

Team-Based Learning in Nuclear Engineering

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Author Biography

Dr. Tristan Utschig is Director for Scholarly Teaching in the Center for the Excellence in Teaching and Learning (CETL), and Associate Professor of Nuclear Engineering in the Department of Mechanical Engineering at Kennesaw State University. He conducts research in the scholarship of teaching and learning and facilitates workshops, faculty learning communities, and other programming supporting faculty development as teacher scholars. He has extensive experience consulting with faculty about teaching and learning in their classrooms, about grant proposals with educational components, and in assessing educational innovations. He teaches courses in mechanical and nuclear engineering.

Introduction

I began experimenting with Team-Based Learning (TBL) in 2010, and I have never seen anything like it in terms of the way it engages students in the subject. Among the students there are high fives, exclamations of joy, even hugs! I have been using it ever since. Behind this decision, the scholarship supporting my teaching approach centers on Biggs' concept of constructive alignment, consisting of carefully constructed learning outcomes, *well-designed learning activities directly addressing those outcomes*, and thoughtful assessment practices (Biggs, 1996). The learning activities for my implementation of the constructive alignment model are designed using the Team-Based Learning approach (Michaelson, Sweet, & Parmelee, 2008), and are leveraged by a variety of tools in the process education literature (Apple, Ellis, & Hintze, 2016).

Goals for my TBL Activities

I work to develop critical skills for my nuclear engineering students as learners and professionals. Specifically, I use TBL to help my students achieve learning outcomes related to becoming better engineering problem-solvers (through visualization, modeling, and reflection among other skills) and more effective team members who are valued by teammates and who communicate well. Most engineers work in professional teams, and as social beings we benefit from variety in perspective (Doolittle & Hicks, 2003). By using TBL, I can foster this in a performance-based learning environment to help students process and practice what they are learning (Michaelson, Knight, & Fink, 2004).

Description of my TBL Activities

In my TBL classroom, students work in teams of four to seven (size depends on the course) throughout the semester. I usually assign roles for different learners to play such as captain, recorder, spokesperson, optimist, skeptic, and spy. This provides structure for each learner to contribute to the discussion and provides opportunity to practice important collaborative learning skills (Felder & Brent, 2007; Johnson, Johnson, & Smith, 2014).

Typically, students spend around 50% of class time in cooperative teams working to answer critical thinking questions; justify decisions; solve problems; and process what they are learning through compare and contrast, directed paraphrasing, or other activities. Other class time includes testing and just-in-time interactive lecture on the most challenging aspects of the material. Each day, teams open their team folder to sign in and find their assigned classwork and other materials. After completing activities, team members then indicate ways in which they contributed to the teamwork for the day.

Here are examples of typical prompts for the TBL activities in my course:

- How many fewer powerplants would be required in the US if all household room lighting were converted from compact fluorescent to LED? (a) 1 plant, (b) 10 plants, (c) 50 plants, (d) 100 plants.

- In which type of energy should the U.S. government invest most heavily in research and development over the next decade? Why? (a) clean coal, (b) nuclear, (c) solar, (d) wind, (e) other.
- Dr. Farfan does research on new detector designs in collaboration with Dr. Das. In order to help promote KSU and faculty research, they sometimes need to explain to donors or others how detectors work. Make a brief “elevator speech” to give to Dr. Farfan and Dr. Das explaining how a particular type of radiation detector works. Use at least four steps in your explanation.

Figure 1 displays the individual contributions to teamwork chart I use in my class:

Figure 1: Individual contributions to teamwork table

Team member initials						
Found data or other needed information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Offered solution method	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Provided constructive criticism on solution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Performed estimates or other calculations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Offered rationale for decisions made	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (describe)	_____	_____	_____	_____	_____	_____

These in-class group learning activities serve as a large part of the overall TBL learning cycle I use for my course (Michaelsen, Knight, & Fink, 2004), as shown in Figure 2.

Figure 2: TBL learning cycle

Phases of Team-Based Learning									
Activity	Preparation		Practice					Assessment	
In-class		R.A.P. -Individual test -Group test -Appeals -Corrective instruction		Group Work (simple)		Group Work (harder)	Continue pattern as long as needed	Exam or other assessment	
Out of class	Reading		Homework		Homework		Review		
Approximate level of content understanding (%)									
40		50		70-80				80-100	

Reflection on evidence of TBL impact towards reaching my goals for students

I collected data for three semesters in a senior level nuclear engineering course. Initial implementation involved partial adoption of the TBL process in fall of 2010 with 40 students. I next taught the course using the full TBL process in 2013 with 61 students, and again in 2014 with 28 students. I also used the full TBL approach in an introductory level course with 25 students in 2017, and with 33 students in 2018.

I measured student learning outcomes for both technical learning outcomes and professional learning outcomes through multiple types of assignments aggregated into an overall level of achievement for each outcome. Figure 3 displays results for the nine technical outcomes in the senior course. Clearly, the partial TBL implementation in 2010 was not as successful as the full TBL implementation in 2013 and 2014.

Figure 3: Technical learning outcomes

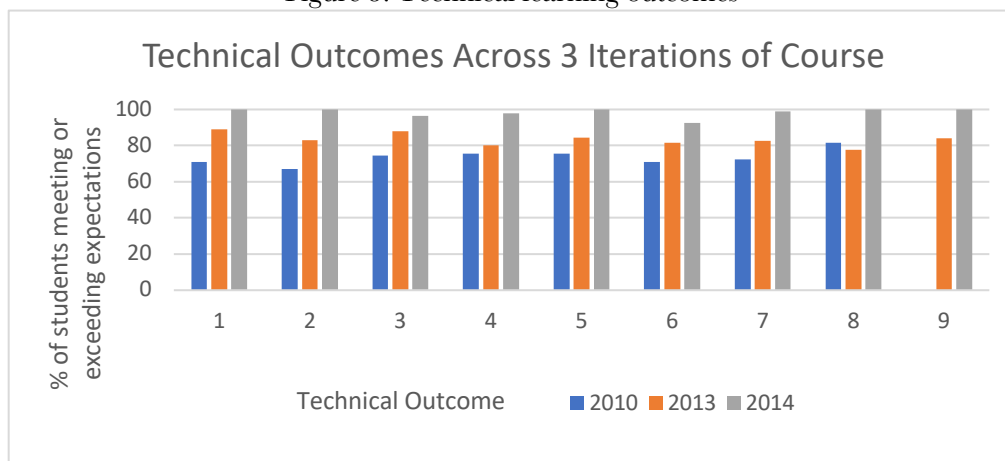
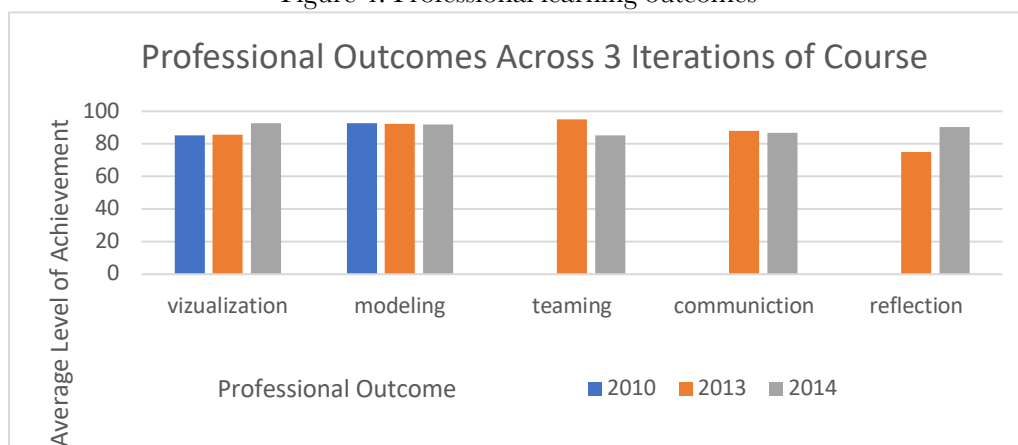


Figure 4 displays results for the senior course professional outcomes. Team skills, communication skills, and reflection skills were not measured in the first (partial) instantiation.

Figure 4: Professional learning outcomes



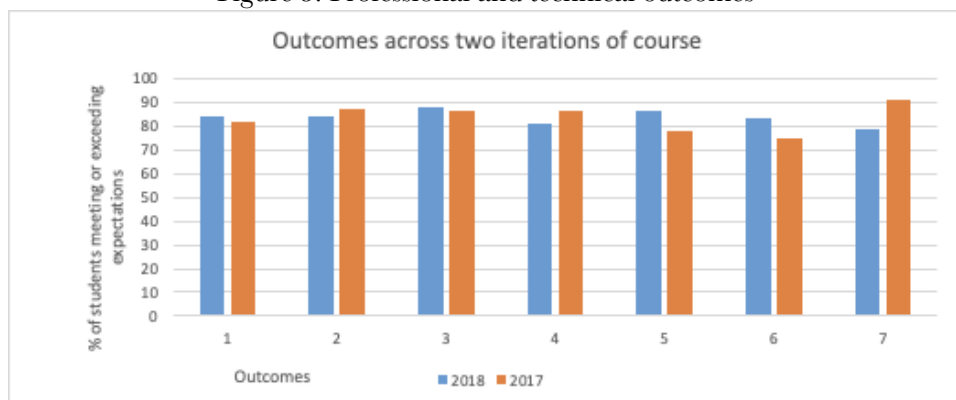
Further, DFW rates (those students who get a D, F, or withdraw from the class) dropped significantly in sections using the TBL approach when compared to all offerings of the course over the same time period, as shown in Table 1.

Table 1: DFW rates

	GPA	A%	B%	C%	D%	F%	W%
All offerings	2.56	23	33	19	15	5	5
TBL	3.31	33	41	5	2	0	3

In the introductory level courses, a similarly high level of achievement was attained, as shown in Figure 5. In 2018 one student stopped attending after the fifth week but remained enrolled. That student's data is included in the figure.

Figure 5: Professional and technical outcomes



Finally, the TBL approach provides the following general benefits:

- Promotes ABET criteria such as lifelong learning, effective teamwork, effective communication, and understanding professional and ethical responsibilities.
- Students find the course format valuable due to its parallels to real-world working environments. This is substantiated by comments from students who completed internships/co-ops.
- The use of teams can reduce grading workload.
- Student learning becomes more efficient in the TBL mode. An entire textbook chapter (requested by students at the end of the first implementation) and a team project were added to the senior course during the second and third offerings without diminishing performance on technical objectives.

For more information on TBL, visit <http://www.teambasedlearning.org/>.

References

- Apple, D. K., Ellis, W., & Hintze, D. (2016). 25 years of Process Education. *International Journal of Process Education*, 8(1).
- Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education*, 32(3), 347–364. <https://doi.org/10.1007/BF00138871>
- Doolittle, P. E., & Hicks, D. (2003). Constructivism as a Theoretical Foundation for the Use of Technology in Social Studies. *Theory & Research in Social Education*, 31(1), 72–104. <https://doi.org/10.1080/00933104.2003.10473216>
- Felder, R. M., & Brent, R. (2007). Cooperative Learning. In P. A. Mabrouk (Ed.), *Active Learning* (Vol. 970, pp. 34–53). <https://doi.org/10.1021/bk-2007-0970.ch004>
- Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative Learning: Improving University Instruction by Basing Practice on Validated Theory. *Journal on Excellence in College Teaching*, 25, 85–118.
- Michaelsen, L. K., Knight, A. B., & Fink, L. D. (Eds.). (2004). *Team-based learning: a transformative use of small groups in college teaching* (1. Stylus paperback edition). Sterling, Va: Stylus Publishing.
- Michaelson, L. K., Sweet, M., & Parmelee, D. X. (Eds.). (2008). *Team-based learning: small-group learning's next big step*. San Francisco: Jossey-Bass.