Collaborative Learning Strategies in Software Engineering Course

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Abstract

This paper presents the research design for a Scholarship of Learning and Teaching project that aims to explore how the collaborative learning strategies can impact student learning in Software Engineering course. Collaboration for software engineering is central as multiple engineers work together on a project. Besides the specialist individual skills, it is important that IT professionals complement each other and collaborate. Future trends place utmost importance to the skill and thus it is important that our university teaching incorporates activities and tasks that foster group work and collaboration. The existing literature for collaborative learning strategies used in University teaching is reviewed in light of demand in the industry for team work and collaboration.

1. Introduction

With the increasing significance of teamwork in occupations, it has become imperative in higher education setups to incorporate effective strategies that can provide students with an opportunity to learn latent skills like communication and cooperation besides gaining academic knowledge. One of the meaningful strategies that focus on holistic learning experience is collaborative learning. Collaborative learning is when students are required or encouraged to work together to achieve a common learning goal [Dil99]. In this process, students interact with each other in small groups where they can share their ideas and at the same time learn from their peers. This is different from a didactic teaching method which is the traditional teacher-centered classroom setting where the primary agent of learning is a teacher without much interaction between students. The benefits of collaborative learning include higher achievement, enhanced confidence, enjoyment in the process, positive motivation and development of social skills in the students [SBPVW16][BCM14][JJS07][ZC18]. Collaborative learning resonates with the social interdependence theory which says that when individual accomplishment is affected by the action of others, there is social interdependence [JJ89]. This interdependence can be either positive (cooperation) or negative (competition). When the tasks are designed such that students are believed to perceive that they can achieve their goals only if they cooperate and promote each other's efforts, it leads to positive interdependence in collaborative learning set up. According to Vygotsky [Vyg80], when social activities are combined with learning processes, the students can solve problems beyond their current development level as learning takes place through the support of peers under the guidance of the instructor. Despite numerous advantages of collaborative learning, the implementation of collaborative learning remains a challenge due to difficulties in embedding these practices into the curriculum. The practitioners are not able to implement these

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activities owing to the amount of time it requires to plan such activities. Designing such activities requires consideration of numerous factors like group size, task design complexity, and creation of social communication opportunities in the activity [BFVP17]. Friction amongst the group members arising due to free riders or dominant members is also a concern. There is a need to focus on the design and implementation of collaborative learning strategies in an effective manner to support learning.

Collaborative learning method has been adopted in many disciplines and education levels, however, its full potential has not been tapped in Information Technology (IT) discipline. This literature review is an attempt to develop an understanding of collaborative learning practices in IT and its impact on student learning. The review first focuses on challenges and barriers to learning Software Engineering and to understand the problems faced by students worldwide in the subject and correlating it with my own experience. Then, existing research studies on applying collaborative learning methodologies and their impact on academic performance, social skill development and satisfaction of the student are explored. The review concludes with the study plan and the hypothesis for research on collaborative learning and its impact on student learning and satisfaction.

2. Challenges in teaching Software Engineering

Teaching Software Engineering involves specific challenges and concerns, owing to heavily technical content and the absence of relatable examples that can utilize student's existing knowledge. In this discipline, over the years it has been realized that the programming subject which is the foundation subject for all other subjects in Software Engineering course is more often than not a dreaded subject for the students [GHR05][Raa07]. Teaching programming is a complex task as it aims at developing multiple skills like problem solving, logical thinking, debugging strategies, creativity, and abstraction besides learning the syntax and semantics of the programming language[Raa07][MFL08][MLM08][MSCISH14]. With all these skills to be developed, it can be only possible if learners develop all of them in parallel and apply them in practicals concurrently. This can be overwhelming for the students and may stretch the cognitive abilities of a learner. Various teaching methodologies and tools have been used by teachers for making the learning effective in Software Engineering. Animations and games have been used for creating visualizations of abstract concepts to support learning [Liu16][FS10]. The use of technology helps in effective learning for students from diverse backgrounds. However, not all the concepts can be learned through games and it is very hard to come up with the games or animations on many topics. This signifies the attention required for learning and teaching strategies to enhance student learning in a Software Engineering course.

3. Literature Review on Collaborative learning strategies

Software Engineering teaching is often conducted in a competitive environment that prepares the student for IT occupations usually perceived as solitary occupations. This belief is now rapidly changing in academia and industry and efforts are being made for collaborative practices as IT professionals are now involved in active interactions with stakeholders and often work in teams. For this reason, researchers are exploring ways and means to incorporate collaboration amongst students in teaching and learning. In higher education, though predominantly the delivery method is lecturing, active learning strategies like collaborative learning are strongly encouraged by universities to enhance student achievement and develop their social skills. At its core, collaborative learning creates a learning environment where students learn from one another facilitated by the instructor rather than an instructor-centered setup.

The impact on student learning and achievement is an important measure of a learning strategy. For an undergraduate computing course, Tsai et al. [TEC10] have used a case study to explore the impact of the collaborative learning approach by using wikis on student learning. They analyzed the student scores and survey data about student satisfaction and conclude that collaborative activities lead to better learning. However, the study did not consider the effect of group size and whether scaffolding was required to support the learning in teams. Without a control group set up or a comparative analysis, it is difficult to substantiate such claims. A design-based research study was conducted to explore the influence of group size and absence of scaffolding when working with small and large groups for creating knowledge collaboratively using wikis [LR16]. An analysis of quantitative data from the wiki platform analytics and qualitative data from focus group interviews concluded that effective learning happened in small groups even when scaffolding faded, whereas, large groups were unable to

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build knowledge collaboratively. The study highlights the importance of group size which is an important factor to be considered when designing collaborative learning tasks. Barkley et al. [BCM14] emphasized on the appropriate group size to be between 2-6 students to promote communication and involvement of group members. In teaching practice, it is observed that when students are given easy tasks, it may lead to students completing the tasks quickly without actual learning happening and without actually interacting with their peers. The complexity of the task is also very critical to engage students in a synergistic manner in collaborative learning activities.

Retnowati, Ayres & Sweller [RAS18] suggest that collaborative learning is only superior to individual learning when students have some pre-existing knowledge, and interaction with peers helps to fill up the gaps. They used a 2X2 factorial experimental design with 228 students taking novice and knowledgeable learners in both individual and group set up with dependent variables performance and mental effort. The participant's cognitive load was measured subjectively in learning, retention and delayed test phases using a mental effort rating scale and performance was measured in different phases. Quantitative analysis of captured data suggested that when the students have no existing knowledge; individual learning is superior as they need instructor's careful guidance to understand the task complexity to be able to comprehend and process it in agreement with the cognitive load theory [SMP19]. Perhaps, there is also a need to emphasize clearly on instructing students on how to work collaboratively on a specific task when implementing collaborative activities as that is often lacking in the studies conducted. Students often find it challenging if they are left on their own to find ways to collaborate on the learning tasks. In some cases, in spite of active learning strategies and scaffolding from the instructor, enabling learning in a collaborative environment can be challenging. The group size, composition, complexity of the task, time required, pre-existing knowledge and relevance of the learning outcomes are among various factors that need consideration before designing these activities.

Collaborative activities help to bring together students of diverse abilities and motivate them to learn the concepts together. A qualitative research study on exploring factors for effective collaboration was conducted by Scager et al[SBPVW16]. The study involved focus group interviews with students from courses with successful collaborative learning results and revealed that factors like the feeling of shared ownership, sense of responsibility contribute to positive interdependence in collaborative tasks. However, positive interdependence can only be developed in groups when the task at hand is challenging and requires various kinds of skills from the group members. Each member of the group should be able to contribute in some way or the other to lead to positive interdependence among the students, if the task is of less complexity it can be done by an individual and interdependence is not created. The composition and size of the group are also important factors to be considered when designing collaborative tasks [BB15]. The team composition promotes divergent thinking, innovation, and willingness to experiences among the students [Cham17][CLCT18]. However, diverse teams may also have some students who hide in groups and do not actually contribute to the learning or even gain from the learning activity. This may be because of a lack of social skills or the student wanting to be a free rider. In such cases, it is important that the assessment methods or the learning activities are designed such that the role and contribution of each group member can be captured.

Collaborative learning practices help in developing positive interpersonal relationships amongst peers which in turn help in the self-esteem and satisfaction of the learners. Students develop a feeling of shared identity when working with groups and feel more empowered than when working individually [JJS07]. A quasi-experiment to determine if collaborative visual language based mobile app development can garner student's interest, attitude changes and content knowledge was conducted with a group of 34 participants [Rah18]. Quantitative analysis of pre and post survey data indicated that student's attitude towards the subject increased on the introduction of collaborative and visual learning activities and also led to more satisfaction and a sense of achievement in them. The level of challenge in the task should be considered in relation to the sense of achievement to understand the impact on learning. A qualitative study of findings from a focus group interview and online questionnaire has revealed how international students perceived lack of belongingness and low social engagement in higher education institutes in Australia [ADBP19]. Universities need to encourage more collaborative learning practices to promote interaction among diverse peers, bring in different perspectives, improve language skills and also bring in a sense of belongingness among students. Here, the role of the instructor who is more of a facilitator in the collaborative learning environment becomes important so that the students are

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positively motivated to interact with the peers to achieve the learning outcomes and have better satisfaction and the feeling of belongingness.

4. Learning Design

In an attempt to improve the existing design, Agile Instructional Design approach has been used as shown in figure 1 [Got 2011]. Agile Instructional Design provisions a flexible, incremental approach to redesign the subject in short iterations [CG2009]. Agile approach is a flexible model that places focus on learners and their interactivity with the blended learning course besides offering faster response to change as compared to ADDIE [G2012][Raw2005].

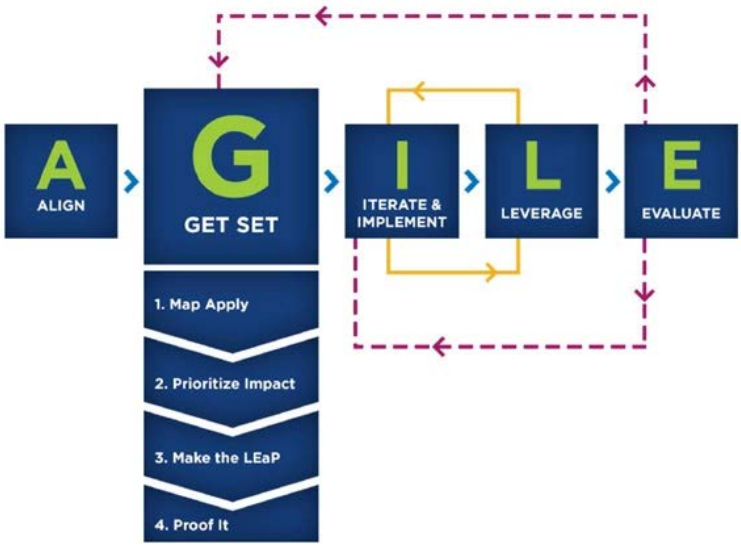

Figure 1 AGILE Instructional Design Model (Gottfredson, 2011)

Align

The first step of the model aligns the learning design with university strategy and learner outcomes to make them future ready software professionals. The new technologies and changes need to be incorporated in a way that transforms learning environments, creating more virtual opportunities for students, and merging the physical with the virtual [PS18]

Get Set

The second stage of AGILE lays emphasis on analysis of the learners, the operational demands of the project and plans how the performance goals can be achieved so that a robust learning design is created for a high quality learning experience for the students. In this stage, a learning experience and Performance plan (LEaP) is created to support the achievement of the subject learning outcomes [Nei13].

In order to develop a robust design, one has to be mindful of the learners' profile. For software engineering course , majority of the enrolled cohort are from diverse international backgrounds. Blended learning has been introduced in the redesign as it is more effective for catering to the needs of diverse students compared to only face-to-face learning or online learning alone [Nor11]. This learning design blends traditional face-to-face teaching experiences and virtual learning experiences to deliver this subject in the most effective way. The online activities will complement the subject content delivered in the classroom. This will help me make the lecture delivery concise and engage in active learning activities in the classroom [Big03]. Most appropriate blended learning media based tools for subject delivery and assessment are videos, discussions, quizzes and interactive activities.

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Appropriate media for educational purposes is selected based on the SECTIONS model, which offers careful analysis of different criteria [Bat15].

For developing teamwork and good communication skills, collaborative learning approaches have been successfully used in higher education [Sca16]. In-class group activities using digital technologies and group discussions can be added to encourage collaborative learning amongst students beyond their current development level as learning takes place through the support of peers under the guidance of the instructor [Vyg80].

According to Brown & Race [BR12], the assessment should be relevant to the real world i.e. authentic and following the corresponding conditions [HH06]. In the LEaP plan the solutions are created at task stage so that the resources required for the project can be determined and smooth implementation can be carried out in the next stage [Nei14]. It helps in planning of pre and post learning activities, assessments, blended tasks and student support.

Iterate and Implement

During this phase, primary focus is on creating an instructional material or activity according to the prioritization decided at previous stage. Focus is on the learner experience and how the new activity or assessment will impact the learner performance. Various technological tools are used to implement the planned activities like interactive video using H5P, discussion forum, LearnJCU quizzes, padlet, and twiddla for creating blended and collaborative experience for learners. If at this stage there are any changes to the design it is mapped to LeAP plan.

Leverage

Digital technologies, research, online learning platforms and people support comes together at this stage to create a learning experience with an effective support for the students. This means that efficient technology solutions, current awareness of learning and cognitive theories in research and social media or virtual collaboration among people are appropriately utilized to ensure effective performance support in the moment of need.

Evaluate

The final but most important step of Agile is evaluating the quality of the learning design and getting feedback from the learning experience of the students. Learning design here also provides measurement strategies and infrastructure for seeking feedback on the learning experience. This involves setting up both formative and summative assessments that helps make judgement of merit of the learning design. student feedback and formal assessments at JCU help in collecting feedback. Besides these, analytics in learning management system provides insight on usage patterns of blended learning activities like discussion forums, interactive videos or quizzes. Perceptions and assumptions made during early stages of design are also evaluated to identify the strengths and limitations.

The reflection on initial goals and evaluation of effectiveness of the newly incorporated changes will guide any further revisions and changes to this design in view of a positive futuristic learning experience for the students.

5. Research Design

Learnings from the literature review in the previous section will be taken to design an SoTL (Scholarship Of Learning and Teaching) project with 100 undergraduate students aiming at the following research questions:

1. How will number of participants in collaborative learning strategies, task complexity and gender of the participants impact student learning in the Information Technology course?
2. How collaborative leaning strategies effect student satisfaction and attitude towards social engagement?

The study will follow a mixed design wherein quantitative data will be analyzed using statistical methods like ANOVA and t-test as shown in figure 2. The experiment will have 2X3X2 factorial design with the following variables:

Independent variables: Gender (2 levels): Male vs female, Task Complexity (2 levels): Easy vs Difficult Collaborative Setting (3 levels): Strategy 1: Group of 5 students, Strategy 2: Pair of students, Strategy 3: No collaboration (Individual learning)

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Dependent variables: Academic performance: Measured through weekly assessments and end of trimester results Student satisfaction: Qualitative survey

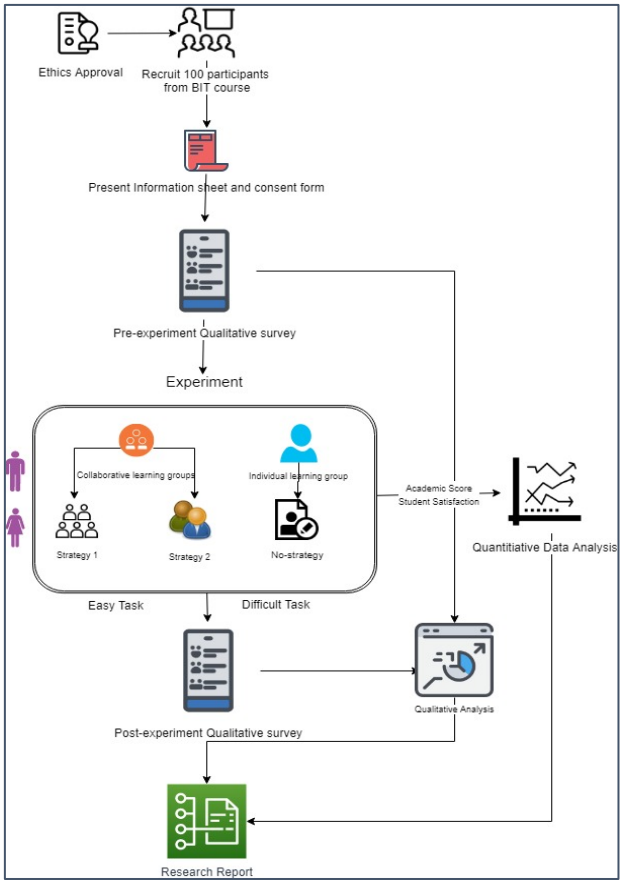

Figure 2 Research Design for studying impact of collaborative learning

The three independent variables will be gender (2 levels), class setting (3 levels) and task complexity (2 levels). Dependent variables will be academic performance operationalized through task scores and student satisfaction operationalized as satisfaction survey score. Quantitative data analysis will be done to evaluate student's academic performance and qualitative data analysis for satisfaction for task complexity level. The following data collection and analysis plan will be used for the study:

- Pre-experiment qualitative survey will be to capture students' attitude towards social engagement in classroom.
- Academic performance will be measured through weekly online quizzes.
- Student satisfaction will be captured through a quantitative survey at the end of course.
- Qualitative survey will be done at the end of experiment to capture attitude towards social engagement in classroom.

The following hypothesis are assumed for the study:

- H1: Students will exhibit better academic performance when working collaboratively than individually.
- H2: When given difficult tasks students will perform better when working collaboratively.
- H3: There will be greater student satisfaction when they are exposed to collaborative learning activities.
- H4: There will be no difference in performance in collaborative works for males and females.

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- H5: There will be increased openness to social engagement when students undertake collaborative learning activities.

Analysis will be done using various statistical tests for quantitative data on different class setting, gender and complexity. Thematic analysis of student responses to pre and post survey questions will be done to find if collaborative learning has increased their receptivity to collaboration and positive learning experience.

6. Conclusion

This paper establishes that collaborative learning activities have benefits like improved student learning, enhanced social skills, and better student satisfaction. However, there are gaps in the existing literature that need to be addressed to effectively implement collaborative learning activities in higher education settings. Collaborative learning in technical subjects like Software Engineering can be successful if the activities are designed carefully which can tap the potential of students, enhance learning and support peer interaction. The factors like task complexity, pre-existing knowledge, group composition, and size need to be considered to design an effective collaborative learning activity. The SoTL project will help in exploring the predictors for better student performance and development of latent skills like cooperation and communication which is often lacking in IT course design. The project will enable future directions of research on better assessment evaluation methods for collaborative projects.

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