

Think-Pair-Share: Application of an Active Learning Technique in Engineering and Construction Management Classes

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The traditional lecture technique of teaching has long been criticized for its inability to involve the student continuously in the learning process. Active Learning techniques, designed to make the students active and collaborative participants in the learning process, are gaining popularity as a supplement and alternative to traditional lectures. In this paper, we discuss a pilot project where we are implementing an active learning technique, Think-Pair-Share (TPS), in a traditional construction management class (Estimating), and in a civil engineering class (Transportation Engineering) in two universities. TPS is designed to encourage critical thinking, collaboration, and sharing knowledge with peers. Our initial impressions from TPS exercises indicate that they provided a structure for students to participate in class discussions. This paper presents a work in progress. We are in the process of designing a rigorous research study to evaluate the benefits of TPS in a CM context. This paper discusses our motivation, specific exercises we conducted, methods of implementation in the classroom, and our experiences. Finally, we present the benefits, limitations, and scope for further research in this area. The main objective of this paper is to share the TPS technique, associated exercises and our impressions with our fellow CM educators.

Key Words: Active Learning, Think-Pair-Share, Collaborative Learning, Construction Education

Introduction

The traditional lecture based method of teaching has been utilized in college and university classrooms across the world for centuries. This paradigm of teaching, which conforms to behaviorist pedagogy, involves the transfer of a well synthesized body of knowledge from the teacher to the student in a structured manner in a classroom (Kamardeen, 2014). In this style of teaching, the student is a passive recipient of knowledge. This can result in inattention from students, often resulting in students "checking out" of the class (Lumpkin et al., 2015). This problem has recently been exacerbated by the ubiquitous presence of devices such as tablets and smartphones.

Active learning techniques, on the other hand, conform to constructivist pedagogy. In this paradigm, the student becomes an active participant in the learning process, supported by a collaborative learning environment and group work (Eklund, 1995 in Kamardeen, 2014). Active learning techniques are designed to help students learn by doing things, thinking about the things they are doing, and sharing their knowledge with their peers. In contrast to the traditional lecture based method, learning in this style of pedagogy is student-centered. Examples of active learning techniques include hands on demonstrations (Kresta, 1998), project based learning (Maskel, 1999), and use of simulation models (Nirmalakhandan et al., 2007). According to Bean (2011), students can improve their critical thinking skills when they learn through active learning methods such as case studies, role-playing, and small group work. These techniques help them critically evaluate situations from various points of view and implement creative solutions. A significant body of research has evaluated and proven the efficacy of these active learning methods in various technical and non-technical college courses. The students in undergraduate construction management programs have grown up in a social media driven world where instantaneous interaction is a norm. As educators, we need to develop more effective ways to engage our students in ways that are collaborative and interactive in nature.

Active Learning Techniques in Construction Management Courses

Researchers in Construction Management Education have experimented with several active learning techniques to verify their effectiveness. Leathem and Tatum (2012) used an innovative Jeopardy style game to gage students' engagement in their learning process. Recently, Martin et al. (2014) used three classroom games: "Prisoner's Dilemma", "$20 Negotiation Game", and "Parade of Trades Game" to teach the basic principles of Integrated Project Delivery to undergraduate students. They report that their students felt that the games enhanced their understanding of project management. The flipped classroom approach is currently enjoying popularity in universities as a tool to encourage active learning. In this approach, students watch recorded lectures first and then they solve homework problems in the class; thereby flipping the traditional sequence of learning. Burgett (2014) evaluated the effectiveness of this strategy in a construction management class and found that the success of this technique depends upon students' motivation to watch recorded lectures. Further, Burgett (2014) commented that recorded lectures may be a good tool to teach basic concepts but they are not an effective tool to teach complex concepts. Bhattacharjee (2014) evaluated the effectiveness of role-playing as an active learning tool and found that the students that were taught using role-playing as a teaching strategy demonstrated a better understanding of the subject matter and showed a positive attitude towards construction as a profession.

In the autumn semester of 2015, the authors started a pilot project of implementing a well-established active learning technique, "Think-Pair-Share" (TPS) in one class (Construction Estimating and Costing) at the University of Cincinnati and one class (Transportation Engineering) at Syracuse University. This method was implemented in conjunction with traditional lecture based teaching style. This method consists of three main components: thinking or reflecting on a question posed by the instructor, pairing with another student or a group of students to discuss and debate solutions to the question, and finally sharing the conclusions with the peers in the class. This technique was implemented in two classes, Construction Estimating and Cost Control, and Transportation Engineering. The TPS exercises were designed with two different objectives in mind. The TPS exercises in the Construction Estimating and Costing class were designed to make students draw from their educational and practical experience in construction management to identify the factors that should be considered when estimating the cost of specific items in a construction project. The TPS exercise in the Transportation Engineering class was designed to encourage students to critically assess the benefits and impacts of various alternatives as a part of a large scale reconstruction / replacement problem. Students were asked to reflect on their daily experiences with the highway section in question (which is in very close proximity to the campus area), and combine this personal view with the technical information presented in a guiding document. The distinguishing feature of TPS is that it provides a structured process for an instructor to create a forum for peer to peer collaborative learning in the classroom. The objective of this paper is to share these exercises, our methods of implementation, and specific strategies for success in application of TPS with the educators from the construction management community.

Think-Pair-Share

The Think-Pair-Share (TPS) technique was first proposed by Frank Lyman (Lyman, 1981). The classic TPS implementation consists of three steps:

1. THINK

First, the instructor poses a challenging or an open ended question to the students at the beginning of the exercise. At this point, students are given a few minutes to reflect on the question; drawing from the knowledge gained in the classroom as well as their experiential knowledge.

2. PAIR

Each student is then asked to pair with one or more peers to form a group. This group could either be composed of the student's neighbors or assigned by the instructor randomly. Students typically tend to sit with their friends in the class. The second method ensures that the students are exposed to different points of view from people with whom they normally do not interact. The students discuss their solution / point of view within their group for several minutes. In this step, students get the opportunity to discuss their experiences and ideas, and defend their decisions in a small group environment. The discussions among group members can result in collaborative learning through shared experiences. This component is typically not present in a traditional lecture style class.

3. SHARE

After giving the students sufficient time, the instructor then initiates a class-wide discussion of the problem at hand. In this situation, the instructor can ask one representative from each group to briefly discuss their point of view or their solution to the problem. In every class, there is a tendency for a few students to monopolize the conversation. This component of the exercise gives a voice to the students who typically do not participate in class discussions. At the end of the exercise, the instructor can summarize the conversation. This ensures that the collaborative learning outcomes, which occurred through the discussion, are accessible to every student in the class. The instructor can also use this opportunity to validate the innovative solutions that were suggested by students.

TPS has several advantages to instructors and students. It helps the instructor in making the class more interactive in comparison to regular lectures. It helps the instructor organize course content and track students' progress for that specific topic as it is being discussed in class. It gives the students a structured way to prepare for a specific concept that will be discussed in the class (Radhakrishna et al., 2012). It allows for integration of the student's experiential knowledge into the class's learning. It provides opportunities for students to interact with each other and learn from each other's experiences.

Implementation of Think-Pair-Share

The methodology described in the previous section was implemented in Engineering and Construction Management programs of two universities. While the underlying motivations remain the same, the implementation of the methodology in terms of the problems under consideration, and the questions posed highlight the versatility of the method. The following two cases provide details of the mechanics of Think-Pair-Share method in two different environments.

Case 1(Instructor 1): Implementation in a Construction Estimating and Cost Control Class

The TPS exercises have been carried out in a class with thirty-five students at the University of Cincinnati. The students were juniors and seniors from Construction Management, Civil Engineering, and Architectural Engineering programs. The students have typically completed two to three semesters of co-ops where they work with either design or construction companies in various capacities. Many of the students have worked as members of estimating teams where they were responsible for one or more estimating activities in a project. The students typically work on a wide variety of projects such as commercial construction, heavy civil construction, retrofit projects, and healthcare projects etc. Thus, the students in this class can potentially have specific experiences that, if shared with the class, would diversify the knowledge of the class.

In a construction estimating class, the quantity takeoff part is fairly deterministic. If one assumes that the students know how to read drawings and calculate areas and volumes, given a set of drawings, all students should be able to provide reliable estimates for the quantities of items under various divisions of MasterFormat. The same logic applies to using RSMeans Data books. The unquantifiable factors that can affect the cost of various items vary widely across different types of projects. The objective of the TPS exercises in this class is to create a collaborative learning environment, where students discuss various factors that may affect the cost of items in each division of MasterFormat as it is discussed in class.

Example of the TPS Exercise

The instructor discussed various underlying studies that a contractor typically performs when developing the estimate for a large project. Site study is commonly performed by the contractor. The instructor discussed the importance of the study, how it can reveal factors that may impact the cost of a project. At the beginning of the following lecture the students were provided with a handout for a TPS Exercise, which consisted of three separate steps.

THINK

Problem Statement: "Imagine that you are on an estimating team which is bidding for a high rise building project that will be under construction near the university on a congested street. If the Chief Estimator tasks you with visiting the site and making a list of all the factors that may affect the construction execution plan and the cost of the project, which factors would you consider?"

The students were allowed approximately 5 minutes to reflect on the problem, recollect what they had learnt in the previous class and write their list on the handout.

PAIR

In this step, the students were asked to pair with two more students near them and compare and contrast the factors that others had listed. If another student had thought of a different, important site related factor, they were encouraged to add it to a separate list. Students were given five minutes to update their lists.

SHARE

In this step, the instructor facilitated a class discussion. In the discussion, each group was asked to list the factors that they had identified to be important. Usually, the students in the first two rows always participate in class conversations. Hence, the instructor asked the group in the last row to list their answers first. Then, groups were randomly selected from all over the class to ensure that everybody had an opportunity to provide their input. The students were asked to note the new factors that were identified by other groups.

Thus, the TPS exercise allowed students to learn from each other in small groups and then learn from the entire class itself. This also provided an excellent platform for otherwise shy students to participate in the class discussion. The clear structure also allowed them to understand the power of collaborating with others and sharing knowledge.

Instructor's Observations

The author / instructor was initially worried about the possibility of lack of communication within the smaller groups in the "Pair" stage of the exercise. During the exercise, it was a very pleasant surprise to see students actively engaging with each other and discussing their ideas. The time allowed for, in this step should be carefully controlled. If too little time is provided, students do not get an opportunity to complete their discussion. If too much time is provided, the discussion can easily get derailed to non-class related subjects. In this case, the instructor walked through the classroom and made sure that the conversations were not going off topic. Lastly, the instructor observed that many students who had not participated in the class conversations actively participated during the TPS exercise. The diverse nature of the class, i.e. having a mixture of Civil Engineering, Architectural Engineering, and Construction Management majors in the classroom, added to the quality of the discussion. The Construction Management majors, many of whom had worked in estimating teams during their co-ops, were able to share their experiences with the class. The Civil and Architectural Engineering majors, who typically do not look at a project from a construction contractor's point of view, were able to gain a different perspective in the process. Overall, the exercise was beneficial to the students.

Case 2 (Instructor 2): Implementation in a Transportation Engineering Class

Think-pair-share (TPS) exercise was implemented in a Transportation Engineering class in the Fall 2015 semester. The Transportation Engineering class was offered as a mixed-level class to a total of eighty-six students. Seventy-two students were enrolled as undergraduate students and the rest were enrolled as graduate students. The exercise focused on students' opinions with respect to the reconstruction / replacement alternatives for a major interstate highway that are being considered by the New York State Department of Transportation. The objectives of the exercise included:

1. Increasing participation of students to the class discussion;
2. Familiarizing students with the various stages involved in decision making procedures utilized by transportation agencies,
3. Ensuring students would be well-prepared for a presentation that was going to be offered by a guest speaker from New York State Department of Transportation two days after the TPS exercise.

Students were given a reading assignment in which they were asked to read certain sections of the scoping report on reconstruction / replacement alternatives for the interstate in question five days prior to the in-class TPS exercise. The topics of the reading assignment included overview, background, and purpose of the project; need for the project, and the alternatives that were considered by New York State Department of Transportation. The class exercise was run during the last thirty-minute section of an eighty-minute class hour. A question sheet was distributed which consisted of three separate parts corresponding to different stages of Think-Pair-Share.

THINK

Problem Statement: "I-81 Project Alternatives that advanced to the Environmental Impact Statement (EIS) stage include: i)No Build Alternative; ii) Viaduct Alternatives (New Viaduct Fully Improved to Current Standards, New Viaduct with Substantial Design Improvements, New Viaduct with Considerable Design Improvements); and iii) Community Grid Alternatives (Boulevard, One-Way Traffic on Almond Street and Other Local Street(s), Two-Way Traffic on Almond Street and Other Local Street(s). Suppose you have been requested to make a recommendation in terms of the ideal solution to this reconstruction/replacement problem. Provide your preferred alternative and make a list of the factors that played an important role in your decision making process."

First part was to be answered by each student individually. The instructor asked the students to move to part 2 (pair) as soon as they completed the first part. A major portion of the class completed the first part within five minutes and moved to the second part.

PAIR

In the second part, students were asked to form pairs, discuss their answers with each other, and report on any factors that were not common in their answer sheets. Students were given a total of fifteen minutes to complete parts 1 and 2; hence, the class discussion was conducted in the remaining fifteen minutes.

SHARE

In the last part, students were asked to pay attention to the discussion made in class and report on any factors that can be added to the list of factors they identified in the previous parts. This portion of the question sheet was prepared in exactly the same format as in the first implementation.

Instructor's Observations

As a result of the implementation, a total of 77 responses were collected (9 students were absent on the day of implementation). 36 students indicated that they would prefer conversion of the portion of I-81, that is designated as the priority area by the agency, into a boulevard or arterial; while 40 students indicated that they would prefer reconstruction of the viaducts to eliminate the existing structural deficiencies and the non-conforming portions of the interstate highway. Only one student chose the "No Build" alternative. Later on, the guest speakers from New York State Department of Transportation indicated that the results obtained from the TPS exercise mimics the responses they obtained from public review sessions very closely. When the responses submitted by the students were examined, it was also observed that almost all students answered all three parts of the exercise sheet. A few students indicated that they had the same factors listed in their partners' answer sheet (part 2).

Students showed a high level of participation in the fifteen-minute discussion period. Seven students shared the results of their group discussions with the rest of the class. The instructor elaborated on the opinions raised by students and led the discussion in a way to promote engagement of students. As an interesting point, a student listed some of the factors that may be considered in favor of a community grid alternative even though he stated that his preference was reconstruction of portions of the interstate highway through new viaducts.

The instructor believes that the implementation of TPS in transportation engineering class was highly beneficial due to the following reasons: i) The exercise encouraged students to talk to each other, share their ideas, and report on their findings; ii) Instead of a traditional unidirectional lecture style a dialogue was formed, which increased students engagement in learning; iii) The presentation given by New York State Department of Transportation official, two days following the TPS exercise, was very well received by the class and the discussion that followed the guest's

presentation featured several well-thought questions about the subject.

Discussion

Unlike some active learning strategies such as flipped classroom, the TPS strategy does not require a complete overhaul of an instructor's style. It can easily be used to integrate active and collaborative learning strategies into classes that feature traditional lectures. The exercises described in this paper can be shortened and performed several times during a class period to break the monotony of lectures. The authors have recently started implementing this method. In order to ensure that students do not stray from the topic, it is very important that the instructor provides just enough time for the second step (pair). If too much time is provided, the discussion can easily stray away from the topic. Interestingly, we have observed that the current seating arrangement of our classrooms was designed for a lecture type learning. This limits the students' ability to sit together in a group, in a circle, to effectively discuss with their peers. In the future, we plan to poll the students and collect their feedback about their perceptions of the exercise, how they would like to improve the process and how to increase its effectiveness. More importantly, the students' learning during these exercises is currently not being evaluated. Our objective for the pilot project was to refine the mechanics of this process for future implementation. The questions that we hope to address in the near future include:

1. What metrics can be utilized to evaluate the students' learning during a TPS exercise?
2. What metrics can be utilized to evaluate the students' participation during a TPS exercise?
3. What metrics can be utilized to evaluate the students' collaboration with their peers during a TPS exercise?
4. What is the instructor's role in ensuring the success of a TPS exercise?

Conclusions

In this paper, applications of an active learning technique, Think-Pair-Share (TPS), in a traditional construction management class (Estimating), and in a civil engineering class (Transportation Engineering) are discussed. The motivation behind implementing TPS as a pilot project, specific exercises that were undertaken, and the experiences gained are presented. This paper provides the results of a work in progress. As such, the main objective of this paper is to share our initial findings with other CM educators and to facilitate discussion with regards to how TPS can be more effectively used in classes of similar nature. Based on initial observations, TPS offers great potential to improve collaboration and communication between peers. It can also be used to improve student engagement in the learning process. We observed that the exercises were well received by the students. Students energetically participated in the exercises and discussed their ideas / opinions with their peers and instructors. It allowed students to be active participants in the learning process. It also encouraged them to share their practical, experiential knowledge with their peers. We also observed that several students who typically did not participate in class discussions were actively involved in TPS discussions. The procedure will have to be further refined. We are encouraged by our initial observations in the classroom. Much work still needs to be done to refine this method and rigorously evaluate its efficacy. We hope that our experience will help our colleagues experiment with TPS in their classrooms.

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