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Student Engagement in Software Engineering Group Projects: An Action Research Study

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***Abstract*—We present an action research study on student engagement in group work. The study was carried out within *CPT202 Software Engineering Group Projects*, a UK Level Two module with 370 students enrolled during the 2020-2021 academic year. The primary finding of our action research is that peer evaluation could encourage student engagement in group work. In addition, student engagement in group work positively correlates with their academic performances. We also discuss several effective strategies in supporting student engagement in the group work of software engineering projects. The results and findings have pedagogical implications in encouraging student engagement not only in software engineering group projects, but also in general activities that involve students working in a group.**

***Keywords*—student engagement, group engagement, software engineering, group project, teaching and learning, action research**

I. Introduction

Being able to work in a group is a desired learning outcome for many modules, but encouraging group work in a big classroom can be challenging. This article presents an action research that aims to encourage group work in software engineering group projects. The research took place within *CPT202 Software Engineering Group Projects*, a compulsory module for the third-year students from two programmes at the Xi'an Jiaotong-Liverpool University: BSc Information and Computer Science and BSc Information Management and Information Systems. During the academic year 2020-2021, this module involved a total amount of 370 students that were divided into 44 groups. We adopted Merlter's nine-step process of action research [18] and implemented an action research cycle. At the planning stage, we identified the problematic situation that some students tended to work individually but rarely help with each other in the group work. This situation often leads to the students' disengagement in their group work. After gathering relevant information and reviewing related literature, we developed an action research plan to encourage students' group work engagement, with a peer evaluation in the middle of the semester as the primary intervention . We used Macgowan and Newman's [17] Groupwork Engagement Measure (GEM) to obtain students' self-evaluated group work engagement before and after the actions. The results showed a significant increase in student engagement in group work at the end of the semester. Specifically, students' evaluations on relating with members and working with members' problems have significantly increased after implementing the actions. The correlation analysis between group work engagement and academic performances showed that students who engaged more in group work also obtained higher marks in their assessments. The results and findings of this research have pedagogical implications in encouraging student engagement not only in software engineering group projects, but also in general activities that involve students working in a group.

II. Related Work

This research is related to the learning and teaching in software engineering group projects. Software engineering is a core component of many computer science and engineering programmes. In software engineering projects, students are expected to be able to apply their programming skills and to carry out development work to solve real-world problems. A group project is an effective way to simulate such a real-world scenario: students need to work actively in a group to collect user requirements, specify system requirements, and incrementally develop a piece of software that can help solve a practical problem. Therefore, instead of delivering a module with formal lectures and seminars, group project is an effective approach in software engineering learning and teaching. It adopts a 'learning by doing' approach [8] and encourage students' active learning [21]. This means that students need to learn from their own experience in software development, and instructions are provided to students in a 'just in time' manner [19].

A. Scrum Framework

One widely adopted approach in software engineering is the Scrum framework [20]. It allows students to frame, plan, and manage a group project and their collaborations through sprint activities, such as sprint planning, daily Scrum meeting, sprint review and retrospective meetings (see Fig. 1), and is used in the industry for developing and sustaining complex projects by helping teams be adaptive and generate solutions to problems. A Scrum group consists of a Scrum Master (SM,

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managing the group and the Scrum process), a Product Owner (PO, managing the product) and developers. Nevertheless, all students have the same right to speak in a Scrum group and should reach an agreement on their decisions. Scrum groups engage in sprints, time-defined 'pushes' to achieve short-term goals necessary to complete a larger project. Each sprint lasts for a constant amount of time, such as two weeks. After several sprints, the software is incrementally developed.

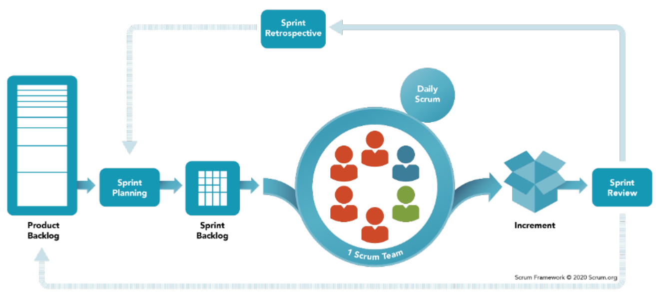

Fig. 1. Scrum framework in software engineering [22]

B. Student Engagement in Group Work

It is well understood that students' engagement in learning and teaching plays a vital role in their academic success [5]. Engagement is often articulated as the about of energy that a student puts back into the classroom [3]. Sustaining students' engagement in group work is thus essential to the learning and teaching in software engineering group projects. Macgowan [16] summarised seven dimensions of group work engagement. He pointed out that a member is engaged in group work when there is evidence of 1) attendance, 2) contribution and or participation in group activities, 3) support for the work of the leader, 4) interaction with members, 5) adoption of the mutual contract, 6) work on own problems, and 7) helping members in their work on their problems.

These dimensions concern both internal and external dynamics, which were identified to have influences on student engagement in the classroom [23]. The internal aspect of engagement is the individual, cognitive engagement with learning; the external is behavioural engagement with group work, and both of these elements are related to the emotional element [10]. Specifically, the external dynamics are largely determined by the causal feedback loops that provided by the teacher and their peers. Gielen et al. [12] showed that the justified feedback provided by peers improves students' academic performances on writing assignments. Similar peer evaluations have been adopted in group work as an assessment approach [11], but few investigated the effectiveness of peer evaluations on group work engagement.

C. Action Research

Action research is a self-reflective, systematic and critical approach that is widely adopted in learning and teaching activities, aiming to identify problematic situations or issues and to bring about critically informed changes in practice [6]. It is a cyclical process that involves four stages of activities, including planning, acting, observing, and reflecting [18]. Mertler further identified nine specific steps that can be mapped to the four-stage procedure (see Fig. 2). It provides more concrete and actionable steps than the abstract four-stage procedure. Therefore, we adopt this nine-step process to present our action research.

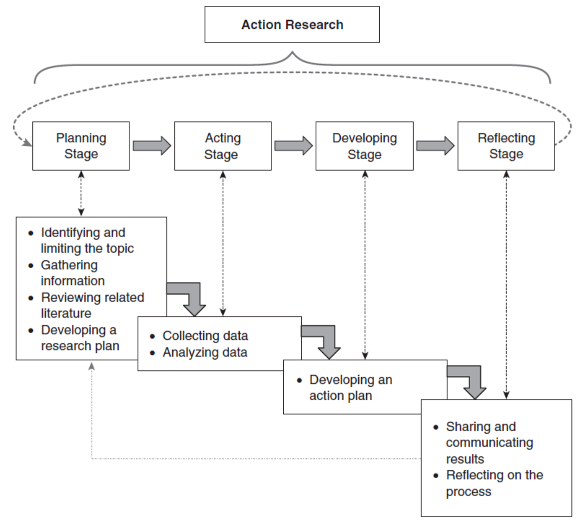

Fig. 2. Nine-step process of action research [18]

III. Methodology

This action research took place as a part of the delivery of the *CPT202 Software Engineering Group Projects* module in the second semester of the academic year 2020-2021. This module involved 370 students from two programmes at the Department of Computing: BSc Information and Computer Science and BSc Information Management and Information Systems. This module was delivered by two teachers with help from eight teaching assistants. Students were encouraged to form their own groups and propose their own projects at the beginning of the semester. We asked students to use Microsoft Azure DevOps to implement the Scrum framework for their software development and operations. Students were expected to attend a three-hour supervised session every week. Ethics approval has been obtained from the University Ethics Committee at the Xi'an Jiaotong-Liverpool University prior to any data collection. The following two sections present the first 6 steps during the *Planning* and *Acting* stages. The 3 steps of the *Developing* and *Reflecting* stages are presented in the Discussion section.

A. Planning Stage

Step 1. Identifying and limiting the topic. At the beginning of the semester, we met with the co-teacher to identify a topic to address, helping them plan the process from the beginning to set them up for success and to ensure they were on the right track with manageable projects to learn about software development . We believe that students' engagement in group work plays an essential role in achieving the learning outcomes of this module, and it is worth investigating effective approaches to encourage student engagement in software engineering group projects.

Step 2. Gathering information. The teachers then talked to two teaching assistants who also helped with this module in the previous year to get background on how students had been performing and engaging with learning at this level at the University. It was agreed that some students showed low engagement in their group work, indicated by poor attendance, inadequate contributions, and most prominently the lack of communication with other members. Reflections on the previous experience showed that it is important to keep students on track of the process by first, encouraging students to attend the weekly sessions together with their group members; second, providing timely feedback to each group and to the entire class as a whole; third, supporting student collaborations within the group.

Step 3. Reviewing the related literature. We first reviewed related literature on the learning and teaching of software engineering projects and found that it is a common practice to let students learn from their own experiences. Theories supporting this approach include the cone of experience [7], learning by doing [2], experiential learning [14], active learning [4], and flipped classroom [1]. We then looked further into the related work on group work engagement and decided to establish the current work on Macgowan's work [16], because it was based on solid review and it provided reliable and valid measures with empirically examined factor structure [17]. A further investigation showed that a significant amount of related work used peer evaluations as a part of group work [9], [11], [13], [15], [24], most of which used it as an assessment approach by the end of the module. However, peer assessment is different from peer feedback [12]. We were interested to see if using peer evaluation at an earlier stage, and disclosing the peer evaluation results to students as a feedback mechanism can support their engagement in group work. In addition, we wanted to confirm if there are correlations between group work engagement and academic performances in software engineering group projects.

Step 4. Developing a research plan. Following the gathered information and published literature, we found enough evidence to focus our research on the following questions:

RQ1. Can peer evaluation encourage student engagement in software engineering group projects?

RQ2. Does student engagement in group work correlate with their academic performances?

Based on the review of related literature, we propose the following hypotheses:

H1. Peer evaluation can encourage student engagement in software engineering group projects.

H2. Student engagement in group work positively correlates with their academic performances.

In order to investigate the effects of the proposed actions, we decided to run a comparison study . That is, to measure the group work engagement before actions, and measure it again after actions. Fig. 3 illustrates the timeline of the action research.

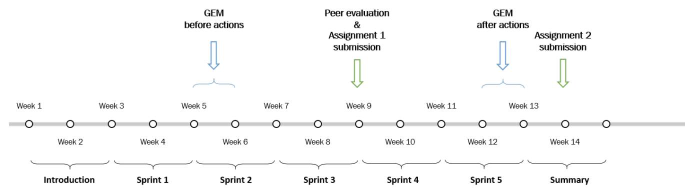

Fig. 3. Timeline of the action research.

B. Acting Stage

Step 5. Implementing the plan and collecting data. During the 14-week long semester at XJTLU, the middle 10 weeks were allocated for students to implement five Sprints of development. We measured their group work engagement after the first Sprint (Week 5-6) for baseline comparison in order to evaluate the effectiveness of the change in pedagogy. Students performed their peer evaluations around Week 9, during which they are encouraged to provide constructive comments on their members' work. We asked students to evaluate their group work engagement again by the end of the final Sprint (Week 12-13).

We used Macgowan and Newman's Groupwork Engagement Measure (GEM) [17] to obtain students' self-evaluated group work engagement before and after the actions. The original GEM has 37 questions in 7 scales. We removed 5 questions that are related to the engagement with the leader, as neither the Scrum Master nor the Product Owner should be the leader of the group. In total, 32 questions in 6 scales were used to measure students' group work engagement in software engineering group projects. In the peer evaluation, students evaluated their peers' group work engagement using the six questions that are summarised from the GEM. The questionnaires were hosted on the XJTLU Survey platform and released to students on the University VLE.

Step 6. Analysing the data. After each round of data collection, data analysis was undertaken. We used IBM SPSS Statistics to run statistical analysis. GEM questionnaire results were summarised, compared, and correlated with students' academic performances. Detailed results are presented in the Results section.

IV. RESULTS

A. Participants

With 370 students in total, the response rates for the two evaluations are 32.08% and 58.22% respectively. The evaluation before actions has received 119 responses, including 53 (44.5%) female and 66 (55.5%) male aged between 16 and 27 (M=21.06, SD=1.08). The evaluation after actions have received 216 responses, including 84 (38.9%) female and 132 (61.1%) male aged between 19 and 28 (M=20.87, SD=0.78).

B. Group Engagement Measure

Results from the analysis of the group work engagement measure are shown in Table I. In the evaluation before actions, students showed a lower engagement in *relating with members* (M=4.09, SD=0.94) and *working with members' problems* (M=3.93, SD=1.00) as compared to other scales. The scores on these two scales showed significant increases after implementing the actions.

TABLE I
MEANS (WITH STANDARD DEVIATIONS) OF GROUP ENGAGEMENT BEFORE AND AFTER ACTIONS AND BETWEEN-SAMPLES COMPARISON($N = 335$).

	Before actions	After actions	t	Sig. (2-tailed)
Attendance	4.33 (0.87)	4.48 (0.73)	1.677	.094
Contributing	4.34 (0.78)	4.57 (0.53)	3.156	.002**
Relating with members	4.09 (0.94)	4.36 (0.75)	2.905	.004**
Contracting	4.42 (0.89)	4.50 (0.80)	0.792	.429
Working on own problems	4.35 (0.76)	4.59 (0.54)	3.289	.001***
Working with members' problems	3.93 (1.00)	4.26 (0.81)	3.298	.001***
Overall GEM	4.24 (0.69)	4.46 (0.53)	3.187	.002**

C. Group Engagement Comparison

We first performed an independent samples t-test to compare the group work engagement before and after actions. The results in Table I showed that the overall group work engagement (M=4.46, SD=0.53) after actions is significantly greater than the group work before actions (M=4.24, SD=0.69), t(333) = 3.187, $p<.01$. Therefore, **H1** is supported: peer evaluation can encourage student engagement in software engineering group projects. Specifically, significant increases can be seen from the four scales: *contributing*, *relating with members*, *working on own problems*, and *working with members' problems*.

We further mapped the samples of the two evaluations and extracted a subsample (N=70) of students who provided responses in both before and after actions. The results are shown in Table II. Overall, the group work engagement after actions (M=4.50, SD=0.58) is greater than the group work engagement before actions (M=4.33, SD=0.63), although the difference is not significant (p=.06). Participants' evaluations on *attendance*, *contributing*, and *contracting* scales are higher after actions, yet the differences are also insignificant.

A paired samples t-test (see Table II) showed a significantly higher score in *relating with members* in the evaluation after actions (M=4.43, SD=0.74) than before actions (M=4.20, SD=0.81), t(69) = 2.38, $p<.05$. Similarly, students scored significantly higher in *working with members' problems* in the evaluation after actions (M=4.30, SD=0.77) than before actions (M=4.04, SD=0.87), t(69) = 2.38, $p<.05$. Students also evaluated significantly higher on *working on own problems* in the evaluation after actions (M=4.62, SD=0.62) than before actions (M=4.38, SD=0.69), t(69) = 2.45, $p<.05$.

D. Group Engagement and Academic Performances

The correlation analysis on students' group work engagement and academic performances showed significant positive results. Therefore, **H2** is supported. Specifically, students' self-evaluations on their group work engagement correlate positively with their academic performances both before actions (R2=0.05, $p<0.05$) and after actions (R2=0.09, $p<0.01$) in the end-term assignment. However, no significant correlations were found between GEM before action and mid-term assignment (R2=0.001, p=0.73). One potential reason is that every student in the same group received the same group mark in the mid-term assignment. It is reasonable that individual evaluations of their engagement do not have significant correlations with the group mark.

TABLE II
MEANS (WITH STANDARD DEVIATIONS) OF GROUP ENGAGEMENT BEFORE AND AFTER ACTIONS AND WITHIN-SAMPLES COMPARISON ($N = 70$).

	Before actions	After actions	t	Sig. (2-tailed)
Attendance	4.43 (0.79)	4.51 (0.74)	.668	.507
Contributing	4.40 (0.67)	4.55 (0.64)	1.524	.132
Relating with members	4.20 (0.81)	4.43 (0.74)	2.375	.020*
Contracting	4.50 (0.84)	4.60 (0.71)	.711	.480
Working on own problems	4.38 (0.69)	4.62 (0.62)	2.448	.017*
Working with members' problems	4.04 (0.87)	4.30 (0.77)	2.380	.020*
Overall GEM	4.33 (0.63)	4.50 (0.58)	1.888	.063

V. DISCUSSION

A. Developing Stage

Step 7. Developing an action plan. With the results from the data analysis, we have confirmed the two hypotheses and decided to implement the strategies in the future delivery of the module. It is helpful to make students aware of how other members' perceived their engagement in the group work, and ideally with constructive feedback. Using peer evaluation as a feedback mechanism in software engineering group projects has a positive impact on students' group work engagement, specifically in *relating with members* and *working with members' problems*. With improved engagement in group projects, students are more likely to achieve better academic performances, as indicated by the positive correlations between group work engagement and assignment marks.

B. Reflecting Stage

Step 8. Sharing and communicating the results. Following Mertler's (2017) stages for action research, specifically reflecting on, sharing and making public the findings, we presented the action research plan and the initial results at the XJTLU Learning and Teaching Colloquium on 16 April 2021. During the Q&A session, we have engaged in discussions with colleagues on the action research design, methodology, and the assessment of software engineering group projects. We also presented some lessons and reflections that were learnt from the teaching experience.

Step 9. Reflecting on the process. Peer evaluation was adopted as the primary intervention in this action research. During the delivery of the module, we have done in-action reflections and implemented some other strategies that were found to be helpful. For example, walking around and asking "where are the others?" is an effective strategy to encourage attendance before the class. As some students tended to be quiet within a group, it is helpful to initiate a conversation with them and encourage them to talk to you and their group members. In addition, "Come together and show me at [a time] when everyone is here" is a good strategy that encourages students to engage in group activities, communicate with each other and present their work.

The action research we undertook was during a period when travel restrictions due to COVID made the return to campus (China) impossible for our international students. We therefore adopted a blended teaching approach to meet all students' needs and to ensure equity in learning opportunities. Separate online meetings with off-campus students were arranged to give them opportunities to present their group work and ask questions. We also found it extremely helpful to record, summarise and update a list of Q&As, and to use Announcement function (an email that automatically went to all enrolled users) on the VLE to send notifications to all students. We observed that students were more willing to send emails to teachers and ask questions face-to-face than posting their questions on the shared forum. Considering the big size of the cohort (370 students), similar questions were asked repeatedly. Therefore, compiling this information from one-to-one conversations and sharing them with all students can save effort and time. Specifically, it is necessary to have regular meetings with TAs to collect common questions asked by students and provide consistent answers to students.

VI. Conclusion

We present this action research on encouraging student engagement in software engineering group projects. The primary action was using peer evaluation as a feedback mechanism for students to evaluate their peers' group work and to obtain feedback on their work. Two research questions were identified based on the information gathering and literature review: 1) Can peer evaluation encourage student engagement in software engineering group projects? 2) Does student engagement in group work correlate with their academic performances? Our hypotheses were supported by the data analysis results. Students have shown significantly greater group work engagement after actions, with significant improvements in *relating with members* and *working with members' problems*. Their group work engagement was also found to correlate positively with their academic performances. Future delivery of the module will keep this approach to encourage students' group work engagement in software engineering group projects. We also presented several useful strategies in the reflections on the teaching experiences, such as encouraging attendance before the class, initiating conversations with quiet students, checking students' work as a group in full attendance, summarizing and updating a list of Q&As, and having regular meetings with teaching assistants.

The results and findings of this research have pedagogical implications in encouraging student engagement not only in software engineering group projects, but also in general activities that involve students working in a group. The teachers will continue to adopt this strategy in the future delivery of this module in order to keep students engaged in learning.

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