Supporting Instructors in Implementing Team-Based Inquiry Learning

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Team-Based Inquiry Learning (TBIL) is a novel active learning pedagogy designed to facilitate the use of inquiry-based learning in lower division courses. This preliminary report examines supports provided by the TBIL project to instructors, as well as the fidelity of implementation of TBIL by participants of the project. Initial findings suggest that classroom-ready materials and ongoing support, both synchronous and asynchronous, were most helpful to faculty in their TBIL implementations.

Keywords: inquiry-based learning, team-based learning, professional development

Introduction

Inquiry-Based Learning (IBL) is a well-established collection of pedagogies with many documented benefits for students (Laursen et al., 2011; Laursen & Rasmussen, 2019). Despite its benefits, IBL is more likely to be implemented in upper level courses, smaller courses, and courses for mathematics majors (Ernst et al., 2017). Team-Based Inquiry Learning (TBIL) is a novel active learning pedagogy implementing Team-Based Learning in an effort to facilitate the use of IBL in lower division courses (Lewis et al., 2021). TBIL was initially studied by the authors in the context of a linear algebra course at a single institution, where it was shown to improve students' content mastery, grades, and procedural flexibility (Lewis & Estis, 2020).

This paper reports preliminary findings from ongoing work to study the effectiveness of TBIL across varied instructional contexts. The authors conducted faculty development workshops (described below) to train interested instructors, who then implemented TBIL in their Calculus I, Calculus II, or Linear Algebra course. These instructors were invited to participate in the present study aimed at addressing the following research questions.

RQ1: (A) Which of the supports provided to faculty led to a successful implementation of TBIL in various instructional contexts? (B) Which additional supports would aid faculty in their implementation of TBIL in various instructional contexts?

RQ2: How faithfully do faculty implement TBIL after participating in the training workshops?

Team-Based Inquiry Learning

Team-Based Learning (TBL) is a highly structured active learning pedagogy that focuses on application of course content through collaborative problem-solving. Each module, or unit of instruction, consists of three phases: Preparation, Readiness Assurance, and Application of Course Concepts (Michaelsen & Sweet, 2008). TBL balances individual preparation and responsibility with the benefits gained from working together as a team to solve problems. Students receive frequent and timely feedback, and assignments are designed to promote team development, as well as learning. This is typically operationalized through the usage of four practical components: permanent teams; a readiness assurance process; so-called '4-S' application activities (in which students work on the **S**ame problem, which is to be a **S**ignificant

problem, and make a **S**pecific choice that is **S**imultaneously reported); and peer evaluations (Michaelsen et al., 2004).

Team-Based Inquiry Learning (TBIL) utilizes the structure, flow, and principles of TBL to implement IBL in lower division mathematics courses. The 4-S application activities are designed to allow students to engage deeply with coherent and meaningful mathematical tasks, while the simultaneous reporting structure helps the instructor to inquire into students' thinking. The readiness assurance process is designed to remind students of prerequisite knowledge needed to fully engage with the challenging 4-S inquiry tasks by reducing extraneous cognitive load. A further explanation of how TBIL fulfills the four pillars of IBL is found in (Lewis et al., 2021).

The TBIL project, led by the authors, began in 2021 with goals to (1) Determine the extent to which TBIL is effective across differing instructional contexts; (2) Create and publish a library of accessible, classroom-ready, open-source TBIL materials for lower division courses; and (3) Train and support faculty as they implement TBIL at a diverse group of institutions and instructional contexts.

Supporting TBIL Instructors

The TBIL project provided a number of supports to instructors, beginning with an intensive faculty development workshop. Two cohorts of 13 instructors each participated in these workshops in the summers of 2021 and 2022, respectively. The first workshop was held in a hybrid format to maximize participation (5 faculty participated in person, with 8 connecting remotely), while the second workshop was entirely in person. The first workshop was five days in duration, while the second was three days; this was done to allow time for the first cohort to contribute to development of the curricular materials (described below). Both trainings included sessions on the fundamentals of team-based learning, integrating IBL into team-based learning, and mock teaching activities.

Instructors were also provided with a set of curricular materials prior to implementing TBIL. The linear algebra materials were initially written by the authors, and then revised by participants in the first cohort; while the single variable calculus materials (both Calculus I and Calculus II) were developed by participants in the first cohort, building on existing open-source calculus active learning materials such as *Active Calculus* (Boelkins et al., 2018). These materials included a full set of classroom-ready, student-facing activities, in addition to other support materials such as banks of exercises for practice and assessment, readiness assurance resources and quizzes, and videos.

In addition to initial training, previous work on adoption of IBL has shown that ongoing support during implementation is crucial (Hayward et al., 2016). Thus, the project team provided instructors with Online Working Groups (Fortune & Keene, 2021; Wawro et al., 2023), which were synchronous meetings of the instructors and a project team leader to have informal conversations about challenges and success in their TBIL implementations. Additionally, the project team created and maintained a Slack community devoted to TBIL. This ongoing resource serves to provide instructors with asynchronous support, again both from peers and from the project leaders.

Methods

We employed a survey methodology with the 26 instructors who completed the provided TBIL training. These instructors were located at 23 different institutions, 17 classified as predominantly white institutions and six classified as minority-serving institutions. Of the 23

institutions, 21 were four-year colleges and two were two-year colleges. To answer the first research question, this paper reports on a single survey administered at mid- and end-of-semester for each semester in which participants implemented TBIL. This survey contained three open-ended questions about instructor supports ("Of all the provided support, which has been most useful and why?", "Are there additional supports that have aided in your implementation of TBIL?", and "What additional supports would aid you in your implementation of TBIL?"), as well as four Likert-scale questions asking the frequency at which the instructor implemented the four practical components of TBIL (Permanent Teams, Readiness Assurance Process, 4-S Application Activities, and Peer Evaluations). Twenty-five of the 26 participants completed the faculty support survey at least once, with a total of 54 responses across all participants and semesters of data collection--Fall 2021 through Spring 2023.The three open-ended questions about supports were coded by the first author using open coding to identify the kind(s) of support described in each response.

In addition to the surveys, the 26 instructors were also invited to submit a syllabus from their TBIL course. 12 responses were received, which were coded by the first author for the presence or absence of the same four practical components of TBIL (Permanent Teams, Readiness Assurance Process, 4-S Application Activities, and Peer Evaluations).

Results

When determining which supports faculty identified as either leading to a successful implementation of TBIL, or which additional supports would be helpful in implementing TBIL, five codes emerged, with their frequencies presented in Figure 1. The most frequently mentioned support was 'Materials' in reference to the curricular materials provided. In discussing materials as a helpful support, one participant said, "Ready-made materials for the obvious reasons: I've really been able to focus my time on my students and facilitation, rather than higher level course design work." In contrast, when materials were described as a needed support, instructors desired either additional ancillary student resources (such as videos), or a desire to customize the materials to meet their unique needs. It should also be noted that 13 of the 14 respondents who identified materials as a needed support also identified elements of the materials as a helpful support. The next most frequent codes were 'Online Working Groups' and 'Slack,' referring to the synchronous and asynchronous informal support from the project team and their peers that extended through the academic semesters. The code 'Training' was unique in that there were more codes specific to additional supports needed (n=8) versus the training being helpful in implementation (n=7). Those instructors with a desire for additional support related to training either wanted a more nuanced understanding of creating TBIL activities, "how-to-guides" related to generating additional fluency-building or assessment questions, or desired to have additional training specific to TBIL implementation, possibly a refresher on in-class implementation or facilitation strategies. The last code was 'Peer', which referred to support from peer instructors, either through the project or at their institution.

To address the second research question, we first considered the frequency with which participants reported they implemented various components of TBIL in two ways. Since instructors were invited to respond to the survey in several semesters, we considered their initial response (n=25), as well as the most recent response from those who responded multiple times (n=19). We see a high implementation rate of permanent teams and the readiness assurance process in the initial response, with the latter waning somewhat in the final response. Implementation of the 4-S application activities was somewhat lower; only 72% of initial responses indicated that they were implemented 'Most of the time' or 'Always,' though this rose

to 95% in the final response. Peer evaluations were the least used component; notably 47% of the final responses indicated that they were never used.

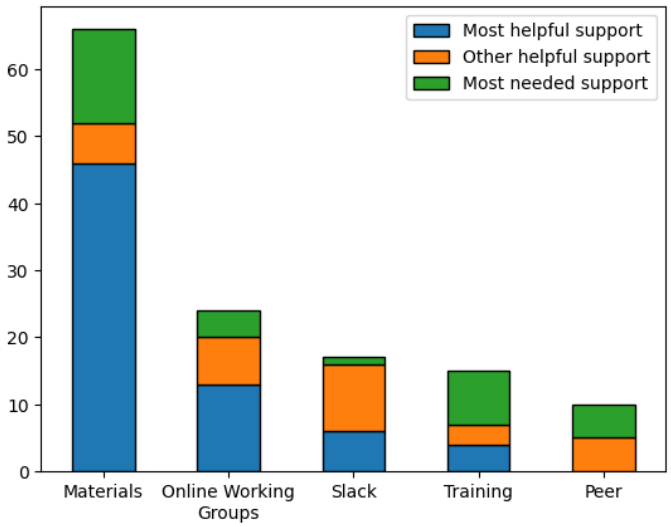

Figure 1. Supports identified as the "Most helpful support" provided, "Other helpful support" provided, or an "Additional needed support".

As noted above, 12 participants provided a syllabus for analysis. All of them indicated the use of 4-S application activities, with 92% indicating a Readiness Assurance Process and 83% indicating the usage of permanent teams. Only 67% of syllabi indicated that peer evaluations would be used.

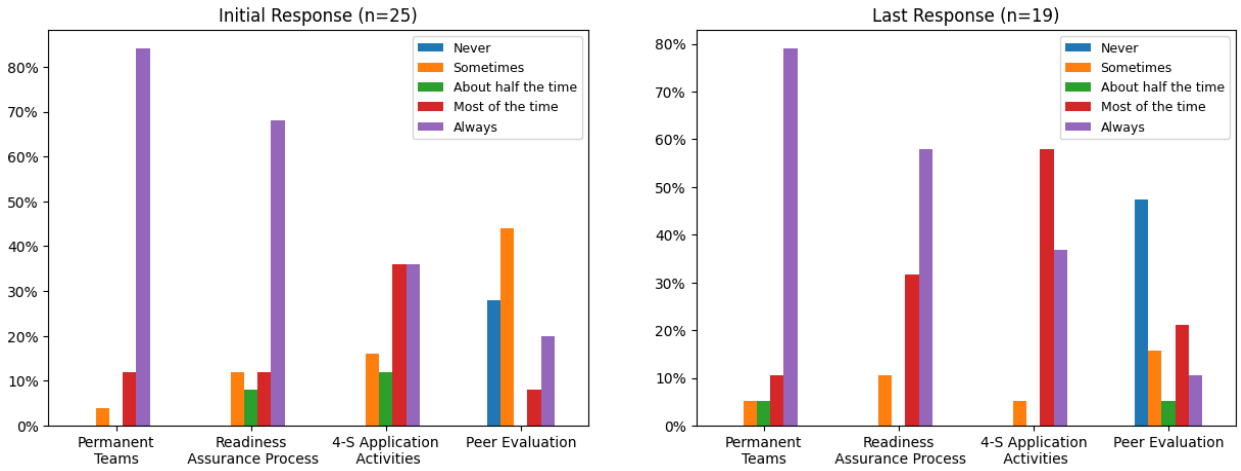

Figure 2. Initial and final responses of the frequency at which participants reported implementing components of TBIL

Discussion

Overall, we found participants identified two key supports in their implementation, namely the provided curricular materials, and ongoing support from peers and project leaders. Several participants specifically noted that having the provided curricular materials reduced the planning time necessary for the course, allowing them to focus on the novel aspects of the TBIL pedagogy such as classroom facilitation. We interpret this as the provided materials serving to reduce the

cognitive load on participants as they learned to implement the other aspects of TBIL. We also note that one participant observed that the choice of the project to distribute the materials without requiring a login made it easier to share the materials directly with students.

We note this latter ongoing support was described by participants and coded separately as referring to either the synchronous online working groups or the asynchronous Slack community. The prevalence of both suggests that each communication modality offers something valuable to instructors that the other does not. The implications of these results are that leaders of similar pedagogical and curricular reform projects need to design ongoing faculty development efforts that accommodate these support preferences. While some aspects like the Slack channel almost maintain themselves after the initial setup, the synchronous online working groups are resource-intensive in terms of investigator time, which needs to be taken into consideration in the project design. An additional observation: the project's financial investment was greatest in materials development and initial training workshops. While the curricular materials were viewed as very valuable by our participants, the training was not. In fact, the online working groups and the Slack are both mentioned as more important than the initial training. However, we expect the community-building aspects of the intensive workshops, which led to participants' participation in the online working groups and Slack, were quite important second order benefits that do not appear in participants' responses.

Regarding the second research question on fidelity of implementation, we observed very high usage of permanent teams and the Readiness Assurance Process across both the self-report and syllabi. Usage of 4-S application activities was also quite high on both measures, but the self-report showed many instructors only used them most of the time. Usage of peer evaluations was much lower. We suspect one aspect contributing to this is the growing movement in mathematics (and other disciplines) to use alternative assessment and grading practices. Indeed, we (Lewis et al., 2021) specifically advocate for the use of Standards-Based Grading (e.g. Elsinger & Lewis, 2020) in our paper describing the TBIL pedagogy. We assume this stance implicitly permeated our trainings and support structure. We also note that Lewis and Estis (2020) reported that peer evaluations had no correlation with content mastery. It seems likely that participants may similarly have not found value in the evaluative nature of the peer evaluations, and instead opted for other peer feedback and team-building pedagogical moves.

Future Work

While this preliminary report represents partial progress towards addressing the research questions, we believe additional qualitative work is needed to fully answer these questions. In particular, we have collected (but not yet analyzed) video recordings of classroom sessions to further address the second research question regarding fidelity of implementation, particularly with a view toward facilitation moves and the usage of the 4-S application activities. We intend to conduct follow-up interviews with some of the participants at the end of the academic year to try to paint a fuller picture of the utility of various supports (in regards to the first research question), as well as to try to understand why various aspects of TBIL (such as peer evaluations) were implemented less frequently.

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