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Planting a Soft Skills Seed In a First-Year Introductory Programming Class Using Team-Based Learning

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Abstract

Today's competitive global market demands that engineers possess "soft skills" in addition to technical skills. Currently, engineers learn leadership, teamwork, and management skills while working "soft skills the hard way". In order to meet the demands of this changing world, engineering programs in different universities are challenged to come up with innovative ways to teach classes so that graduates are prepared to take on the challenges twenty-first-century engineers face. Team-Based Learning (TBL) is an advancing teaching pedagogy that shifts instruction from a traditional lecture-based teaching paradigm to a structured learning sequence. TBL has shown to be effective in student academic success and retention; however, it may also aid in the development of soft skills required for the industry. This study focuses on 165 students who were enrolled in a freshman-level programming course in the Fall 2019. The students were all asked voluntarily to fill a "Soft Skills Survey" in the second week of the semester that consisted of 38 questions evaluating various categories of soft skills. At the end of the semester, the same survey was given and both were used to evaluate the effectiveness of TBL on students' soft skills. The conducted survey is designed to assess five overarching factors within the TBL framework: The first is how group work improves individual motivation; the second is how group work stimulates academic growth; the third is the individual student's creative and critical thinking skills; the fourth is the value of group work for their overall education; the last is confidence in their own academic skills. Traditionally, the effectiveness of TBL has been assessed through grades and numeric measures of performance; however, TBL was designed to both enhance learning as well as team collaboration and critical thinking skills. These two surveys were conducted to assess the "soft skills" outcome gains. Preliminary results for this study showed modest gains in critical thinking and external motivation. The results show that using TBL will organically enhance the students' soft skills.

Keywords

Team-Based Learning, Soft Skills, Programming, Engineering

Disciplines

Educational Methods | Engineering Education

Comments

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PLANTING A SOFT SKILLS SEED IN A FIRST-YEAR INTRODUCTORY PROGRAMMING CLASS USING TEAM-BASED LEARNING

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Abstract

Today's competitive global market demands that engineers possess "soft skills" in addition to technical skills. Currently, engineers learn leadership, teamwork, and management skills while working "soft skills the hard way". In order to meet the demands of this changing world, engineering programs in different universities are challenged to come up with innovative ways to teach classes so that graduates are prepared to take on the challenges twenty-first-century engineers face. Team-Based Learning (TBL) is an advancing teaching pedagogy that shifts instruction from a traditional lecture-based teaching paradigm to a structured learning sequence. TBL has shown to be effective in student academic success and retention; however, it may also aid in the development of soft skills required for the industry. This study focuses on 165 students who were enrolled in a freshman-level programming course in the Fall 2019. The students were all asked voluntarily to fill a "Soft Skills Survey" in the second week of the semester that consisted of 38 questions evaluating various categories of soft skills. At the end of the semester, the same survey was given and both were used to evaluate the effectiveness of TBL on students' soft skills. The conducted survey is designed to assess five overarching factors within the TBL framework: The first is how group work improves individual motivation; the second is how group work stimulates academic growth; the third is the individual student's creative and critical thinking skills; the fourth is the value of group work for their overall education; the last is confidence in their own academic skills. Traditionally, the effectiveness of TBL has been assessed through grades and numeric measures of performance; however, TBL was designed to both enhance learning as well as team collaboration and critical thinking skills. These two surveys were conducted to assess the "soft skills" outcome gains. Preliminary results for this study showed modest gains in critical thinking and external motivation. The results show that using TBL will organically enhance the students' soft skills.

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1 INTRODUCTION

The market for engineering has been redefined. Employers are not only looking for engineers that are technically skilled but also engineers that are very skilled in communication and teamwork. These are known as "soft skills". Recent studies show that employers are seeking skills such as teamwork, flexibility, and learning orientation from university graduates [6, 10]. And because engineering jobs frequently require employees to work on projects in team settings, team skills are especially sought out by engineering employers [5]. The issue lies in the disparity between the soft skills graduates believe they have acquired and the soft skills employers are seeing [10]. The studies claim that there may be a lack of soft skill development in university curricula due to rapid changes in the engineering industry. These new demands are thus requiring educators to reevaluate and redesign their course structures and teaching methods to more effectively prepare students for post-education employment.

In order to better implement professional skill development in university curricula, educators are now adjusting their typical lecture-based courses to more interactive class sessions. The Team-Based Learning (TBL) methodology, colloquially referred to as the "flipped classroom," is an emerging teaching philosophy for improving student learning and understanding of class material through group efforts. Over the past two decades, TBL has been implemented in a small range of disciplines for both undergraduate and graduate students.

In the past, TBL has chiefly been implemented in health professional fields such as nursing and animal and veterinary sciences and graduate-level courses [11]. In recent years, TBL implementation has slowly shifted to engineering-related fields and in freshman-level classes [5, 8, 1, 4]. Until now, TBL has

been correlated with a dramatic decrease in first-semester class drop rate as well as a drastic increase in overall grade improvement [1, 4, 6, 9, 11]. Even so, not only has it shown evidence of improving student learning and student retention in specific degree programs, but it also shows potential in developing students' teamwork, communication, and other professional skills [3, 4, 6, 2, 11]. Because it shifts away from the traditional lecture and instead utilizes lecture time for group work and discussion of class materials, TBL has been said to increase student engagement, enthusiasm, and group performance in addition to learning and understanding [3, 8, 9]. It is not uncommon for many students to have had poor teamwork experiences in past traditional lecture-based courses and other experiences. Nevertheless, TBL can be implemented with the underlying goal of the professional development of soft skills in addition to technical skills.

TBL requires students to independently study the class materials outside of class time. In standard TBL, student preparation mainly involves watching pre-recorded lectures, reading lecture slides, and/or textbooks [1, 3, 4, 7]. This leaves the class time for questions regarding the preparation materials. With this class structure, students spend most of the class time collaborating with group members to complete group assignments and in the process, discussing course concepts. As a result, students develop both their technical and soft skills, which they will take to future courses and further down their career paths. Hence, this publication summarizes our modified implementation of TBL in an introductory programming course for Computer and Software Engineering students and reflects on its effects on team-skill development. This study utilizes survey questions made available by M. C. Dorneich et al. [2].

2 IMPLEMENTATION AND METHODOLOGY

Problem-Solving in Software Engineering is a 3-credit freshman-level course that is required for all software engineering students at Iowa State University. It was modified from an active learning style course to a Team-Based Learning course starting from Fall 2019.

This course has two one hour lecture periods and a two hour lab period every week. During the first week of class, students filled out a survey that aided the instructor in grouping students into diverse teams in terms of their technical and collaboration skills. Factors considered in the survey were: background in programming (experienced/not experienced) as well as how comfortable students were collaborating with team members (comfortable/not comfortable). Based on the survey results, the instructor then constructed teams of five to six students, including at least one student in each category (experienced, not experienced, comfortable, and not comfortable). The assigned groups were permanent throughout the semester.

Each one hour lecture period consists of two group activities:

1. Team Readiness Assurance Test (tRAT)
2. Application Activity (AA)

These group activities are delivered to foster both soft skills and technical skills development. The tRAT is a short five-question multiple choice quiz that is given in the initial 15 minutes of each class hour. tRAT questions are directly related to the assigned readings that students are required to do before the class period. The purpose of the tRAT is to test the basic conceptual understanding of that day's topics. During the tRAT period, students are encouraged to debate, discuss, and explain with their group members to come to a consensus, as all group members will receive the same tRAT grade.

After the tRAT has been administered, the class results and common misconceptions will be debriefed by the instructor. Then, the lecturer will proceed with a 15-20 minute mini-lecture that reiterates the topics for that day. Note that the topics are being "reiterated" because the students have already been exposed to the material before class as part of their individual preparation for that specific class. Also note that in standard TBL, the lecture period does not include any sort of lecture; this is one of our modifications to the TBL structure. During the mini-lecture, students have a chance to ask any questions that they may have had while independently studying.

The AA is a programming problem given in the last 15 minutes of each class hour that requires students to write their code to meet the given problem specifications. As with the tRAT, the AA will require the students to focus on that class's topic as the primary implementation in their program. The purpose of the AA is to focus on student application of materials and to display their conceptual understanding on a deeper level. At this point, the students have independently studied the material, discussed the tRAT

with their group members, listened to the mini-lecture, and asked any questions they may have. Thus, due to those factors and the nature of programming problems, the AA is intended to be much more difficult than the tRAT questions. As with the tRAT, the group members will receive the same AA grade and are required to work together on their program. To do this, groups may choose to delegate parts of the problem to each member or work through the whole program as a group. Regardless, the students will discuss and create their solution synchronously on a shared document.

Regarding student preparation before class, in addition to pre-recorded lecture videos, interactive textbook readings, and challenge questions (homework), the students also have the opportunity to take the Individual Readiness Assurance Test (iRAT). This quiz is precisely the same as the tRAT (and the students are aware of this), only it must be taken individually and before class time. The iRAT is not graded and is, therefore, an optional component to individual preparation. However, there are obvious benefits to attempting the iRAT in terms of coming to class more prepared for the tRAT. Note that in standard TBL, the iRAT is administered during the class period, before the tRAT and that shifting the iRAT responsibility to the students is another one of our modifications to the TBL structure. The intention behind it is to maximize class time and make time for the mini-lecture and discussion time.

Lastly, all labs were completed individually and its structure was not adjusted for the TBL format. Thus, we are not covering any details related to the two-hours labs.

3 THE SURVEY

The survey questions were refined from a publicly available survey [2] that reflects the goals of TBL, which is to develop both soft and technical skills.

The initial survey (prior to TBL) contained 39 questions, 34 of which pertained to soft skills. The final survey (after TBL) carried the same 34 questions for the soft skills portion, as well as two qualitative questions that asked for student evaluation of this particular TBL course. All soft skills questions were offered as multiple-choice questions where responses ranged from "Strongly Disagree" to "Strongly Agree". If the questions did not strongly pertain to a student, they also had the option of responding with "N/A".

The survey questions are delivered all together, but implicitly categorized into five different groups:

1. External motivation (3 questions)
2. Academic growth (5 questions)
3. Critical thinking (5 questions)
4. Group/Peer Learning (7 questions)
5. Self-Efficacy (14 questions)

Note that in the following sections, the responses are quantified and treated as a scale of 1-5, 1 denoting "Strongly Disagree" and 5 denoting "Strongly Agree".

3.1 Object

The survey was used for one semester (Fall 2019) as part of a research project. The project objective was to implement TBL into the first-year course Problem-Solving in Software Engineering (S E 185). The goal of this implementation was to evaluate soft skills improvement in addition to grade improvement over active learning (the course delivery before Fall 2019). Active learning shares similar aspects to TBL in terms of class activities; however, the main delivery of the material was through the lecture. The active learning delivery of S E 185 did not embody the "flipped classroom" structure.

Students were given both a pre-course survey as well as a post-course survey to communicate improvement or digression in soft skills and grades due to the new TBL format.

3.2 Participants and Procedures

The survey was delivered to 165 students who were enrolled in a first-year Software Engineering course during the Fall 2019 semester. Both pre-course and post-course surveys were delivered electronically. Since participation in this survey was not mandatory for students, there were 157 participants in the

initial survey and 141 participants in the final survey. No extra credit or other benefits were given to students who participated in either survey.

4 RESULTS

In this section, each figure displays the results of the survey before (blue) and after (red) TBL implementation. It is worth noticing that the initial survey had 157 responses, while the final survey had 141 student responses.

Figs. 1 shows the overall change in each team's skills on a scale of 1-5 (strongly disagree to strongly agree).. Figures 2-6 show the change in each individual skill without a numerical scale. Each figure displays the percentage of students who responded with each qualitative rating, comparing before and after percentages.

To generate Fig. 1, we grouped "Strongly Agree" and "Agree" respondents together and grouping "Strongly Disagree" and "Disagree" respondents. "Strongly Disagree" and "Disagree" equated to a rating of 1, "Neutral" equated to 3, and "Strongly Agree" and "Agree" equated to 5. The "N/A" respondents were omitted. In grouping the respondents and creating a new scale for the "Average Score Per Area, we see drastic increases in academic growth, critical thinking, and self-efficacy; however, both external motivation and group/peer learning have decreased in student rating. The factors in which this occurred are also further explored.

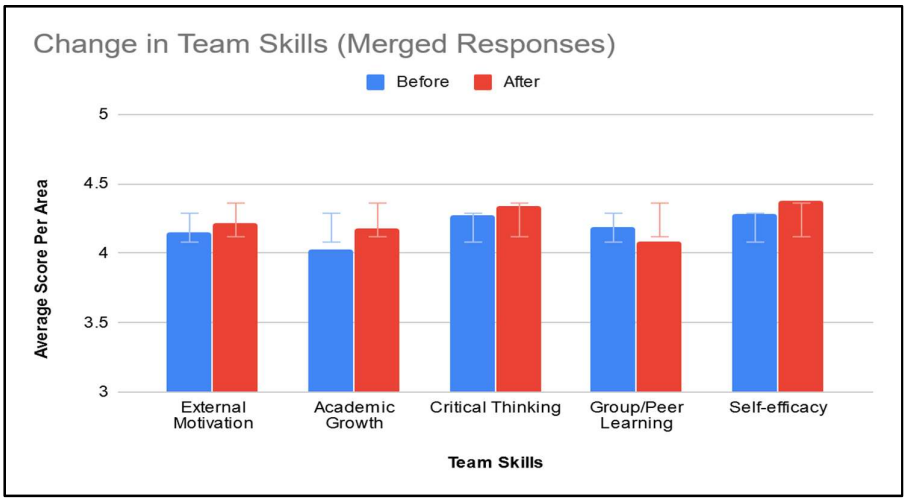

Figure 1. The overall change in team skills (three categories).

Fig. 2 displays student responses to questions asking how group work affects their motivation to succeed at the beginning of the semester survey as well as the end of the semester survey. Although the original survey had response categories from "Strongly Disagree" to "Strongly Agree", similar categories were merged to more efficiently display the results. The individual "Agree" responses dropped from 53.51% to 51.34%; however, the "Strongly Agree" responses increased from 12.71% to 18.46%. The disagree responses remained relatively unchanged. For this reason, we found it appropriate to justify the response category to overall "Agree", "Neutral," and "Disagree".

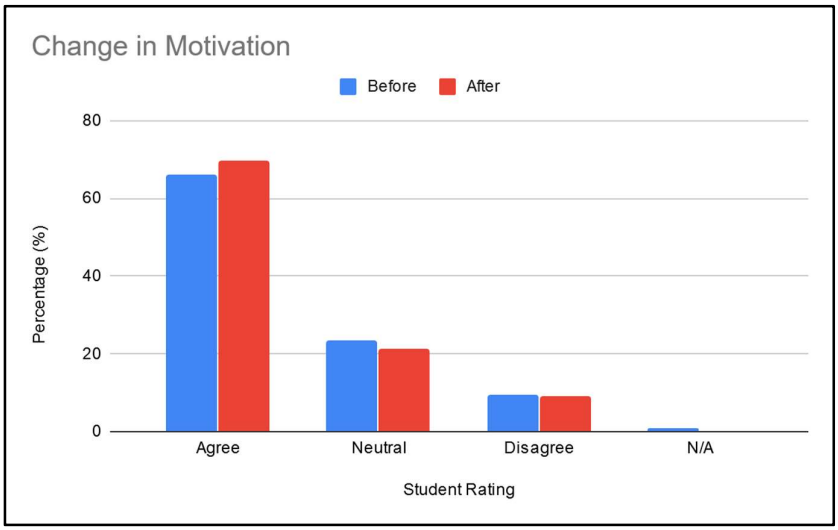

Figure 2. The overall change in students' motivation.

Fig. 3 displays student responses to questions asking how group work affects their academic growth for the beginning of the semester survey as well as the end of the semester survey. Likewise, in Fig. 2, the "Agree" responses decreased from 49.8% to 48.8% while the "Strongly Agree" responses increased from 14.06% to 22.11%. The disagree responses did not show much change. Thus, we felt it appropriate to merge the responses.

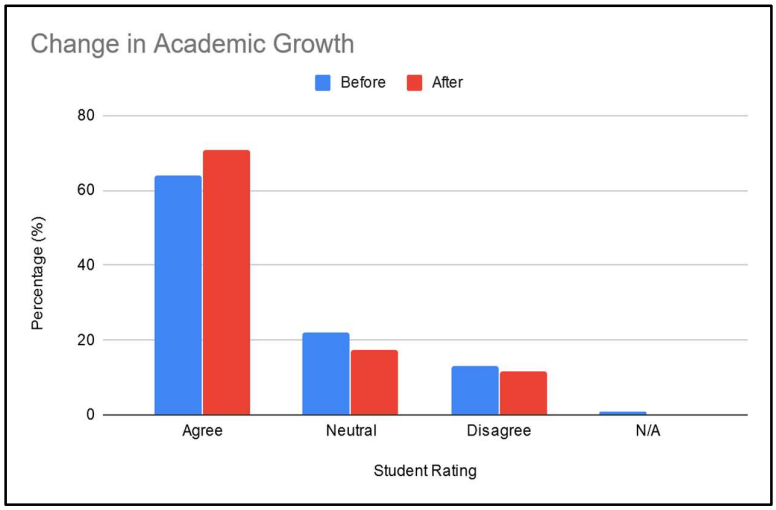

Figure 3. The overall change in academic growth.

Fig. 4 displays student responses to questions asking how group work affects their creative/critical thinking for the beginning of the semester survey as well as the end of the semester survey. For these survey questions, the "Agree" responses remained the same while "Strongly Agree" increased from 17.47% to 20.8%. Again, the disagree responses showed little change.

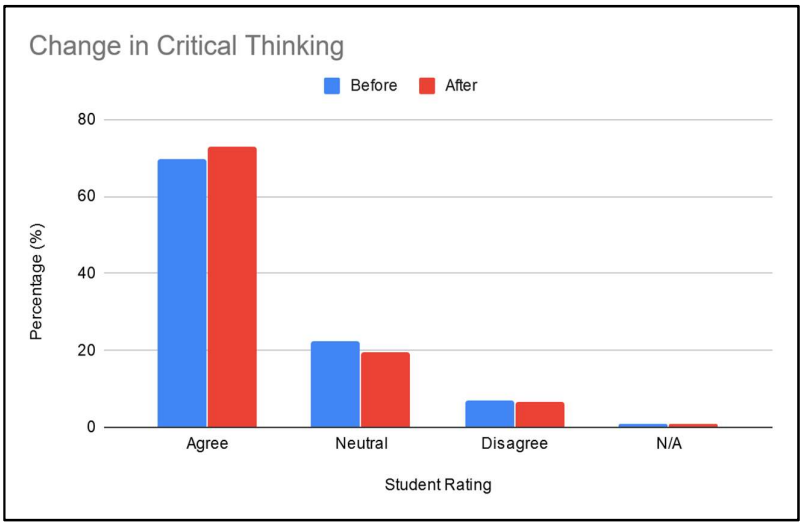

Figure 4. The overall change in students' critical thinking abilities.

Fig. 5 displays student responses to questions asking how group work affects how they value group work for the beginning of the semester survey as well as the end of the semester survey. In this category of team skills, the "Strongly Agree" responses increased from 19.73% to 21.33% and "Agree" responses decreased from 49% to 45.53% resulting in an overall decrease in agree responses. On the contrary, "Disagree" responses increased from 7.36% to 8.17% and "Strongly Disagree" responses increased from 2.34% to 4.5%. "Neutral" responses remained relatively unchanged. The results of this category are further expanded on in the following subsection.

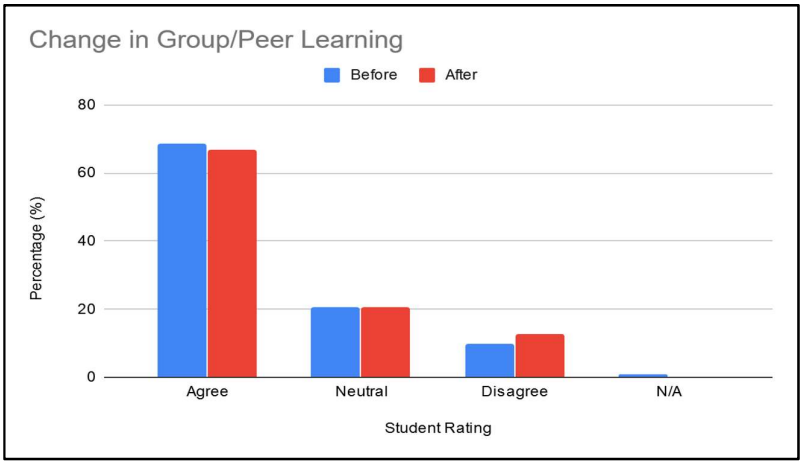

Figure 5. The overall change in students' ability to learn in groups.

Fig. 6 displays student responses to questions asking how group work affects their academic confidence and success for the beginning of the semester survey as well as the end of the semester survey. Like figures 3-5, "Strongly Agree" increased more than "Agree" decreased while there was little change in the disagree responses. "Agree" decreased from 48.57% to 45.36% while "Strongly Agree" increased from 23.64% to 30.07%.

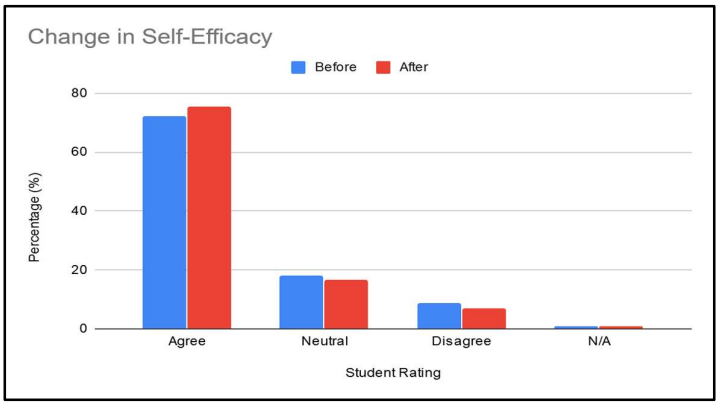

Figure 6. The overall change in students' self-efficacy.

5 STUDENTS' FEEDBACK

The students had the opportunity to provide written feedback on their TBL experience and what may have enhanced their experience. The main factors that may explain the decline in "Group/Peer Learning" were lack of reliability on team members, shortness of class time, lecture hall seating, and group members had different lab sections.

The main complaint from students regarding the class time group activities was of team members repeatedly not showing up or not contributing, leaving the remaining 2-3 members to struggle with the tRAT and AA. One student responded that "constant check-ins with teams" would have enhanced his TBL experience as "one member of [his] group stopped showing up around week 4." Regarding lack of contribution, another student commented that "it always boils down to 2 or 3 people working since it is too crowded for any more to help." These comments provide better insight into the student responses and are part of the justification for the decrease in the Group/Peer Learning team skill.

Many students reported that the shortness of each class activity also discouraged collaboration. One student stated, "It is hard to give people who don't know how to code the opportunity to work on it if I know my grade is on the line." It did not appear that students did not like collaboration. In fact, many students reported that they enjoyed working as a group for the final project and requested that there be more group projects throughout the semester. Based on their feedback, students seemed to have a higher quality of teamwork while working on the final project. One student commented that more opportunities for collaboration outside of class would allow them to "be more of a team than just classmates."

Another common comment was that students would have benefited from TBL more if their group members shared the same lab section. One student specified that something that would improve their TBL experience was "having the same lab section so we could help out each other in labs." The fifteen minutes of tRAT and AA did not seem substantial enough for most groups to foster good collaboration and a sense of being a team or being friends, whereas the final project was.

Another factor that may have reduced the students' TBL experience was the location of their class. Classtime took place in an auditorium where students could not easily face each other. "As it is, I have to turn all the way around to speak with half of my team." A handful of students commented on this and suggested a different classroom where groups were seated at round tables, and they could sit face to face. Thus, lack of collaboration and participation from some team members can be explained by lack of accountability, crowdiness in the classroom, lack of class time, and lack of in-depth group projects.

6 CONCLUSIONS

The results of this study show small-scale improvements over a range of professional development skills as a result of the TBL delivery of the introductory programming course. The categories of growth included motivation, academic growth, critical thinking, and self-efficacy. Slight decline in group/peer learning skills coupled with student feedback revealed areas of improvement to the TBL structure of this

course. Based on the feedback, there are several alterations to the existing TBL course structure that could be made. The time allotted for the class time could be extended to prevent class activities from being rushed. This would potentially allow more collaboration without the students feeling as if their grades are being jeopardized. Another option would be to alternate between having a tRAT or an AA each class rather than having both. This method would allow more time for discussion as well. There are several other options that can be explored, such as making labs team-based or incorporating more group projects throughout the semester. The decision to form groups based on lab sections will also be highly considered. Future implementations of introductory programming courses in TBL format can incorporate the same survey given in this study to evaluate what is useful in developing professional development skills in freshman-level students in programming-related fields.

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