohuslav Bušov and Vladimír Dostál	TRIZ - Trans-disciplinary innovation methodology	104
22	Antonette Mendoza, Harald Sondergaard and Anne Venables	Making sense of Learning Management System's quiz analytics in understanding students' learning difficulties	112
23	Guien Miao, Lynn Berry and David Lowe	What can we do to better support students in Thesis?	121
25	Jonathan Scott, Elaine Khoo, Michael Cree and Sinduja Seshadri	Assessment of Self-Management Skills in a Project-Based Learning Paper	129
26	Hossein Askarinejad and Matt Ramezani pour	Integration of Applied Research in Polytechnic Engineering Education	139
27	Lynn Berry	Integrated Engineering may be necessary, but perhaps design would be taken more seriously?	147
31	Beverly Coulter, Roslyn Petelin, Justine Gannon, Kate O'Brien and Corrie Macdonald	Enhancing Technical Writing Skills for Undergraduate Engineering Students	160
32	Anne Gardner, Keith Willey and Thomas Goldfinch	Characterising the learning dispositions of first year engineering students	170
33	Tiyamike Ngonda, Corrinne Shaw and Bruce Kloot	Mechanical engineering students' perceptions of workplace mentoring: A case study at a South African University of Technology	180
36	Iuliia Shnai and Leonid Chechurin	Teaching creativity creatively	188
37	Homero Murzi, Andrea Mazzurco and Beverly Coulter	Integrating Professional Practice in the Engineering Curriculum: BE/ME Chemical Engineering Students' Experiences in Industry Placements	198
39	Stuart Palmer and Tiffany Gunning	Engineering Student Use of Facebook as a Social Media 'Third Space'	206
40	Dawn Bennett	Metacognition as a graduate attribute: Employability through the lens of self and career literacy	214
44	Jarred Benham, Jonathan Li and Linda McIver	Tangible Teaching Tools: The Use of Physical Computing Hardware in Schools	222

45	Konstantin Shukhmin and Iouri Belski	Introducing TRIZ Heuristics to Students in NZ Diploma in Engineering	230
46	S. Ali Hadigheh and Daniel Dias-Da-Costa	Implementing MUSIC Components to Enrich Engineering Capstone Projects: The Students' Perspective and the Instructors' Standpoint	238
47	Viktor Berdonosov, Elena Redkolis and Won Young Song	International Student Online TRIZ (Teoriya Resheniya Izobretatelskikh Zadach) conferences: organizational experience and perspectives	245
49	Miranda Ge and Jonathan Li	STEM Intervention Strategies: Sowing the Seeds for More Women in STEM	254
51	Andrea Mazzurco, Homero Murzi and Ilje Pikaar	Moral Development of Students Entering the Civil Engineering Bachelor	263
53	Alison-Jane Hunter, Dorothy Missingham, Colin Kestell and Linda Westphalen	Refocusing Marking Practices to Enculturate Learning: Developing a Practice Architecture	271
54	Jennifer Harlim, Debra Nestel and Iouri Belski	Developing a simulated Work-Integrated-Learning (WIL) program to improve problem solving skills of young engineers	279
55	Pavel Livotov	Modelling Innovation Process in Multidisciplinary Course in New Product Development and Inventive Problem Solving	287
56	Jennifer Harlim and Iouri Belski	The Allocation of Time Spent in Different Stages of Problem Solving: Problem finding and the development of engineering expertise	295
60	Sally Inchbold-Busby and Rosalie Goldsmith	Developing three-dimensional engineers through project-based learning	303
64	Jeremy Smith, Nick Brown, Alison Stoakley, Jennifer Turner, Bianca Anderson and Alanta Colley	The Rise of Humanitarian Engineering Education in Australasia	312
65	Iouri Belski	Engineering Creativity – How To Measure It?	321
66	Serene Lin-Stephens, Shaokoon Cheng and Agisilaos Kourmatzis	Future-Proof Engineers with Transformative Calibres	329
67	Dylan Cuskelly and William McBride	A new, common, experiential 'Engineering Practice' course	337
68	Dorothy Missingham, Antoni Blazewicz, David Strong, Mei Cheong and Harry Lucas	Understanding Capacity in Creativity and Problem Analysis among Engineering Students	346
69	Gavin Buskes and Iouri Belski	Prior Knowledge and Student Performance in Idea Generation	354
70	Margaret Jollands, Wageeh Boles and J. Fiona Peterson	Developing students' employability in work placements	362
71	Jeremy Leggoe and Sally Male	Student Experiences of Threshold Capability Development in a Computational Fluid Dynamics Unit Delivered in Intensive Mode	369
72	Matthew Hughes, Ricardo Bello Mendoza, Manaia Cunningham, Kendra Sharp and Richard Manning	Towards integration of the Māori world view and engineering: A case study on student design projects for the Koukourarata community, Aotearoa/New Zealand	378
74	Luke Alao and Llewellyn Mann	Using Narrative Research Findings as Student Voice for Providing Insights into Transition Experiences in Engineering Education	390
75	Sally Male	The Emerging Suite of Virtual Work Integrated Learning Modules for Engineering Students	399
76	Tim Wilkinson	Long term study of attendance rates in a civil engineering unit of study	407
78	Andrea Mazzurco and Homero Murzi	Evaluating Humanitarian Engineering Education Initiatives: A Preliminary Literature Review	415

79	Kali Prasad Nepal	Offshore Students' Perception of Intensive Engineering Subject Delivery: Case Study at an Indian University	423
80	Bronwen Cowie, Margaret Paiti and Janis Swan	Engineering as a "Thinkable" Career for Women	430
81	Alison Stoakley, Nick Brown and Sarah Matthee	The role of a humanitarian focus in increasing gender diversity in engineering education	438
82	David Holmes and Michelle Lasen	Explicitly teaching teamwork and written communication within a problem based curriculum: Development of a generalised framework	448
84	Brent Phillips, Trudy Harris and Lynette Johns-Boast	Student Expectations: The effect of student background and experience	456
87	Anisur Rahman, Mohammad Aminur Rahman Shah and Sanaul Huq Chowdhury	Students' social and behavioural factors influencing the use of lecture capture technology and learning in engineering education	466
88	Peter Doe, Seeta Jaikaran-Doe, Sarah Lyden, Ming Liu, Bingzhong Ren, Peng Yang and Sally Male	Intensive Mode Teaching for the delivery of engineering content to students at a Chinese university	474
89	Bernadette Foley, Tiffany Gill, Bouchra Senadji, Edward Palmer and Elisa Martinez Marroquin	Developing a Management System for Engineering Education (MaSEE)	484
91	Warren Smith, Craig Wheeler, Colin Burvill, Alex Churches and Tim Riley	The Warman – Looking Beyond 30 Years	491
92	Mark Tunnicliffe and Nicola Brown	Evaluation of a redesigned Engineering degree founded on project based learning	503
93	Iain Skinner	Ethics problems found challenging by research students	512
94	Subeh Chowdhury	Deviating from traditional lectures: Engineering students' perception of active learning	518
95	Heather Weltman, Furqan Hussain and Nadine Marcus	We Built It and They Came: An Adaptive eLearning Experience	528
96	Charles Lemckert and Amir Etemad Shahidi	Mixing Teaching Approaches to Maximise Student Learning Experiences	536
97	Louis Taborda, Li Liu and Lynn Crawford	Role of Experiential Learning in PM Education	542
98	Kacey Beddoes	Professors' Discourses on Why Underrepresentation Matters	550
99	Fiona Johnson, Stephen Foster, Carla Frankel, Sam Johnson, Stephen Moore, Richard Stuetz and Jacqueline Thomas	Making a difference: creating opportunities for undergraduate students to contribute to humanitarian engineering projects	558
104	Chris Whittington and Sangeeta Karmokar	STEM for Women and Ethnic Communities in Aotearoa (New Zealand)	566
105	Bill Collis, Chen Wang, Gerard Rowe, Elizabeth Rata and Graham McPhail	Towards an informed course design	576
106	Jiachun Huang, Scott Wordley and Ashlee Pearson	Self and Peer Assessment of Teamwork Activities	586
108	Bill Collis, Gerard Rowe and Claire Donald	Redeveloping an introductory course in microcontrollers through the lens of educational theory	595
109	Huaizhong Li and Sushila Chang	Does 'just in time' design thinking enhance student interest and appreciation of customer needs in the design of machine elements?	606
110	Niccolò Becattini and Gaetano Cascini	A scientific framework for testing creativity enhancing techniques	613
111	Christoph Dobrusskin	What is easier to solve: open or closed problems?	621
114	Sangeeta Karmokar	Changing Role of Modern Engineers and Social Responsibility	630

115	Braden Phillips and Michael Liebelt	A flipped classroom with low-stakes assessment to maintain student engagement and integrate theory and practice	639
116	John Vulic, May Lim, Stefan Felder, Shaun Chan, Jesse Jones and Lorenzo Vigentini	A Problem Shared is a Problem Halved: Benefits of Collaborative Online Engineering L&T Content Development	647
117	Nicholas Yee Kwang Tee, Hong Seng Gan, Andy Huynh, Veronica Halupka and Jonathan Li	Through the Looking Glass: Visualising Design Details with Augmented Reality	657
118	Tiffany Gunning and Siva Krishnan	A systematic approach to teaching and learning development in engineering	668
119	Van Thanh Huynh, Siva Chandrasekaran, John Long, Yufei Guo and Ian Gibson	Transformation in Engineering Education – A Case Study of Remote Learning experiences in China	677
120	Samuel Cunningham-Nelson, Andrea Goncher, Michelle Mukherjee and Wageeh Boles	Pointers to Conceptual Understanding	687
121	Nicola Brown and Mark Tunnicliffe	Staff competencies/capabilities required and challenges faced when delivering project based learning courses	696
125	Keith Willey and Anne Gardner	The use of threshold exams to change students learning culture and provide assurance of learning	706
126	Helen Fairweather, Margarietha de Villiers Scheepers, Renee Barnes, Jane Taylor, Irene Visser and Katryna Starks	Engineers learning about Entrepreneurship: The journey through the lens of an engineering academic	715
127	Samuel Cunningham-Nelson, Mahsa Baktashmotlagh and Wageeh Boles	Visualising Student Satisfaction	722
128	Emily Cook and Llewellyn Mann	The engineering fundamentals are important...but what are they?	731
129	Lokesh Padhye and Marion Blumenstein	In-Class and Asynchronous Student Response Systems: A Comparison of Student Participation and Perceived Effectiveness	738
131	Aaron Blicblau and Andrew Ang	First year engineering students problem solving in different scenarios.	750
133	James Theodosiadis, Steve Steyn and Steve Mackay	Assessing the efficacy of embedding online laboratories in e-learning tutorials to enhance student engagement	758
135	Varghese Swamy, Vineetha Kalavally, Ta Yeong Wu, Alena Tan and Jonathan Li	Cultural Contexts of Learning Preferences: Relative Dominance of Self-Directed versus Other-Directed Learning Styles	771
136	Michael Liebelt, Stephanie Eglinton-Warner, Wen Soong, Brian Ng, Braden Phillips, Said Al-Sarawi and Matthew Sorell	An Engineering Approach to Engineering Curriculum Design	777
139	Catherine Watson and Kelly Blincoe	Attitudes Towards Software Engineering in Industry	785
140	Kamanashis Biswas and Vallipuram Muthukkumarasamy	Quantitative Research Design to Evaluate Learning Platforms and Learning Methods for Cyber-security Courses	793
141	Roger Hadgraft, Rob Jarman, Justine Lawson and Beata Francis	Student-Centred Curriculum Transformation	800
142	Antonija Mitrovic, Peter Gostomski, Alfred Alfred Herritsch and Vania Dimitrova	Improving Presentation Skills of First-Year Engineering Students using Active Video Watching	809
145	Jiachun Huang, Ashlee Pearson, Nathan Sherburn, Thanh Huynh Nguyen, Tony Vo and Veronica Halupka	Educats: A Community of Practice	817
146	Ashlee Pearson, Scott Wordley, Jiachun Huang, Stephanie Duggan and Christopher Meikle	Engaging prospective students with Mechanical Engineering	826
150	Selena Griffith	Developing student capacity for Start Up through integrating engaged, action and threshold learning models with a design thinking framework.	833

151	Felix H. Kong, Brian K.M. Lee and Ian R. Manchester	Motivating diverse student cohorts with problem based learning in undergraduate control engineering	846
153	Rod Fiford	History and Philosophy of Engineering	854
157	Dahlia Han, Melissa Gunn and Rachel Chidlow	eLearning initiatives - can their effectiveness really be measured?	862
159	Kevin Sevilla, Andrea Goncher and Jim Morgan	The Self Directed Learning Styles Survey as a Predictor of Success in a Problem-Based Learning Environment	867
160	Dorian Hanaor, David Airey and Peter Cafe	Mining students work experience reports	873
162	Andrea Goncher and Josh Devitt	Development of Global Competencies through Humanitarian Engineering Experiences	881
165	Scott Daniel, Llewellyn Mann and Alexander Mazzolini	Defending interpretivist knowledge claims in engineering education research	889
166	Simon Cavenett	Inclusiveness in Australian Engineering Education	898
167	Timothy Smith, Alicen Coddington, Jennifer Turner, Llewellyn Mann, Enda Crossin, Emily Cook, Sivachandran Chandrasekaran and Andrea Mazzurco	Grounded by values: An emergent engineering practice	910
168	Jennifer Turner and Llewellyn Mann	Creating shared value: An industry project framework	919
169	Abu Shadat Muhammad Sayem, Benjamin Taylor, Mitchell Mcclanachan and Umme Mumtahina	Effective use of Zoom technology and instructional videos to improve engagement and success of distance students in Engineering.	926
171	Scott Daniel and Llewellyn Mann	Integrating Social Impact throughout an Engineering Curriculum	932
174	Fabian Steger, Alexander Nitsche, Cayler Miley, Hans-Georg Schweiger and Iouri Belski	Laboratory Learning: Hands-on versus Simulated Experiments	940
176	John Long, Simon Cavenett, Jason Steinwedeland Leanne Collins	Fast-Cars in Schools: a CADET Outreach Initiative	948
177	Alicen Coddington and Llewellyn Mann	Generating an architectural brief for a twenty-first-century engineering education working and learning environment.	955
179	John Long, Siva Chandrasekaran and Michael Pereira	Implementation of Project-Oriented Design-Based Learning in a Second-Year Mechanical/Mechatronics Subject	963
182	Jacqueline Thomas, Kiran Ijaz, Benjy Marks and Peter Gibbens	The Immersive Learning Laboratory: employing virtual reality technology in teaching	974
183	Benjamin Taylor, Lois Harris and Joanne Dargusch	Towards the development and delivery of sustainable assessment in foundation engineering studies	982
184	Alan Blair, David Collien, Dwayne Ripley and Selena Griffith	Constructivist Simulations for Path Search Algorithms	990
185	Marina Belkina	Inclusive engineering education: making engineering degree work for more students	999
186	Jacqueline Thomas, Petr Matous, Peter Cafe and Abbas El-Zein	Lessons learned from the design and delivery a new major in Humanitarian Engineering	1006
188	Sam Cheah and Christopher Browne	Towards a framework for evaluating diversity in STEM outreach programs	1017
194	Peter O'Shea and Philip Terrill	A systemic approach to improving tutor quality in a large unit	1028
196	Peter O'Shea	What can be learned from the humanitarian successes and failures of Thomas Edison	1035
197	Yun Dai and Ang Liu	What Difference Do the Differences Make: Cultural Differences as Learning Resources in a Global Engineering Course	1041

198	Poovarasi Balan	Application of Research Skills Development Framework (RSDf) in Sustainable Engineering Teaching and Learning	1049
203	Jim Morgan, Euan Lindsay and Kevin Sevilla	A “MetroGnome” as a tool for supporting self-directed learning	1058
207	Paul Briozzo, Rodney Fiford and Peter Lok	Creativity in Mechanical Design: Exploring Suitable Methodologies for Better Practice	1065
212	Michael Netherton, Lisa Nelson and Bill McBride	A New Project Management regime	1076
213	Ali Altalbe and Neil Bergamnn	The Importance of Student and Faculty Feedback in Development of Virtual Engineering Laboratories	1085
214	Sarah Barns, Edmund Pickering and Les Dawes	Worked Example Videos as a Valuable Blending Learning Resource in Undergraduate Engineering Units	1093
215	Meng Wai Woo	Case study based teaching of process economics in the context of Chemical Engineering	1101
216	Andrew Valentine, Iouri Belski and Margaret Hamilton	Can Idea Generation Techniques Impede Effective Ideation?	1109
217	Andrew Valentine, Iouri Belski and Margaret Hamilton	Analysis of Usage for Two Digital Format Ideation Templates	1117
218	Andrew Valentine, Iouri Belski, Margaret Hamilton and Scott Adams	Australian electrical engineering curricula and development of creativity skills: How do we rate?	1125
219	Nigel Shepstone	The Correlation between Practice Time and Student Improvement in Mathematics	1133
220	Xi Jin and Roger Hadgraft	Understanding Engineering Competencies in Practice and its Educational Implication	1140
223	Lixin Wang	TRIZ Education in Mainland China	1150
224	Trudy Harris, Johnny Gordon, Bandana Kumar and Paul Price	Integrated Pathways: Connecting the Disconnected	1158
225	Alexander Kist, Hannah Campos Remon, Lindy Orwin, Andrew Maxwell, Ananda Maiti, Peter Albion and Victoria Terry	Running an Open MOOC on Learning in Laboratories	1167
226	Sonia Saddiqui and Maya Marcus	STEAMPunk Girls Co-Design: Exploring a more Integrated Approach to STEM Engagement for Young Women	1175
227	Alan Parr and Xi Jin	Researching reflection in an engineering internship program	1185
230	Ljiljana Brankovic, Stephan Chalup and Mark Wallis	Teaching Advanced Computing Technologies to Managers, Engineers and Other Professionals	1193
231	Claes Fredriksson and Joel Galos	An Integrating Teaching Resource for Materials Science and Engineering	1201
233	Bibiana Arango and Ana Maria Tamayo Mejía	Retention in the School of Engineering of the Universidad Pontificia Bolivariana Medellín-Colombia	1209
235	Graham Town, Nic Tse, Byron Wilson, and Darren Bagnall	Integrated Engineering – Implementation and Transition	1220

Quantitative Research Design to Evaluate Learning Platforms and Learning Methods for Cyber-security Courses

Kamanashis Biswas, Vallipuram Muthukumarasamy
School of ICT, Griffith University, Gold Coast
{k.biswas, v.muthu}@griffith.edu.au

SESSION C1: Integration of theory and practice in the learning and teaching process

CONTEXT Teaching security courses is a challenging task in computer science program since it requires careful integration of theoretical concepts with their practical applications. In this paper, a quantitative approach is used to evaluate effective learning platforms and different learning styles for cyber-security courses. The outcomes of the study show that practice-based learning is the most effective learning method for cyber-security courses and student performance can further be enhanced significantly through social learning instead of solitary learning.

PURPOSE The main goal of this research is to understand the effects of learning styles and platforms for successful adaptation of different pedagogical practices. The following research questions are designed to achieve the expected outcomes.

- ✓ For cyber-security courses, does the performance of a student match with his/her self-specified learning performance?
- ✓ How learning platforms affect a student's performance in cyber-security courses? What factors play significant roles to successfully run a cyber-security course?
- ✓ Which type of learning mechanism is the most effective for cyber-security courses? Is learning in a group better than individual learning?

APPROACH Quantitative research is defined as a scientific method which follows a number of procedures such as generation of models, identifying theories and hypotheses, development of instrumentals and methods for measurement, experimental control and manipulation of variables, collection of empirical data, modelling and analysis of data and evaluation of results. This research follows experimental modes of inquiry which follows a standard form namely, participants, materials, procedures and measures.

RESULTS The results show that there is no single platform that includes all features to successfully run a cyber-security course. However, this problem can be solved by integrating those features with existing platforms. The study also suggests that learning performance can further be enhanced by choosing appropriate learning style.

CONCLUSIONS This paper investigates the impacts of learning platforms and learning strategies for cyber-security courses. Similar experiments from different aspects will be interesting to test their validity. The outcome can be used for further decision making e.g., the correlation of learning style difference could help to determine whether customized learning styles would be more effective for teaching cyber-security courses

KEYWORDS Quantitative research, Learning style, Cyber-security

Introduction

With the increased use of World Wide Web, malware and cyber-threats have also increased exponentially in the last few years. While cyber-attacks have been growing rapidly, it was predicted that there would be a global deficit of about two million cyber-security professionals in 2017 (Zantua, Dupuis, & Popovsky, 2015). This shortfall in critical cyber-security skills can mainly be overcome by promoting cyber-security programs in higher education. However, teaching cyber-security at undergraduate or postgraduate levels has been challenging for a number of reasons and has led to a shortage of qualified people with the right skills. This global phenomenon is due to lack of expertise and resources to develop and teach such programs, and keep up with continuously evolving discipline. The digital disruption and adoption of fast changing technologies by businesses and customers create a perfect environment for adversaries. The unknown vulnerabilities, zero-day exploits, high risk levels and possible consequences with lack of countermeasures leave the governments, businesses and industries off-guard. From world leading organizations to small businesses have fallen victims and became an embarrassing situation for nations.

The solution to cyber-security challenges begins from creating skilled workforce in this space, who will have the fundamental knowledge and skills to evaluate and address issues. Since any security solution is a balancing act, the fact evolving nature of threats require understanding and appreciation of the issues at all levels. This demands immediate action to roll out programs by educational institutions at various stages: undergraduate, postgraduate, professional development, up-skilling of workforce etc. Scholarship of Learning and Teaching needs to happen to steadily improve cyber-security education and cope with future challenges. Since learning platforms and individual learning style play a significant role in students' performance, this study uses a quantitative approach to evaluate them in real classroom environment. Quantitative research deals with systematic and scientific investigation of quantitative properties and phenomena, and their relationships. One of the key benefits of quantitative approach is that the procedure ensures reliability and validity of experiments. The main goal of this research is to understand the effects of learning styles and platforms for successful adaptation of different pedagogical practices. The following research questions are designed to achieve the expected outcomes.

- For cyber-security courses, does the performance of a student match with his/her self-specified learning performance?
- How learning platforms affect a student's performance in cyber-security courses? What factors play significant roles to successfully run a cyber-security course?
- Which type of learning mechanisms is the most effective for cyber-security courses? Is learning in a group better than individual learning?

Related Works

Extensive research have been conducted to investigate the applicability of both new and existing learning styles and platforms during last few decades. This is because learning platforms and learning strategies have significant impacts on learning outcomes. A learning platform is an integrated set of interactive services that provides the participants access to common resources and communication tools as well as exchange information with each other. Similar to learning platforms, learning strategies also offer a number of ways to enhance learning capabilities. For example, problem based learning provides an efficient way to acquire basic competencies where students learn about a topic through the solving of problems (Gorghiu, 2015). In contrast, students are presented with the problem in inquiry based learning and asked to demonstrate self-analysis and critical thinking required to solve the problem (Gordon, 2015).

Sheen (2015) proposed an extensible technology framework for cyber-security education. The paper explores different types of teaching methods, technology, and means used to

explain theoretical concepts. The framework uses a central engine to coordinate learning management with infrastructure in order to reduce administrative burden in cyber-security education.

Alshammari, Anane, and Hendley (2015) proposed an approach for learning style adaptivity and developed an e-learning system to facilitate personalized and adaptive learning. The authors also conducted experiments on sixty subjects and the results indicate that matching learning materials with learning style of the students significantly enhance learning gain and satisfaction.

Bell, Vasserman, and Sayre (2015) developed an assessment tool that can be used to measure student interest and self-efficacy in relation to cyber-security. This tool enables educators to detect changes in student outcomes and thus helps in systematically improve pedagogical strategies.

Cheung, Cohen, Lo, and Elia (2011) used Challenge Based Learning (CBL) methodology to cyber-security courses. In this approach, students are encouraged to collaborate with their peers, ask questions and develop a thorough understanding of the studied concepts and solve real world challenges. In addition to this, participating in cyber-security competitions, publishing research findings and making presentations are held regularly for guiding activities.

In this paper, our main emphasis is on different learning styles and platforms that can be used to enhance learning performance of students in cyber-security courses. Modern learning platforms like PebblePad, Blackboard and Facebook page are also evaluated in the experiments as they are most commonly used tools for interactive learning.

Quantitative Research Methodology

Quantitative research is defined as a scientific method, which generally follows a number of procedures such as generation of models, identifying theories and hypotheses, development of instrumentals and methods for measurement, experimental control and manipulation of variables, collection of empirical data, modelling and analysis of data and evaluation of results (Cresswell, 2003). The quantitative research methodology includes less rigorous experiments known as quasi-experiments, which are more suitable compared to true experimental designs as it does not have any time and logistical constraints. This research follows experimental modes of inquiry, which follows a standard form namely, participants, materials, procedures and measures. The following subsections describe these four forms of experimental methods used in this research.

Participants

For this experiment, 30 undergraduate students of the Network Security course and 21 postgraduate students of the Network Information Security course have been selected, who are studying Bachelor of Information Technology (BIT) and Masters of Information Technology (MIT) programs. This study follows a $2 \times 2 \times 2$ factorial design: resources (learning platforms, learning styles), statement of values (implicit, explicit), and participants' identification (BIT, MIT). In addition, another dimension: individual versus group is also included in the experiments as a control and relevant for learning styles.

Variables

The main objective of this research is to evaluate the impacts of learning platforms and learning styles for cyber-security courses. A number of standard questions are designed for experiments to collect each student's individual preference. The collected data are tested and verified against real time responses conducted throughout the courses. The implicit statement of values condition is measured from the standardized format used in the experiment, whereas the explicit statement of values condition is obtained measuring the

responses of the participants (BIT and MIT). Group experiments are also designed to analyze the treatment variables and the performance measures of the students obtained from the experiments are used to draw the final conclusion.

Instrumentation and Materials

The experiments are conducted for six consecutive weeks during lab hours and each week students are asked to answer or solve a number of questions. In first part, students are provided five technical questions and engaged in a repetitive question and answer session to find the correct solutions. The second part consists of five complex and challenging problems to be solved collaboratively. For the third part, a number of practice questions are provided and on the basis of knowledge acquired to solve those problems, the students are asked to solve five related questions. The answers are collected through three different platforms namely Blackboard, PebblePad and Facebook page. While submitting answers through PebblePad, students faced problems to upload their answers because of missing instructions. A mock experiment with dummy questions is held to overcome the problem. The following topics are used in undergraduate questionnaires: Unix Programming, Public Key Infrastructure, Hash and Digital Signatures, Security Tools, SQL Injection, and Same Origin Policy. On the other hand, postgraduate questionnaires include Advanced cryptographic schemes, Cipher modes, Secure Electronic Transaction (SET), Intrusion Detection System (IDS), Firewalls, and IP traceback. Some of these questions are descriptive (e.g., which features differentiate intrusion prevention system from IDS?) whereas some others are technical (e.g., for a given network scenario, what configurations should be changed to establish a telnet connection between two systems?). At the end of each week's workshop, students' answers are collected through learning platforms for evaluation. The outcomes are the average of the students' six weeks performance.

Experimental Procedures

The experimental procedure includes four steps: i) collection of demographic data, ii) learning platforms, instrument and materials, iii) learning styles and iv) learning tasks. In learning tasks, students answered a number of questions related to weekly lectures. Three learning platforms are used alternately to obtain the answers and the measurement is done on collected data to evaluate students' self-reported learning styles. As mentioned above, a mock session has also been conducted to overcome the PebblePad problem and the new results are recorded for analysis. Another experiment is done by randomly assigning students into groups (ten undergraduate and seven postgraduate groups) where each group consists of exactly two members. We have used the $2 \times 2 \times 2$ factorial design experiment that uses two treatment variables to examine the performance as well as effects of the treatment variables on final outcomes. In this task, students are asked to develop a simple host based Intrusion Detection System. All students received the same background knowledge required to solve the task. The experiment has been conducted from two dimensions: one is problem/ practice based solution (*A*) that seems to be relevant to learning styles whereas individual/ group (*B*) dimension serves as a control. The first group only receives the treatment as shown below.

Group A: $R \text{ ----- } O \text{ ----- } X \text{ ----- } O$
 Group B: $R \text{ ----- } O \text{ ----- } O$

Here, **X** denotes treatment, manipulation, induction, **O** denotes measurement, observation, and **R** is random assignment.

Threats to Validity

Threats of validity are classified into two categories: i) internal validity threats and ii) external validity threats. The following subsections describe each of these threats.

Internal Validity Threat Control

History- In this experiment, both groups have experienced the same current events. So no other current event affected the change in the dependent variable. *Maturation-* No changes occur in the dependent variable due to normal experimental processes because both groups experience the same experimental processes. *Selection-* As all the subjects are selected and all of them have received treatment or control condition, there is no impact on the dependent variable. *Experimental Mortality-* It means that whether some participants drop out and does it affect in the results or not. In the experiments, the same participants involved in the entire study in both experimental and control groups, so there appears to be no bias. *Testing-* Both groups get a pre-test in the experiment but a pre-test may have the experimental group more sensitive to the treatment. *Instrumentation-* The measurement method, materials and instruments have not been changed during the research.

External Validity Threats Control

Unique program features- A motivated set of facilitators for small group discussions may exist. *Effects of Selection-* probably applicable to other computer science courses. *Effects of Setting-* computer science students have their own culture, so it is doubtful if this would be applicable to other types of students such as medical students. *Reactive effects of experimental arrangements-* it would be better to imitate the results in other related programs.

Results and Analysis

The first experiment has been designed to test whether the performance of an individual student matched with his/her self-specified learning performance. The outcomes indicate that problem-based learning is more preferable compared to inquiry-based and practice based learning styles for cyber-security courses. 78.43% students have found right answers through problem-based learning, whereas the amount for practice-based and inquiry-based learning is 62.74% and 54.90% respectively. This outcome is consistent with their self-reported learning styles as shown in Figure 1. The percentile representation of experimental outcomes shows that 40% students learn better through problem-based learning whereas the number is 32% and 28% for practice-based and inquiry-based learning respectively. These figures are very close to their self-specified learning styles where 46% students chose problem-based learning, 30% of them preferred practice-based learning, and the rest 24% students specified inquiry-based learning.

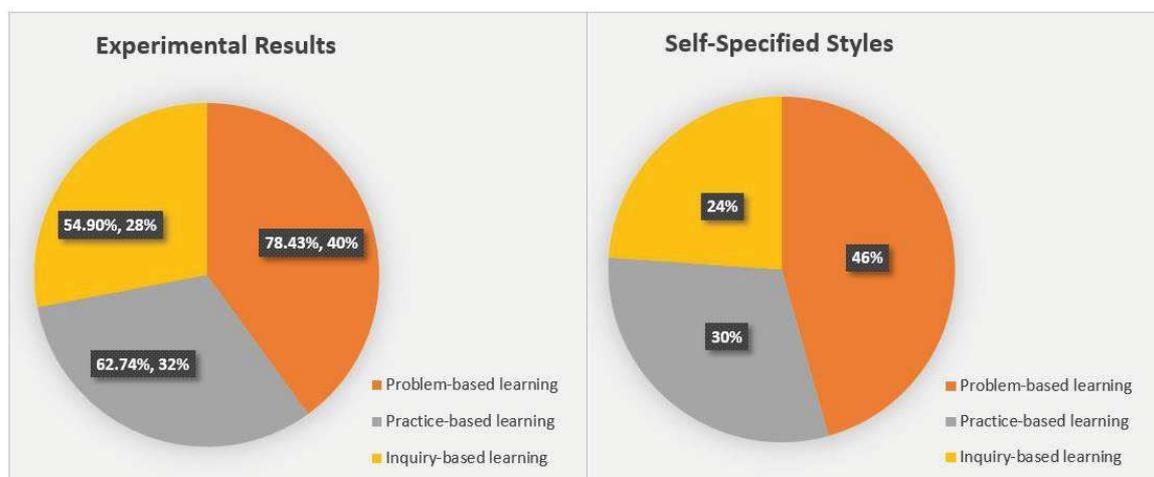


Figure 1: Learning performance outcomes for different learning styles

The second experiment is conducted to examine the impacts of different learning platforms. Students' responses are observed and accuracy is measured in terms of successful

collaboration and effective use of provided resources. The outcomes show that 67.78% accuracy is achieved while using PebblePad, whereas the level of accuracy obtained for Blackboard and Facebook Page is 53.30% and 49.23% respectively. However, in self-specified instrument, 38% students chose to use Blackboard while 33% and 29% of them specified PebblePad and Facebook Page as their preferred learning platforms as shown in Figure 2. Thus, experimental results do not support self-specified learning platforms. We noticed that PebblePad supports some unique features compared to other platforms such as individual feedback, group feedback, sharing workbook with any group member. PebblePad is a good learning platform for collaboration among group members and course instructor. Although Facebook Page is more user friendly, it doesn't provide most of the basic features such as setting submission deadline, student grading and integration of third party tools. On the other hand, Blackboard supports many third-party tools such as SafeAssign, TurnItIn, Tweak and WebAssign. However, in addition to other limitations, Blackboard is not user friendly like PebblePad and Facebook Page. From the experiments, it is understandable that there is no unique platform, which provides all necessary features to run a cyber-security course. In terms of students' satisfaction and learning performance, PebblePad outperforms other two platforms in our experiments.

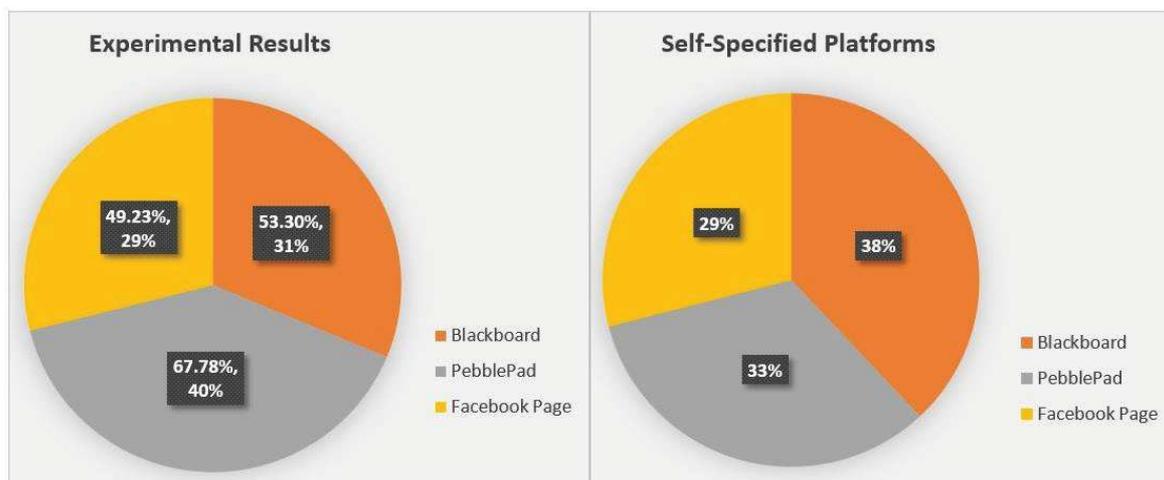


Figure 2: Impacts of different learning platforms on learning outcomes

To address third research question, students are divided into multiple groups with exactly two members: ten undergraduate groups and seven postgraduate groups. In this task, undergraduate and postgraduate students are asked to develop a simple IDS and an advanced IDS respectively using shell script in groups and individually. The IDS has two parts: i) verification file generation and ii) intrusion detection. Practice-based learning method has been implemented as a learning strategy for the first part whereas problem-based approach is followed for the second part. Students are taught basic shell script programming and essential features required to design the IDS. From obtained results, it was found that 88.23% students in groups could solve the part 1 using practice-based method, whereas it is 64.70% for individual. On the other hand, part 2 is solved by 76.47% students working in groups, whereas it is 47.05% for individual learning. We also calculated the *chi-square p* value with one degree of freedom. The *p* value is 0.478, which indicates that there is no statistically significant difference between the observed value and the expected value. Thus, the experimental outcomes indicate that learning in groups is more suitable compared to individual learning for cyber-security courses. Similarly, practice-based learning is more effective than problem-based learning according to obtained results.

Conclusion

This paper investigates the impacts of learning platforms (Blackboard, PebblePad and Facebook Page) and learning strategies (inquiry-based, problem-based and practice-based) for cyber-security courses. Similar experiments from different aspects (e.g., Yammer platform and project based learning) will be interesting to test their validity. The results show that there is no single platform that includes all features to successfully run a cyber-security course. However, this problem can be solved by integrating those features, wherever possible, with existing platforms. The study also suggests that learning performance can be enhanced by choosing appropriate learning style. The outcome can be used for further decision making such as the correlation of learning style difference could help to determine whether customized learning styles would be more effective for teaching cyber-security courses. This paper will provide a good background for researchers interested to perform further research in cyber-security education. Our future work aims to evaluate other learning platforms and learning styles to examine their applicability for cyber-security courses.

References

- Alshammari, M., Anane, R., & Hendley, R. J. (2015). *The Impact of Learning Style Adaptivity in Teaching Computer Security*. Paper presented at the Innovation and Technology in Computer Science Education Conference, (pp. 135-140). Vilnius, Lithuania: ACM.
- Bell, R., Vasserman, E., & Sayre, E. C. (2015). *Developing and Piloting a Quantitative Assessment Tool for Cybersecurity Courses*. Paper presented at the 122nd ASEE Annual Conference and Exposition. Seattle, WA: American Society for Engineering Education .
- Cheung, R. S., Cohen, J. P., Lo, H. Z., & Elia, F. (2011). Challenge Based Learning in Cybersecurity Education . Paper presented at the International Conference on Security and Management (SAM 11), (pp. 524 – 529).
- Cresswell, J. W. (2003). *Research Design : Qualitative, Quantitative and Mixed Meth-ods Approaches*. SAGE publications.
- Gordon, N. B. (2015). Inquiry based Learning in Computer Science teaching in Higher Education. *Innovation in Teaching and Learning in Information and Computer Sciences* , 22-33.
- Gorghiu, G. D. (2015). Problem-Based Learning - An Efficient Learning Strategy In The Science Lessons Context. *Procedia - Social and Behavioral Sciences*, 1865-1870.
- Sheen, F. J. (2015). An extensible technology framework for cyber security education. Brigham Young University. Retrieved May 12, 2017, from <http://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=5374&context=etd>
- Zantua, M., Dupuis, M., & Popovsky, B. E. (2015). *RE-ENGINEERING THE CYBERSECURITY HUMAN CAPITAL CRISIS*. Retrieved May 17, 2017, from <http://faculty.washington.edu/marcjd/articles/Re-engineering%20the%20Cybersecurity%20Human%20Capital%20Crisis.pdf>