DOI: https://doi.org/10.24191/ijsms.v6i1.12879

Effectiveness of Peer Tutoring Program on Students' Academic Performance for Engineering Course

Fei Ha Chiew[1*], Clotilda Petrus[2], Siti Zaidah Othman[3], Joe Davylyn Nyuin[4] and Ung Hua Lau[5]

[1,2,3,4]Faculty of Civil Engineering, Universiti Teknologi MARA Cawangan Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

[5]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Cawangan Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

[1]chiewfa@uitm.edu.my; [2]clotilda166@uitm.edu.my; [3]sitizaida@uitm.edu.my; [4]joenyuin@uitm.edu.my; [5]uhlau@uitm.edu.my

Received: 4 August 2020
Accepted: 30 January 2021
Published: 31 March 2021

ABSTRACT

This study investigated the effectiveness of a peer tutoring program that was implemented for Basic Solid Mechanics course, as an intervention program to improve students' performance in the course. Ten tutors were chosen to provide tutoring services to an experimental group of 36 tutees. Tutees were required to answer an entry test before the intervention program, and another exit test after the program. A control group which shared the same instructor in their lecture classes was included in the study. Comparison between the performances for entry and exit tests of both experimental and control groups were made. Analyses showed an increase in the percentage of students that passed the exit test from the experimental group. The average marks for the experimental group in the exit test also increased, compared to their marks in the entry test. A Mann-Whitney U test conducted indicated a significant difference between the gain scores of the experimental group and control group. A further meta-analysis revealed a large effect size, signaling the practical significance of the results. The findings demonstrated the effectiveness of the peer tutoring intervention program on students' performance of the course.

Keywords: *Intervention; peer tutoring; fundamental engineering courses; academic performance*

INTRODUCTION

Universities and higher institutions today are increasingly seeking alternative approaches that supplement traditional classroom learning, especially when budgets have been cut and student populations have risen in many universities (Miller, Groccia & Miller, 2001; Johari et al., 2018; Jong & Kuan, 2020). Students' retention is a challenge faced by higher learning institutions. Retention among students is often caused by inappropriate study skills and learning approach which do not fit with the traditional lecture and tutorial structure of higher education modules (Fox et al., 2010). The Department of Education, Skills and Employment Australia (2018) reported 14.97% of Australian domestic students who began their bachelor degree program in 2017 did not continue to their second year. In Malaysia, between 2000 and 2010, 30,000 of the total 168, 000 students in diploma and certificate programs did not graduate as reported. Apart from that, 17,000 out of 100,000 students who went for their degree program (between 2000 and 2010) did not actually finish the entire program (Lajiun, 2012). This showed that 17.5% of students in Malaysia's higher learning institutions were not able to finish their programs during that period. On the other hand, from 20 public universities in Malaysia, the Malaysia Educational Statistics Booklet 2018 recorded that engineering, manufacturing and construction programs contributed to the highest number of students who did not graduate (Mustafa, 2019).

Studies (Lassegard, 2008; Colvin & Ashman, 2010) showed that two of the most common and effective interventions in universities and higher institutions that involve students helping other students to ensure their success are peer tutoring and peer mentoring. Peer mentoring is a program where certified and trained peer mentors (selected from senior students from the same faculty) help new students settle themselves into university life. The peer mentors guide new students (i.e., mentee) how to adapt to the new environment and navigate their university life. Peer mentors give support in various aspects including experience sharing, encouragement and academics. Studies (Terrion & Leonard; 2007; Snowden & Hardy, 2012; Chester, Burton, Xenos & Elgar, 2013; Hryciw, Tangalakis, Supple & Best, 2013) showed that universities and colleges have implemented peer mentoring program as part of their student support services. In Malaysia, University of Nottingham Malaysia (n.d.) and

Monash University Malaysia (n.d.) offer peer mentoring scheme to provide a platform for students to create an informal networking and knowledge sharing with other students. In the University of Malaysia Sarawak, peer mentoring system is adopted by the Faculty of Medicine and Health Sciences. In this system, all students from year 1 to year 5 participate in the program. Under the program, each participant has his own "buddy line" which connects the juniors and seniors together. Each participant can be a mentor and mentee at the same time (Lian et al., 2015).

On the other hand, peer tutoring refers to a senior student helping junior students with a specific course content. Peer tutoring is an economically and educationally effective intervention for students with weaker academic achievements. This is because tutors are students, and can be hired at relatively low prevailing wage (Pugatch & Wilson, 2018). A tutor is a senior student in the same faculty that has passed the course with a good grade and is trained in tutoring strategies. In a peer tutoring program, a tutor supports and directs the learning processes through active questioning and explaining during tutoring class, while the tutee is a junior student receiving help and guidance from the tutor (Roscoe & Chi, 2008; De Backer, Van Keer & Valcke, 2012). Several studies (Loke & Chow, 2007; Cheng & Ku, 2009; Chen & Liu, 2011; Arco-Tirado, Fernández-Martín & Fernández-Balboa, 2011) showed that peer tutoring has proven to be a valuable experience and resource, and can benefit both the tutors and tutees, socially and educationally by motivating them to learn (Miller, Miller, Armentrout & Flannagan, 1995; Colvin, 2007; Galbraith & Winterbottom, 2011). A recent study by Pugatch and Wilson (2018) advertised varied peer tutoring services to college students via postcards, in order to encourage students to take up peer tutoring services offered by the university. These postcards included messages to encourage students to attend tutoring, including framing tutoring as a positive social norm or offering small financial incentives to overcome resistance to attendance. The study found that there is an increase in the tutoring attendance after advertising. Another study by Raja, Low and Lim (2018) adopted a peer tutoring program where students who failed a subject were grouped in groups of a maximum of 10 students and each group was tutored by a peer-tutor who had passed the subject with a minimum grade of A-. The tutoring classes were conducted two hours per week for a duration of four to five weeks. Results of the study showed that the academic achievement of the tutees after attending the program was considerably improved.

Alegre Ansuátegui, Moliner Miravet, Lorenzo Valentín and Maroto (2018) did a meta-analysis of findings from 50 independent programs on peer tutoring in Mathematics in their study. The study found that 88% of the programs have positive effects on the academic performance of the participants. In Multimedia University Malaysia (n.d.), the Faculty of Engineering and Technology also initiated a peer tutoring program to help students improve their academic performance. Tutors provide extra classes to supplement normal lecture and tutorial classes for a selected course. The peer tutoring class focuses on discussing tutorial and past year examination questions of the course.

Basic Solid Mechanics is one of the engineering mechanics subjects in civil engineering programs. Studies show that high failure rates (i.e., failure rates greater than 20%) in engineering mechanics subjects are often experienced by universities and higher institutions that offer engineering programs (Goldfinch, Thomas & Carew, 2009; Karim, 2010). Goldfinch et al., (2009) in their research paper mentioned that first year engineering students in three universities in Australia (i.e., University of Wollongong, University of Tasmania, University of Technology, Sydney and the Australian Maritime College) were experiencing failure rates from 20% to 40% in engineering mechanics. Prusty and Russell (2011) in their research also pointed out that it is common to have failure rates up to 50% in introductory engineering mechanics courses, and this has been a continuous concern for Australian Universities and Engineering Schools. Ochoa, Pérez and Puga Berrio (2016) in their research also expressed their concern on students' performance in the Statics course in the engineering program of Engineering School of EAFIT University between 2006 and 2011. Faculty of Civil Engineering at Universiti Teknologi MARA Sarawak Campus has also encountered similar high failure rates problem (i.e., failure rates greater than 20%) for the Basic Solid Mechanics course.

In the Faculty of Civil Engineering at Universiti Teknologi MARA Sarawak Branch, peer tutoring has been adopted as an intervention program especially for courses with failure rates greater than 20%. However, the effectiveness of such programs has never been studied. Therefore, this study investigated the effectiveness of a peer tutoring program that was implemented for Basic Solid Mechanics course. Peer tutoring is used in this study because this method is suitable to be implemented to improve students' understanding in a particular course.

This paper discusses on how a peer tutoring intervention program was conducted for students of Basic Solid Mechanics course, which is a second semester course in the Diploma of Civil Engineering Program. Analyses were conducted to evaluate the effectiveness of the intervention program on the students' academic performance.

METHODOLOGY

This study was conducted to evaluate the effectiveness of peer tutoring intervention program (named "buddy system") on students' academic performance. The fundamental course chosen for this program is Basic Solid Mechanics. This study employed quasi-experimental design. Students who were currently registered under the course were invited to participate in the program on a voluntary basis. From a total of 46 students who have registered for the course, 36 students expressed their willingness to participate in the peer tutoring program. Therefore, all 36 students were accepted to participate in the program and were taken as the experimental group. The remaining 10 students who declined the invitation were taken as the control group in this study. Thus, there were unequal sample sizes for the two groups, and was considered as the limitation of this study. Both experimental and control groups share the same two instructors in their normal lecture and tutorial classes. Prior to the intervention program, both experimental and control groups were given an entry test. There were two questions given in the entry test, which covers the first two chapters in the syllabus of the course.

The intervention program was carried out on the experimental group. The students in the experimental group were divided into small groups with a maximum of 5 members. Each small group was tutored by a senior student, who was chosen from a group of students who have passed the course with minimum grade B. A total of ten mentors were appointed in this program. All the tutors were trained by the two instructors prior to the intervention program. The instructors identified common students' weaknesses and selected topics to be covered during the intervention program. A set of solid mechanics problems was prepared by the instructors. There were two specific chapters being covered in this intervention program namely, from the topics of: (1) linear stresses and strain systems; and (2) stresses, deflection and the influence lines of

statically determinate beams.

The flowchart for this intervention program is shown in Figure 1. Before the program started, all participants (i.e., both experimental and control group) were required to answer an entry test. The time given to answer the test was thirty minutes. After the entry test, the experimental group students were segregated according to their assigned small group and tutor. They then commenced the learning activities by solving the given solid mechanics problems, facilitated by their respective tutors.

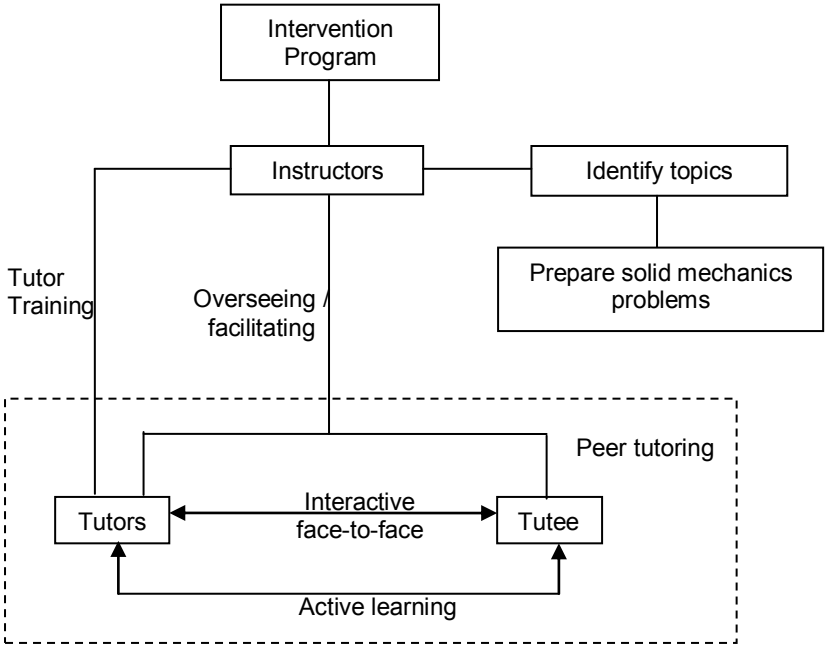

Figure 1: Intervention Program Flow

The learning activities through this peer tutoring program were carried out in an active and well-guided learning process. Tutees were free to ask questions and answer the problems given at their own pace. Additional facilitations were also provided by the instructors who were overseeing the whole activities during the program. The program was conducted for four hours. After the intervention program, all students (i.e., both experimental and control groups) were required to answer an exit test.

This exit test was given to determine the improvement in the level of understanding and problems solving skills on the two chosen topics. Participants of the experimental group were also asked to fill in their feedback about the program in a simple online survey after the program.

RESULTS AND DISCUSSION

The effectiveness of the intervention program in improving the understanding of the participants was analyzed and presented based on the results obtained from the entry and exit tests. Some intangible benefits of the intervention program were also observed and recorded. Figure 2 shows the performance of the experimental group for both entry and exit tests. Generally, 91.67% of the experimental group achieved higher scores in the exit test, 5.56% had the same scores for both entry and exit tests, while 2.77% achieved lower scores in the exit test. Figure 3 shows the performance of control group for both entry and exit test. It was observed that 50% of the control group achieved higher scores in the exit test, 10% had the same scores for both tests, while the remaining 40% had lower scores in the exit test.

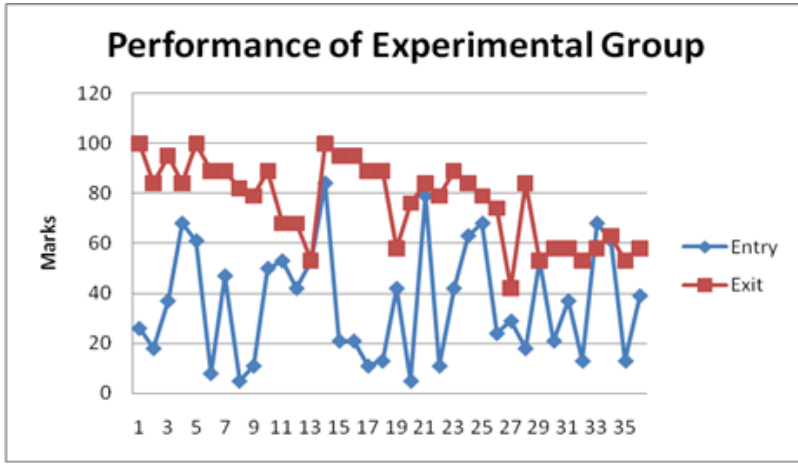

Figure 2: Performance of Experimental Group

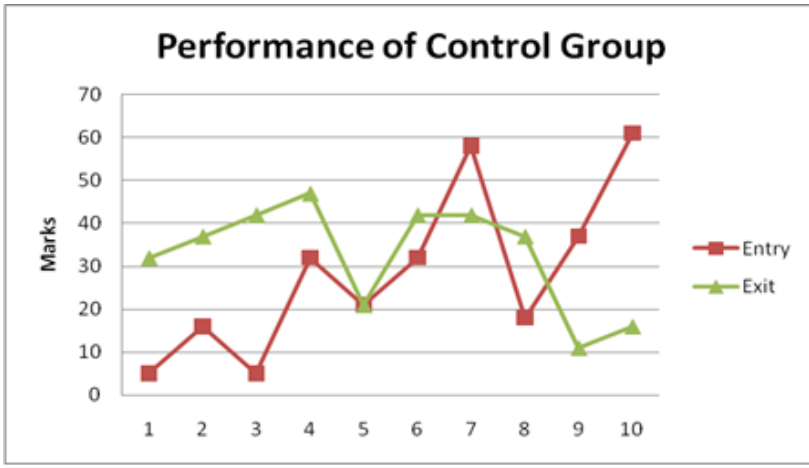

Figure 3: Performance of Control Group

Further comparison between the experimental group and the control group was made. Figure 4 shows the comparison between the performance of both experimental and control groups for the entry test. The performances of students in both groups show similar patterns. The experimental group has an average mark of 36.53%, with 33.33% of the group achieving 50% and above. The control group has an average mark of 28.5% with 20% of the group scoring 50% and above.

Figure 5 shows a graph comparing the performance of students in exit test. It is obvious that the marks obtained by the experimental group in the exit test are higher than the control group. The experimental group has an average mark of 76.42% in the exit test, with 97.22% of the group achieving passing mark (i.e., 50%) and above. The control group, on the other hand has an average mark of 32.7% in the exit test, and all the students in this group are not able to achieve the passing mark.

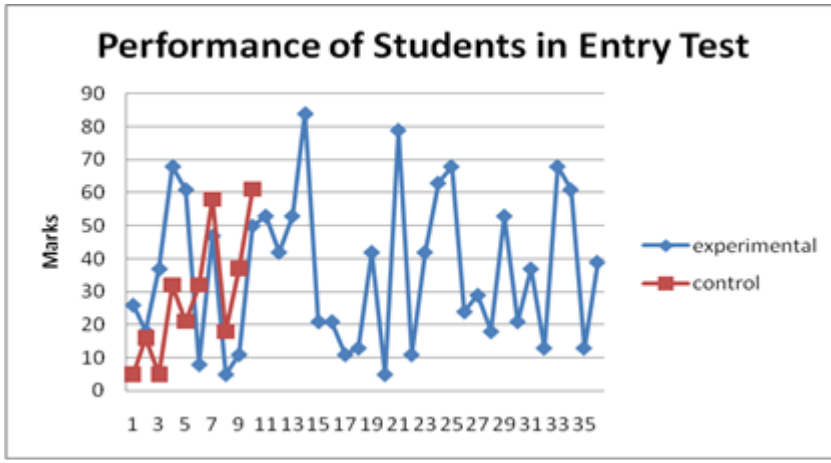

Figure 4: Comparison of Students' Performance in Entry Test

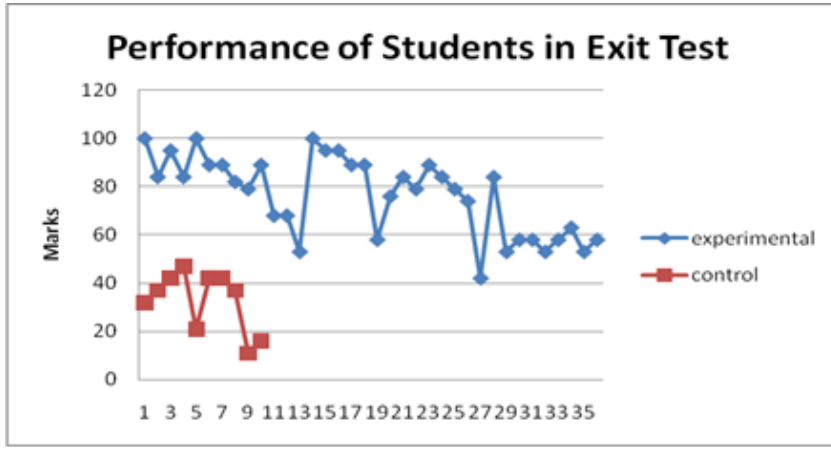

Figure 5: Comparison of Students' Performance in Exit Test

Table 1 shows the descriptive statistics on the gain scores (i.e., difference between exit and entry test marks) of the two treatment groups. A preliminary test on the normality of the gain scores of the two treatment groups was conducted using Shapiro-Wilk Test. Results of the normality test is shown in Table 2. It has detected non-normality in the score for the experimental group. For that, a non-parametric statistical test was then considered for analysis on the significance of the differences between the

gains scores of the groups. A Mann-Whitney U test conducted revealed the result as in Table 3. This test indicated a significant difference in the gain score of the two groups (U=69.50, p=0.03), with the experimental group score (Median=39.50) higher than that of control group score (Median=12.50). A further meta-analysis on the test revealed a large effect size (r=1.35), signaling the practical significance of the result obtain. The findings from this study demonstrated the effectiveness of the peer tutoring intervention program on students' performance of the course.

Table 1: Descriptive Statistics of the Gain Score

	Group	N	Mean	Median	Standard deviation
Gain Score	Experimental	36	39.89	39.50	27.92
	Control	10	4.20	12.50	25.83

Table 2: Normality Test Result

		Shapiro-Wilk		
	Grouping	Statistic	df	Sig.
Gain Score	Experimental	.923	36	.015
	Control	.935	10	.501

Table 3: Mann-Whitney U Test Result

	Gain Score
Mann-Whitney U	69.500
Wilcoxon W	124.500
Z	-2.945
Asymp. Sig. (2-tailed)	.003

FEEDBACKS FROM RESPONDENTS OF PROGRAM

The feedbacks from respondents of the online survey are shown in Figures 6, 7, 8 and 9. Figure 6 shows the responses from respondents of their opinion in the materials used in the intervention program. All of the respondents (i.e., 100%) agreed that the materials used in the intervention program were useful in improving their understanding of the topics (i.e., 52.94% chose "very helpful", while 47.06% chose "somewhat helpful"). When they were asked to give feedback on the tutors (Figure 7), all the respondents agreed that the guidance of tutors was helpful in improving

their understanding of the topics of solid mechanics (i.e., 58.82% chose "very helpful", while 41.18% chose "somewhat helpful"). When they were asked whether they agree that the program is to be conducted every semester (Figure 8), 52.94% chose "very much agree", while 47.06% chose "somewhat agree" that the program is to be conducted every semester. Therefore, we can conclude that all the respondents agreed that the intervention program should be conducted every semester. Figure 9 shows the response of participants on their level of appreciation to the University for conducting the peer tutoring program (i.e., buddy system) for the course. From analysis, 58.82% of the respondents chose "very appreciate", while 41.18% chose "somewhat appreciate". From the respondents' feedback, we can say that the participants of the program generally appreciate the university's effort in conducting the peer tutoring program. Few students also commented in their feedback that the program should include more mentors and be conducted more regularly during the semester. These responses from the respondents generally reflected that the respondents were happy and satisfied with the program.

Some interesting observations were noticed during the intervention program. It was observed that participants of the experimental group enjoyed their learning time very much. There were very active discussion and thus making the learning environment happier, lively and less stressful compared to their normal lecture classes. Participants were seen involved actively and showed impressive teamwork and communication while finding the best solutions for the problems given in tutoring session. Some tutees were also seen to be giving help or advice to their friends sitting at the same table. Therefore, it can be concluded that the intervention program through peer tutoring is effective. Peer tutoring creates an active learning and interactive face-to-face environment that eventually contributes to better understanding for the course amongst the participants.

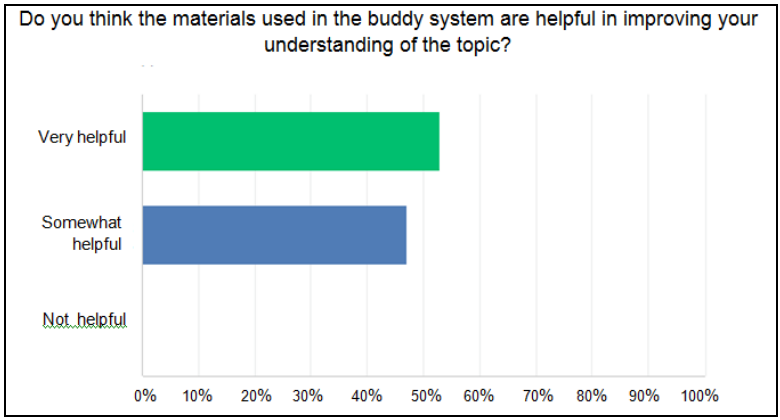

Figure 6: Feedback from Respondents on the Materials Used

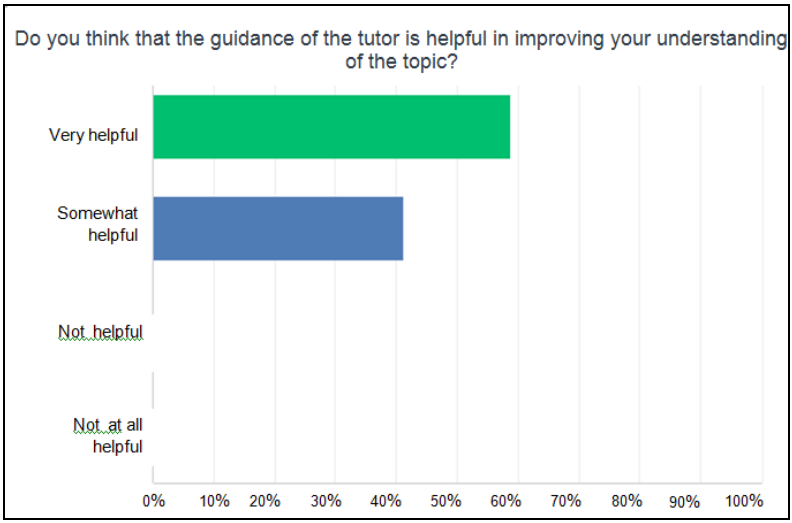

Figure 7: Feedback from Respondents on the Tutors

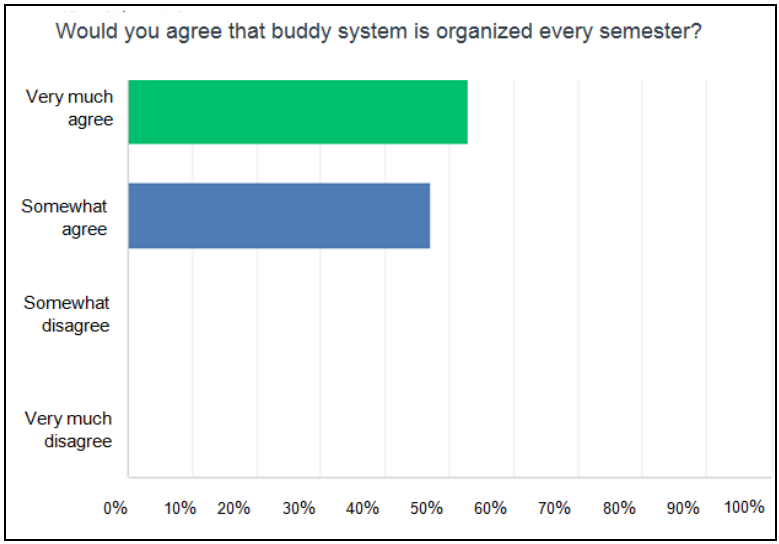

Figure 8: Feedback from Respondents on the Need of Intervention Program

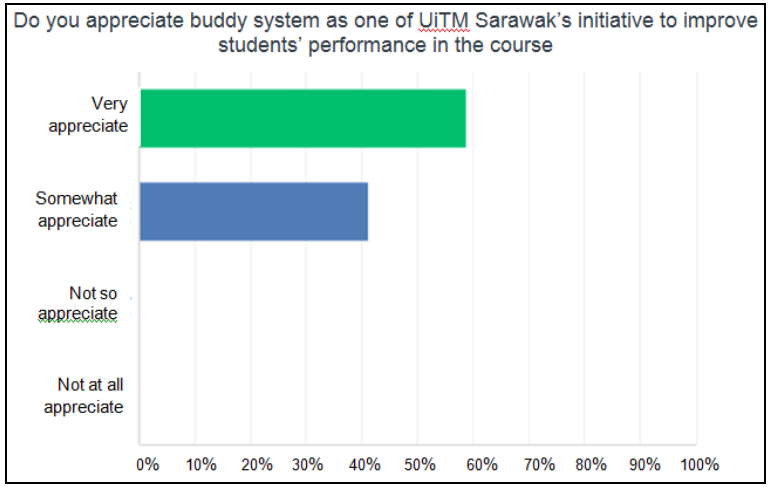

Figure 9: Students' Appreciation of Intervention Program

CONCLUSION AND RECOMMENDATIONS

Each student learns differently and has different strengths and weaknesses in their learning process. Therefore, the intervention program is required to facilitate the ability of students in understanding the basic concepts of engineering courses. This study was conducted for students of Basic Solid Mechanics course, which is a second semester course in the Diploma of Civil Engineering Program through peer tutoring. The analysis of the entry-exit tests was conducted to evaluate the effectiveness of the intervention program.

The analysis shows that the average performance of the experimental group improved significantly. The intervention program through peer tutoring was proven to be effective, where students can be taught best based on individual learning pace, with additional support from their peers. Thus, peer tutoring is suggested to be conducted for courses with high failure rates. This is a pro-active service to the targeted students.

The Intervention Program through active learning activities by peer tutor and tutees with the support from instructors provides great help to weak students to improve their academic performance. Therefore, current research and practices within the intervention programs should incorporate communication and peer support as crucial elements in the higher education student development program. The limitations of this study are unequal sample sizes for the experimental group and the control group due to the quasi experimental design used, and on the duration and the limited chapters covered in the intervention program. Future study can plan for a pure experimental design to achieve a more desirable balance in the sample sizes for the experimental group and control group. It is also recommended to increase the hours of the intervention program, and to include more chapters of the course in the program. More tutors should also be recruited in future intervention programs, in order to ensure that each tutee is properly attended to during the program. Future work on analyzing feedbacks from tutors is also beneficial, as to provide a more complete analysis on the benefits of the intervention program.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support from the Faculty of Civil Engineering, Samarahan Campus 2, Universiti Teknologi MARA Cawangan Sarawak.

REFERENCES

Alegre Ansuátegui, F. J., Moliner Miravet, L., Lorenzo Valentín, G., & Maroto, A. (2018). Peer tutoring and academic achievement in mathematics: a meta-analysis. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(1), 337-354.

Arco-Tirado, J. L., Fernández-Martín, F. D., & Fernández-Balboa, J. M. (2011). The impact of a peer-tutoring program on quality standards in higher education. *Higher Education*, *62*(6), 773-788.

Chen, C., & Liu, C. C. (2011). A case study of peer tutoring program in higher education. *Research in Higher Education Journal*, *11*, 1-10.

Cheng, Y. C., & Ku, H. Y. (2009). An investigation of the effects of reciprocal peer tutoring. *Computers in Human behavior*, *25*(1), 40-49.

Chester, A., Burton, L. J., Xenos, S., & Elgar, K. (2013). Peer mentoring: Supporting successful transition for first year undergraduate psychology students. *Australian Journal of Psychology*, *65*(1), 30-37.

Colvin, J. W. (2007). Peer tutoring and social dynamics in higher education. *Mentoring & tutoring*, *15*(2), 165-181.

Colvin, J. W., & Ashman, M. (2010). Roles, risks, and benefits of peer mentoring relationships in higher education. *Mentoring & Tutoring: Partnership in Learning*, *18*(2), 121-134.

De Backer, L., Van Keer, H., & Valcke, M. (2012). Exploring the potential impact of reciprocal peer tutoring on higher education students' metacognitive knowledge and regulation. *Instructional science*, *40*(3), 559-588.

Department of Education, Skills and Employment Australia. (2018). *Selected Higher Education Statistics 2018*. https://www.education.gov.au/selected-higher-education-statistics-2018-student-data.

Fox, A., Stevenson, L., Connelly, P., Duff, A., & Dunlop, A. (2010). Peer-mentoring undergraduate accounting students: The influence on approaches to learning and academic performance. *Active learning in higher education*, *11*(2), 145-156.

Galbraith, J., & Winterbottom, M. (2011). Peer-tutoring: what's in it for the tutor? *Educational Studies*, *37*(3), 321-332.

Goldfinch, T., Thomas, G., & Carew, A. L. (2009). Students views on engineering mechanics education and the implications for educators. *Proceedings of 20th Australasian Association for Engineering Education Conference 2009,* pp. 624-629.

Hryciw, D. H., Tangalakis, K., Supple B., & Best, G. (2013). Evaluation of a peer mentoring program for a mature cohort of first-year undergraduate paramedic students. *Advances in Physiology Education*, *37*(1), 80-84.

Johari, A., Morni, A., Sahari, S. H., Kamri, T., & Shuib, A. R. A. (2018). Interactive English Language Learning: DishZle Language Game. *International Journal of Service Management and Sustainability*, *3*(2), 1-20.

Jong, L. L., & Kuan, S. V. (2020). An Effective Partial Fraction Decomposition Method for Undergraduate Students. *International Journal of Service Management and Sustainability*, *5*(2), 163-186.

Karim, R. (2010). Teaching and learning of statics and mechanics of solids: Some problems and solutions. *Proceedings of the 21st Annual Conference for the Australasian Association for Engineering Education 2010*, 461-467.

Lajiun, J. (2012, September 26), Staggering dropout rate before SPM. *Borneo Post*. Retrieved from https://www.theborneopost.com/2012/09/26/staggering-dropout-rate-before-spm/.

Lassegard, J. P. (2008). The effects of peer tutoring between domestic and international students: The tutor system at Japanese universities. *Higher Education Research & Development*, *27*(4), 357-369.

Lian, C. W., Hazmi, H., Bing, J. H. C., Ying, C. J., Nazif, N. N. N. M., & Kamil, S. N. A. M. (2015). Peer Mentoring Among Undergraduate Medical Students: Experience from Universiti Malaysia Sarawak. *Education in Medicine Journal*, *7*(1), 45-54.

Loke, A. J. Y., & Chow, F. L. (2007). Learning partnership—the experience of peer tutoring among nursing students: A qualitative study. *International journal of nursing studies*, *44*(2), 237-244.

Miller, J. E., Groccia, J. E., & Miller, M. S. (2001). *Student-Assisted Teaching: A Guide to Faculty-Student Teamwork*. Anker Publishing Company, Bolton.

Miller, S. R., Miller, P. F., Armentrout, J. A., & Flannagan, J. W. (1995). Cross-age peer tutoring: A strategy for promoting self-determination in students with severe emotional disabilities/behavior disorders. *Preventing School Failure: Alternative Education for Children and Youth*, *39*(4), 32-37.

Monash University Malaysia. (n.d.). *Peer Assisted Study Session*. https://www.monash.edu.my/student-services/support-services/peer-assisted-study-session.

Multimedia University. (n.d.). *FET Peer Tutoring Programme*. http://fet.mmu.edu.my/peertutor/.

Mustafa, J. (2019, July 10). Strategies to prevent dropouts. *New Straits Times*. Retrieved from https://www.nst.com.my/education/2019/07/503141/strategies-prevent-dropouts.

Ochoa, J. L. R., Pérez, J. L. B., & Berrio, J. A. (2016). Student acceptance and performance of a virtual platform for training and evaluation of Statics course. *2016 IEEE Frontiers in Education Conference (FIE)*, pp. 1-6. IEEE.

Prusty, B. G., & Russell, C. (2011). Engaging students in learning threshold concepts in engineering mechanics: adaptive eLearning tutorials. *17th International Conference on Engineering Education (ICEE),* pp. 21-26.

Pugatch, T., & Wilson, N. (2018). Nudging study habits: A field experiment on peer tutoring in higher education. *Economics of Education Review*, *62*, 151-161.

Raja, J. E., Low, K. O., & Lim, W. S. (2018). Peer tutoring in higher education – a pedagogical tool for student-centered teaching. In: *Proceedings of Conference on Association of Southeast Asian Institutions of Higher Learning 2018*, 1-7.

Roscoe, R. D., & Chi, M. T. (2008). Tutor learning: The role of explaining and responding to questions. *Instructional Science*, *36*(4), 321-350.

Snowden, M., & Hardy, T. (2012). Peer mentorship and positive effects on student mentor and mentee retention and academic success. *Widening Participation and Lifelong Learning*, 14, 76-92.

Terrion, J. L., & Leonard, D. (2007). A taxonomy of the characteristics of student peer mentors in higher education: Findings from a literature review. *Mentoring & Tutoring*, *15*(2), 149-164.

University of Nottingham Malaysia. (n.d.). *Peer Mentoring*. https://www.nottingham.edu.my/CurrentStudents/Nottingham-Advantage-Award/Modules/Peer-mentoring.aspx.