Flip-J instructional strategies in the first-year engineering design classroom

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Abstract

The effectiveness of a learner-centered pedagogical model called "Flip-J" is evaluated in this work-in-progress paper. First-year engineering students participated in a project-based engineering design process curriculum with a service-learning component. Students were assigned weekly reading materials to be discussed in-class using a four stage Flip-J process. The stages were: 1) individual reading assignments outside of classroom; 2) in-class formation of collaborative expert groups; 3) in-class formation of cooperative Jigsaw groups and 4) in-class reflection exercises. More than 80% of the students indicated a productive experience from the cooperative learning strategy used. Students' feedback also included recommendations on how the activities could be improved upon to promote learning and engagement.

Introduction

Jigsaw is an instructional strategy that was formalized by Elliot Aronson in 1978 as a form of cooperative learning [1]. Cooperative learning is established [2],[3],[4],[5] with an increasing number of instructors specifically using it in the engineering design classroom [6],[7],[8],[9]. As such, Johnson [4] provides an accepted framework for quality cooperative learning: 1. Positive interdependence, 2. Individual accountability, 3. Face-to-face promotive interactions, 4. Appropriate use of collaborative skills, and 5. Group processing. These components are balanced against logistical challenges particularly in large lecture courses. The objective of this paper is to present one strategy for Jigsaw called "Flip-J" in a large, interdisciplinary, first-year engineering design course and discuss its characteristics considering quality cooperative learning.

Method

First-year Interdisciplinary Engineering Course Structure: At [blinded], first-year engineering and computing students are mandated to take a 3-credit, interdisciplinary [blinded] course. Seven sections of the course were offered in the Fall of 2018 with approximately 90 students per section. The course is based on service-learning therefore students work on projects with a designated community partner in teams of up to 5 students per group. Through weekly guides, students are to develop functional prototypes by the end of the semester by using the engineering design process developed by Ulrich and Eppinger [10]. Course meetings are twice a week with a duration of 75 minutes per session. On the first lecture of the week, instructors give lectures on the fundamental engineering design concepts while during the second lecture of the week, students work on activities that aims to master the fundamental concepts introduced earlier and also work other activities that provide professional development opportunities. The second lecture is in a cooperative learning environment where "Flip-J" is one of the methods used.

Four Stages of Flipped-Jigsaw Process: The Flip-J technique used in this course was executed in four stages as depicted in Figure 1. The first stage is the allocation of reading assignment. A lesson module is divided into subsections identified by letters, and each student is assigned a letter and a reading assignment that corresponds to the letter in the subsections. The reading assignment is to be completed outside of the classroom. The second stage is the formation of collaborative expert groups. Here, students with the same letter assignments are considered

subject experts on their respective reading assignments and are grouped for discussion (time allowed ~ 30 minutes). The tasks of the collaborative expert groups are to discuss individual main points learned from the reading assignments, demystify any misconceptions and reinforce concepts. In the third stage, cooperative Jigsaw groups are formed by randomly assigning a number to each student while in their expert groups. Thus, the cooperative Jigsaw group consists of students with the same numbers but different letters and therefore different reading assignments. The objective of the Jigsaw groups is to learn instructional materials from each expert member in the number group by actively listening, intentionally taking notes and asking questions for clarity (time allowed ~ 20 minutes). The fourth stage focuses on reflection on all the reading assignments materials. Instructor poses pre-formulated questions to all students to assess comprehension and clarify any misconceptions (time allowed ~ 10 minutes).

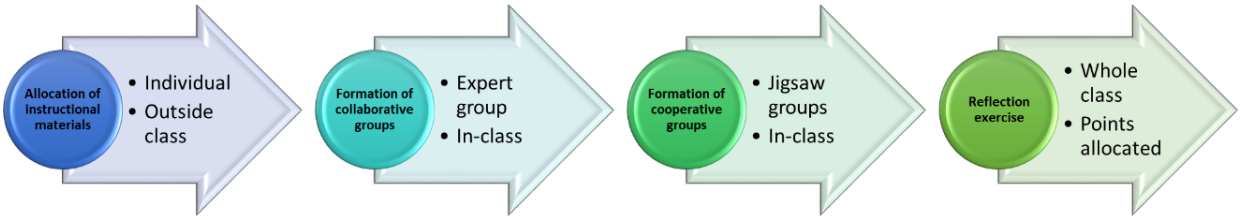

Figure 1: The four stages of Flip-J process for teaching first-year engineering design course.

During the expert group meeting, thirty minutes was allocated for discussion and preparation of teaching materials to their peers in the Jigsaw groups. The task for the first twenty minutes of the allocated thirty minutes was spent on student introductions and their main point from the reading assignment. The remaining ten minutes of the expert group stage covered developing more points and clarifying any misconceptions. After this, students moved into their jigsaw groups. In both group meetings, a time keeper and moderator was assigned within each group.

Mid-term Evaluation: During the 8th week of a 16-week semester, students were given opportunity to influence the course by completing a mid-term course evaluation form in class. Students were asked to list some things positive about the course and to provide suggestions for the things the course could do differently. For every concern listed, students had to provide possible course of action. Only 45 students in one course section completed the questionnaire.

Results and Discussion

Flip-J technique improved acquisition of knowledge: The ability to synthesize concepts in small parts and construct collaborative solutions was deemed valuable with the implementation of Flip-J. Students showed mastery of the small parts of their assigned reading by individually explaining their understanding of the main points and discussing their responses. Generation of new ideas often occurred during the expert group discussions. Students who had different perspectives or took different approaches in the assignment were able to come to consensus. During the Jigsaw group meetings, students took turns to present their subject matter and worked on how concepts of the main points fit together. During the first iteration, students often read their prepared notes in turns and had minimal discussion until questions were posed by the instructor to assess the comprehension of the main points presented by an expert member. In such cases, if no students could answer the question then the expert member will have to re-teach the content to the Jigsaw group. This also lent itself to a discussion about how to best formulate

groups and promote learning and positive interactions. Once the students understood the process, about 60% of the section's Jigsaw groups applied the engineering design process to solving practical problems that were not even assigned. In stage 4, the reflection exercise, students were asked to blindly select a number from a list of reflection questions. And scores were assigned for competition purposes only. Assessment of the Flip-J learning strategy in this section seem to show an effective method for knowledge retention, promotion of student engagement and development of communication skills in this first-year engineering course.

Student feedback indicated positive student engagement and learning assessment: Based on the midterm course evaluations, more than 80% of the students reported that the Flip-J activities provided an opportunity to learn engineering concepts, fostered team building, inspired peer interactions and lectures, encouraged creative thinking and helped strengthen their communication skills. Feedback from students also highlighted areas for improvement, such as time spent on expert (letter) groups were too long compared to Jigsaw (number) groups. Students suggested that opportunities to switch their number groups in subsequent classes would allow more peer interactions. Corrective actions were applied to reflect students' feedback.

Motivation and incentives to participate in this type of learner-based model had to performed by the instructor. Some groups needed no motivation while about 25% of the groups were often very quiet and carried along in a monologue fashion. After the first iteration of the Flip-J technique, the instructor reassigned the group moderators and introduced a point system to facilitate group participation. These points were not used for grades but were implemented as more of an in-class competition amongst groups. Students responded well to this approach especially during the reflection questions where points won would go to the Jigsaw group. Breaking up a large lesson module into smaller parts helped students improve knowledge retention. During the first 10 minutes of the next meeting class time, a retrieval process [11] was often conducted where students were asked to answer the same reflection questions covered in the previous class. Thus far, results show that approximately more than 50% of students in the section accurately answered the questions that were discussed in the reflection questions than the ones only discussed in stages 2 or 3. This observation indicates that the reflection exercise in stage 4 is key to knowledge retention, a confirmation of John Dewey philosophy [12] that stresses that until a reflection piece is conducted, genuine learning can take place.

A future study will include comparison between active and passive learning. An inclusion of graded points that impacts final course grade will be considered. Switching up the type of questions prepared by expert groups may allow for creativity that induces other unique approaches to teaching the materials to the Jigsaw groups. Diversifying the type of reflection questions is also important, thus conducting different forms of activities in stage 4 could be evaluated. Lastly, frequent student reassignment of letters and numbers along with restructuring the duration of stages 2 and 3 should be done to maximize class time and learning.

Conclusion

Implementation of the Flip-J technique allowed for both acquisition of knowledge and applied learning pursuit that is focused on application, evaluation, analysis and synthesis of pertinent information for teaching first-year engineering students. The pedagogical principles elaborated in this paper could be translational to upper-level engineering courses thereby bringing about a plausible transformative learning experience.

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