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Introducing a collaborative learning strategy in a hybrid and traditional laboratory for undergraduate computer science students

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Abstract
Collaborative learning is an advantageous pedagogical strategy to include in e-learning. In this study we aim to demonstrate a methodology created to implement this strategy in an undergraduate student population. We will present our findings from running this experiment in two scenarios, namely an in-person environment and a simulated remote environment. We analyse the impact this methodology has on students understanding of the topic along with how their assessment compares to their peers in a previous year. We also analyse the different perception of personal and collaborative work in both scenarios. We conclude that this methodology is effective in increasing a student's understanding of the work being assessed and contributes to an increase in students' assessment grades.

Keywords: *E-learning; collaborative learning; hybrid; undergraduate.*

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1. Introduction

The exponential rise of accessible e-learning recently has brought forward many different types of strategies and methodologies. Turlaram (2018) discusses that there are several variables that contribute to the success of an e-learning strategy including technological awareness of students, general mathematical ability, and teacher competence. Mhouti et al. (2017) consider how the use of Web 2.0 can be integrated into e-learning practices and how collaboration, not only between students, but between students and teachers, is crucial. They do however report that this aspect of collaboration is usually difficult to achieve if the contents presented are not adapted to the context of collaborative e-learning.

Active learning engages the student and enables the knowledge to be cemented with practice and understanding. When creating an e-learning methodology, it is essential to consider how a student's perception of a task changes in an offline, hybrid and fully remote scenario. Jensen et al. (2017) contribute that e-learning can only reach the same benefits as traditional teaching if an active learning approach supports it. In comparison to passive learning, where students absorb information from a lecture or tutorial, active learning places an effective outcome on the effort put in by the student. Khan et al. (2017) state that integrating active learning into course materials is crucial to engage students, regardless of the learning environment. They acknowledge that when it comes to online courses, an appreciation of the unique approaches to active learning is required.

Motivating the student to the same standard as in-person teaching in a hybrid or fully remote environment can be challenging but it is essential to the student's development in the course material. Collaborative e-learning, as a strategy, enables students to have motivational benefits from social interactions with their peers, even when remote. Collaborative learning as a strategy enables students to relay and gain information from their peers and put into practice the theory that they have learned passively. Each student is different, but many who participate in e-learning positively display similar traits. Punnoose (2012) found three personality variables positively influence students when it comes to e-learning, namely a high level of conscientiousness and extraversion along with a low level of neuroticism. This study aims to foster these traits by means of collaboration and social interaction.

This paper aims to contribute to research around introducing an active e-learning strategy to higher education students. We have focused in this study on how active learning can be facilitated through e-learning and looked at what role collaborative learning plays within that. This study will include a deeper dive into understanding what methodology creates the best learning environment for an e-learning study group, and how that methodology can be replicated outside of one subject. For this study, we have focused on computer science students at the start of their respective degrees, where we have incorporated active learning components within weekly laboratory assignments as a crucial part of their learning experiences.

One priority of this study was to innovate and build upon current educational practices. Students' typical laboratory work involves completing a set list of coding problems, where the majority are released at the beginning of the week and can be completed at home. A further one or two problems are released within the set laboratory time; these are considered more challenging than the initial set. While this work is active learning, the addition of collaborative learning allows students to discuss problems and difficulties they are having with their peers and encourages students to explain their work clearly and concisely.

Introducing a mobile/web application has enabled students to keep a digital log of their discussions and notes. Utilising tools such as this is integral to innovating the teaching and learning experience as the expectation to be technology literate within the workplace is ever-growing. Roehl et al. (2013) conclude that “one's adaptability to new technologies is crucial for graduate students to succeed in the workplace.” This underlines the need for the provision of technology-infused learning environments at educational institutions, where their pedagogical benefits have been identified. Many workplace tools involve a collaborative element, be it paired work or online communication. Building these skills within the classroom helps set students up for success and create a well-rounded workforce.

2. Methodology and Data Gathering

2.1. Methodology steps

This study aimed to understand how students collaborate with coding problems in offline and emulated online environments. To achieve this goal, we designed a strict set of parameters for both settings, as follows:

1. Group Size: A group size of 4 students was used.
2. Access to Questions: Students were only given access to the coding problem, for the collaborative session, at the beginning of the session.
3. Review Time: Students were given 10 minutes to review the question and write notes on the topic.
4. Group Discussion: Students were placed into groups and given 20 minutes to discuss and create a robust pseudo-code algorithm to answer the question.
5. Assistance: Students were allowed to ask for help from a lab demonstrator in the final 10 minutes if they needed help understanding the problem.
6. Survey: Once the session was finished, students completed a survey describing their experience with the session and how helpful each section was in completing the

algorithm. The survey also requested information on the student's background and their contributions to the discussion.

The experiment was run in two separate scenarios:

(1): In-Person, students were face-to-face and expected to communicate and write down information on paper. (2): Simulated Online**,** students were asked to communicate in the simulated online scenario through a web/mobile app. They were expected to discuss the problem and ideas they had for a solution through text chat in the app.

After completing the session, the algorithm was looked over by an experienced demonstrator in both scenarios, and the students were provided feedback on their work.

2.2. Data gathering

In this study, data from 3 distinct student populations were selected over a 12-month period.

1. Group 1 - Undergraduate students in their second semester of university. (n = 476)
2. Group 2 - Higher diploma students in an accelerated introduction to programming module over three weeks. (n = 47)
3. Group 3 - Undergraduate students in their first semester of university. (n= 570)

Group 1 and Group 3 undertook weekly lab assignments, where a new topic was assessed each week. Due to the accelerated nature of the content that Group 2 was receiving, they had multiple lab sessions within a week. For the purposes of this paper, we will report Group 1 and Group 3 in a weekly fashion and Group 2 in a session fashion.

To evaluate the effectiveness of the collaborative sessions, we used an initial survey[1] (https://forms.office.com/e/MbS9vWMs0T) with 12 different items representing a student's background, administered in the first week of the study with each group. Participants provided information on their education, parental education, gender, and geographic upbringing, as well as questions on their perception of collaborative learning.

A follow-up survey[2] was administered within each weekly session, gathering information on the session itself. Participants in the weekly follow-up surveys provided information on their perception of the session, including their understanding of the topic at the beginning of the session versus the end, how effective the group work was on a scale of 1-10. They were also asked about how effective the solo work was on a scale of 1-10.

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[1] https://forms.office.com/e/MbS9vWMs0T

[2] https://forms.office.com/r/7xmmNHcbnD

In total, we received 2341 completed surveys. They were broken down as follows:

1. Group 1 - 571 surveys over four sessions. (202 initial, 369 weekly session)
2. Group 2 - 122 surveys over nine sessions. (15 initial, 107 weekly session)
3. Group 3 - 1648 surveys over seven sessions. (233 initial, 1415 weekly session)

Group 1 took part in the in-person experiment, while Group 2 took part in a simulated online experiment. Group 3 completed the experiment in both an in-person and simulated online scenarios. For Group 3 the students were divided into two groups: a larger group of 540 students who took part in the session in person and 30 students who utilised both in-person and simulated online sessions throughout the seven sessions.

3. Results and Discussion

To determine the effectiveness of this e-learning strategy, we investigated three factors of the student's learning experience. These were:

1. Did the student find the collaborative session useful in increasing their knowledge of the topic?
2. Did the personal or group work affect the students' understanding of the problem?
3. Did the students' grades improve compared to those that did not utilise collaborative learning sessions in the previous year?

3.1. Group 1's findings

We first introduced this methodology to a cohort of undergraduate computer science students, Group 1, after the midpoint of their semester. We have chosen to exclude this data from our final conclusions as it depicts data from the methodology running in a much less strict environment and we could not conclude whether these changes had an impact on the experiment. This group was, however, instrumental in helping to refine the methodology for Group 2 and Group 3. From the feedback we did gather, we know this group had a positive perception of the methodology and could see the benefit it would provide in the future.

3.2. Usefulness of collaborative session

We wanted to gauge the students' perception of the usefulness of collaborative sessions within their weekly laboratory session. Figure 1 presents the average perception of how useful the students in Group 2 found the sessions throughout the experiment. The average response was 7.6 out of 10. The perception of usefulness fell to 6.6 at the midway mark before recovering to its highest in session 8. In general, we can see that the perception was positive and is something the students identify as valuable.

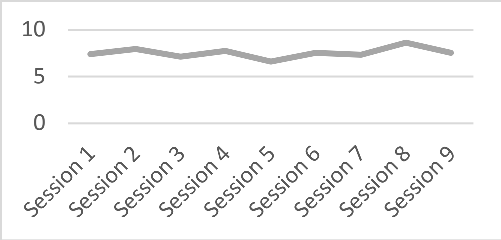

Figure 1. Group 2 students' average perception of session usefulness over a 9-session period.

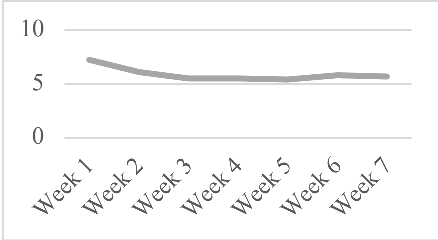

Figure 2. Group 3 students' average perception of session usefulness over a 7-session period.

In relation to Group 3, despite there being a large spread of values week to week on the students' perception of how useful the collaborative learning sessions were, it can be seen in Figure 2 that overall, the students found the session helpful and gained both knowledge and confidence in the topic they were working on. In the initial two weeks, the average perception was scored at 7.25 and 6.1, respectively. The average then balanced towards 5.7 as the students grew used to the sessions taking place.

When asked "how helpful did you find the session", it can be seen in Figure 3, that for each week a minority of students rated the session as having a low impact on their knowledge of the topic, peeking in week 5, with 25.1% of respondents giving the session a low rating. The inverse of this is that at least 74.9% of participants each week found value in completing the session. During Week 1, 70.1% of participants ranked the sessions highly, which fell to 42% by week 7. Week to week, the level of difficulty in the sessions' problems rose gradually, and students' technical skills increased as they built upon past topics.

Variable	High rating 10 – 7	Mid rating 6.9 – 3.1	Low rating 3 – 0
Week 1	83	27	7
Week 2	80	61	30
Week 3	77	84	52
Week 4	64	64	36
Week 5	53	57	37
Week 6	62	54	23
Week 7	53	47	26

Figure 3. Group 3 students' perception of the usefulness of the session over a 7-week period.

3.3. Preference for session work type

In relation to a preference of the type of session work within Group 2, either personal work or group work, the preference seemingly varied widely from week to week, as shown in Figure 4. The average response was 46% in favour of personal work and 54% in favour of group work. Due to the lack of eye-to-eye social interaction, seemingly the students felt little difference between the two.

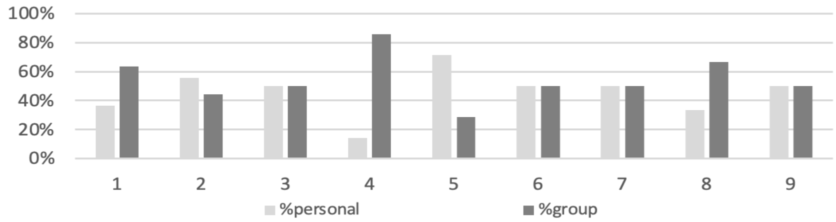

Figure 4. Group 2 students' preference of session work personal vs group.

For Group 3, students mostly preferred to work in their group's week to week. The largest variance in responses received was in week 7, with a difference of 47.9% between the two options, as shown in Figure 5. The smallest difference occurred on week 4, with a difference of 13.5%. The results, in general, follow a parabolic curve with the precipice at week 4. There was a consensus that the group work benefited the student the most. The mid-term break scheduled after week four may have impacted the students' motivation to engage with their classmates and gain more benefit from their discussions.

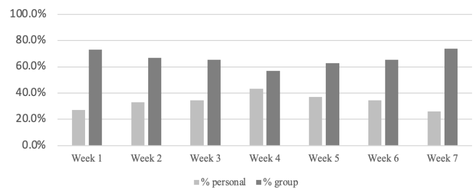

Figure 5. Group 3 students' preference of session work personal vs group.

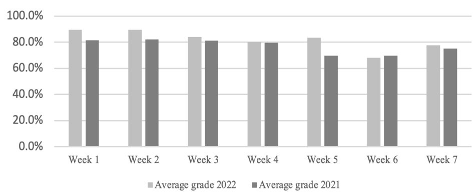

Figure 6. Group 3 students' Grades in 2022 in comparison to 2021.

3.4. Comparison with previous years'

The data presented in Figure 6 shows the average score of students in the module, where 100% means they got the answer fully correct, and 0% means they did not receive a grade for the lab. We identified an increase in the average grade of a student who participated in this study compared to their peers who took the same module in the previous year. Excluding week 6, the 2021 average grade was 1.4% higher than in the 2022 cohort. When comparing student grades with students in previous years, we need to do so with care and note a threat to validity around this. It is worth noting that for this analysis, the lecture content remained the same year by year, along with the lecturer delivering the content and the content covered in the labs.

Figures 3 and 7 show that students' confidence in their understanding of the topic can be mapped to the average grade received each week. A higher perception of understanding correlates with a higher grade received overall.

4. Conclusion

The introduction of a collaborative learning strategy drives engagement and motivation in students to discuss issues with their peers, and consequently gain a greater understanding of the solution to the problem. Our work has shown that most students prefer to work within groups compared to on their own, when it comes to solving technical problems in an in-person session. In an online session, students are more evenly balanced in their preferences.

The grades of students have marginally increased in previous years when this collaborative learning strategy was implemented. Again, we present this result with care, cognisant of the inability to correctly compare distinct student cohorts.

The perception of the usefulness of such a collaborative learning approach fell to its lowest around midway through the module for both in-person and online students. The use of a simulated online medium to utilise this strategy has been successful and opens future work opportunities in re-examining this experiment in a fully online format. In a fully online scenario, it is important to provide adequate social interaction features to ensure students get the most benefit out of the collaborative work possible.

References

El Mhouti, A., Nasseh, A., Erradi, M., & Vasquèz, J. M. (2017). Enhancing collaborative learning in Web 2.0-based e-learning systems: A design framework for building collaborative e-learning contents. *Education and Information Technologies*, 22, 2351-2.

Jensen, J. L., Kummer, T. A., & Godoy, P. D. D. M. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *CBE—Life Sciences Education*, 14(1), ar5.

Khan, A., Egbue, O., Palkie, B., & Madden, J. (2017). Active learning: Engaging students to maximize learning in an online course. *Electronic Journal of e-learning*, 15(2), pp107-115.

Roehl, A., Reddy, S. L., & Shannon, G. J. (2013). The flipped classroom: An opportunity to engage millennial students through active learning strategies. *Journal of Family & Consumer Sciences*, 105(2), 44-49.

Punnoose, A. C. (2012). Determinants of intention to use eLearning based on the technology acceptance model. *Journal of Information Technology Education: Research*, 11(1), 301-337.

Tularam, G. A. (2018). Traditional vs Non-traditional Teaching and Learning Strategies-the case of E-learning!. *International Journal for mathematics teaching and learning*, 19(1), 129-158.