THE ROLE OF TECHNOLOGY IN INVERTED VERSUS TRADITIONAL INSTRUCTION

Reza O. Abbasian
Texas Lutheran University
Department of Mathematics and Computer Science
Seguin, Texas, 78155 USA
rabbasian@tlu.edu

John T. Sieben
Texas Lutheran University
Department of Mathematics and Computer Science
Seguin, Texas, 78155 USA
jsieben@tlu.edu

Abstract
In this paper we will discuss preliminary results of the role of technology and active learning in student success between inverted (flipped) classrooms and traditional lecture formats in natural science and statistics classes at Texas Lutheran University. These results are part of a three-year NSF funded grant titled "Inverted and Active Learning Pedagogies (IALP) for Student Success" with participating faculty from biology, chemistry, physics, mathematics and statistics. We will present the results utilizing data which includes approximately four hundred sample points on pre- and post-tests and the survey of students and the faculty. Our results will compare the student achievement based on the type of instruction, the discipline, the frequency and extent of the use of technology and the group and individual activities using technology in and out of classroom
Keywords: Inverted, flipped, active learning, technology

Introduction
Three years ago, Texas Lutheran university was awarded approximately $300,000 from the NSF-IUSE program for a project titled "Inverted and active Learning Pedagogies (IALP) for Student Success and Retention" to be conducted during the period from September 2016 to August 2019. The main goal of this project is to determine the optimal combination on inverted and active learning practices to maximize student learning in STEM disciplines, specifically in several courses in statistics, biology, chemistry and physics. In addition to the mode of instruction (traditional or inverted), principal investigator, Reza Abbasian and his colleagues are evaluating the effectiveness of other factors, such as technology, type of activities and how the mode of instruction affects the retention of STEM students. Entering its third year, the IALP project has yielded four semesters of data. In this paper, we will be discussing an important aspect of the study, namely how the use of technology affects students' learning in inverted versus traditional classes.

The authors have been using technology in the mathematics and statistics classes at Texas Lutheran University for close to three decades and are true believers in the power of Technology, CAS and online resources as investigative tools to help develop students' understanding of mathematics and statistics. The current study gives us an opportunity to measure the effectiveness of the use of technology versus traditional modes of instruction in inverted vs traditional classrooms.

We will begin our paper with a brief description of the project including the goals, duration, disciplines, and faculty involved. We will then present the methodology used for our study including instruments that were developed to measure the effectiveness of the use of technology and active learning in students' success across multiple sections of the same course and across different disciplines. Finally, we will discuss challenges in the use of technology in and out of classroom and designing technology-based class activities for inverted classrooms. We will then present our results based on three semesters of instruction involving approximately four hundred pieces of data from pre and post-test as well as student and faculty surveys. Our paper is intended for STEM and statistics educators with interest in the use of technology and the effectiveness of the inverted instruction

Description of the project

The PI is interested in the development of inverted classrooms while exploring the cognitive level design space in the small liberal arts university setting. The project has three goals:1) developing classes implementing IALP to optimize content coverage and maximize higher-order student learning, 2) determining the impact of IALP on the success and retention of STEM majors and 3) disseminating to the national STEM community the project findings and course materials to enable faculty to incorporate IALP techniques into their courses and sharing the research design and measurement tools that will allow investigators to replicate and further test the efficacy of IALP courses. Faculty will participate in IALP course development workshops and document course activities and characteristics throughout the semester. The impact of the IALP will be measured in a variety of ways such as: pre- and post-test instruments, student scores on assignments, quizzes, exams, and projects throughout the semester, end-of-the semester faculty questionnaire, and student surveys. The use of course sequences will provide control groups and facilitate measurement of IALP impact on later courses.

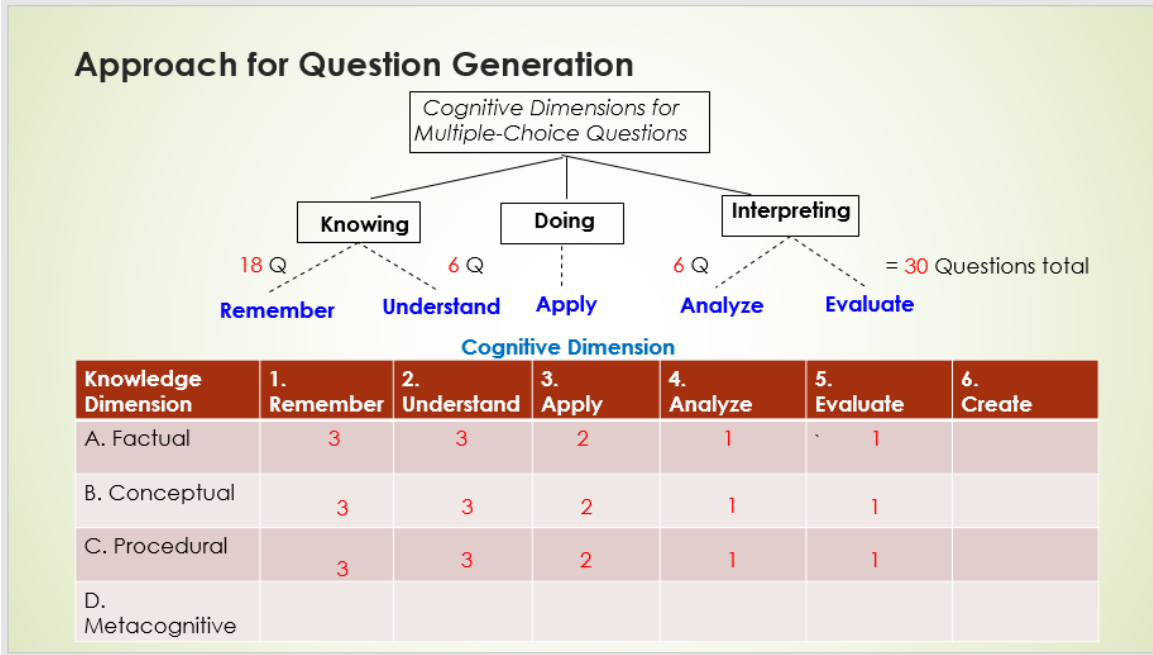
Students partaking in inverted-classroom pedagogy will learn basic concepts from online lectures in the form of short videos leaving the classroom for activities of higher cognitive load. Classroom activities are led by the faculty member who can offer explanations of the most challenging concepts and can foster a collaborative environment for learning higher order thinking and problem-solving skills.

So far six faculty from mathematics, biology, chemistry and physics participated in this project. Three other faculty, who were not initially part of the grant, have also shared their data (pre-post test results and student surveys, as well as responding to the faculty questionnaire). The following courses are part of the study: Elementary and Applied Sta-

tistics (STAT 374-375), Biological systems I and II(BIOL 143-144), General Chemistry I and II (CHEM 143-144), General College Physics I and II (PHYS 141-142)

Methodology and data gathering

Bloom's taxonomy was used to create questions at multiple cognitive levels. Figure 1 summarizes the approach to the question generation. Students in all classes were administered the same pre and post-exams (post-exam contained one problem to address the "creative/application" dimension of Bloom's taxonomy) at the beginning and the end of each semester. Grades and withdrawals over the course of the semester were also examined. Faculty completed a questionnaire at the end of each semester on the organization of the course (use of technology, in-call activities, number and length of videos, etc.) Students completed surveys at the end of each semester to examine their attitude and interest in the mode of instruction. The average class size was 24. Approximately 130 students per semester participated per semester. Mixed MANOVA and ANOVA tests were conducted examining pre and post-test results. Factors were the mode of instruction (inverted or traditional), discipline (statistics, biology, chemistry and physics) and the course term (fall or spring semester). Dependent variables were total test scores, compartmental knowledge scores (factual, conceptual and procedural knowledge) and cognitive dimensions (remembering, understanding, application and analyzing and evaluating).



Knowledge Dimension	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual	3	3	2	1	1	
B. Conceptual	3	3	2	1	1	
C. Procedural	3	3	2	1	1	
D. Metacognitive						

Figure 1

Representative Findings: Fall 2017 through Fall 2018

Following is a sample of our results from the analysis of three semester of data. The complete report on the findings of our study will be published later this year.

As expected, students performed better in post-test compared to the pre-test. Students in statistics had more gain than other disciplines (see figure 2). Students in traditional classes performed better on procedural knowledge (see figure 3). Overall, however, there was no significant difference in the final grades between inverted and traditional classes (see figure 4) in fall 2017. Students in inverted classes performed slightly better in spring 2018 (see figure 5).

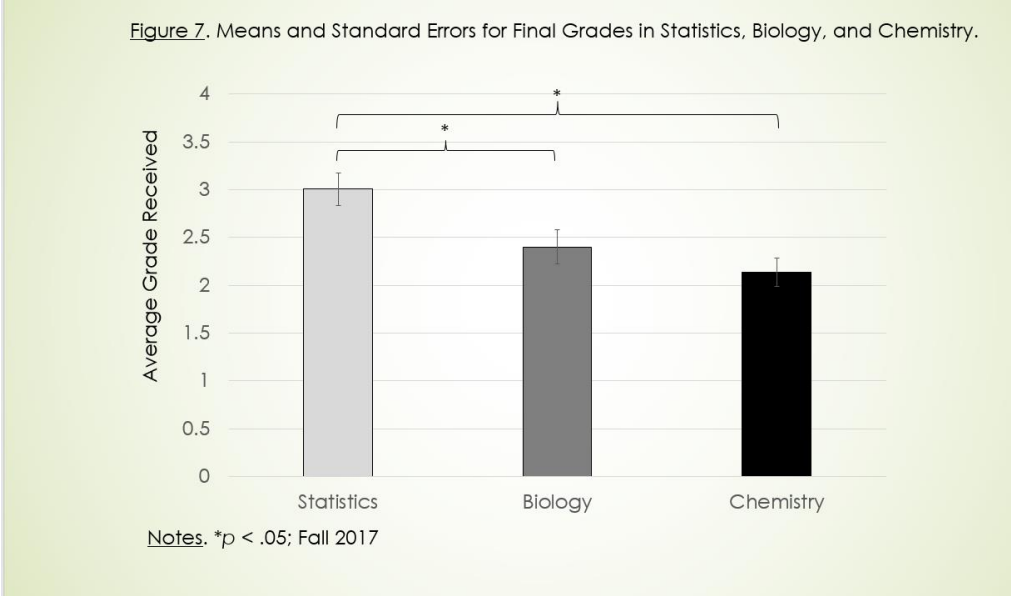


Figure 2

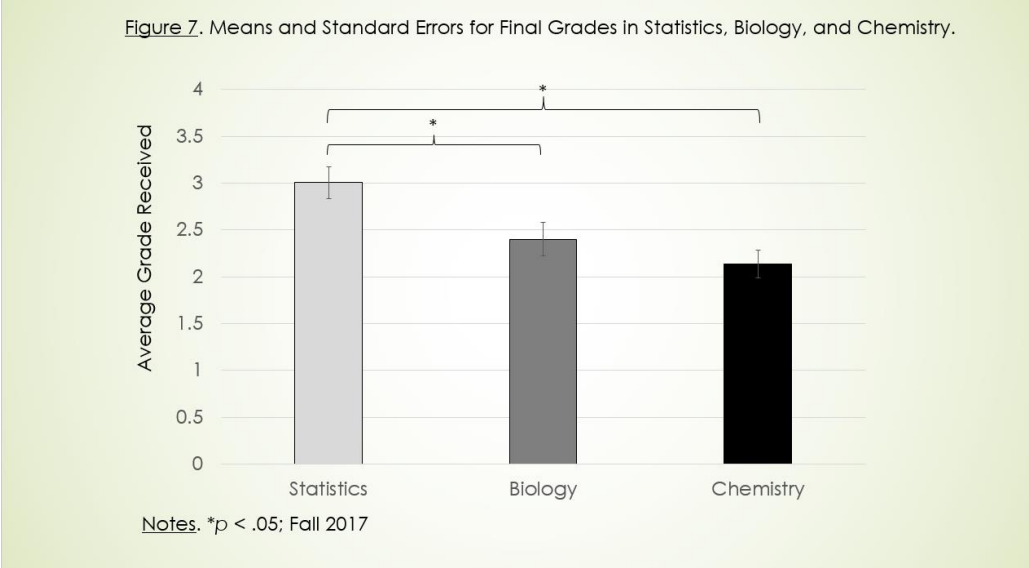
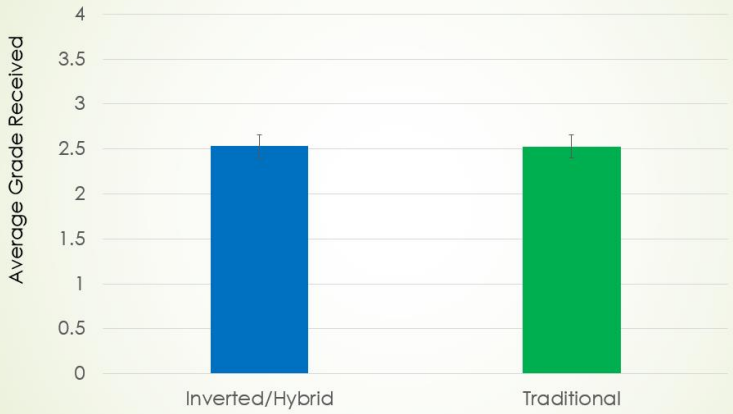


Figure 3

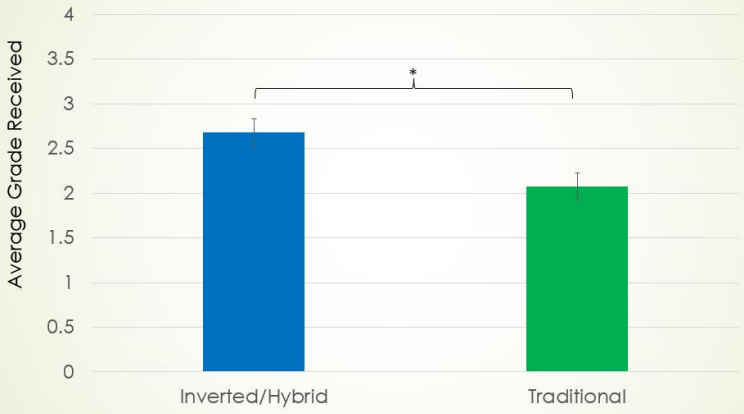
Figure 8. Means and Standard Errors for Final Grades in Inverted/Hybrid and Traditional Classes.



Note. Fall 2017

Figure 4

Figure 10. Means and Standard Errors for Final Grades in Inverted/Hybrid and Traditional Classes.



Notes. * $p < .05$; Spring 2018; Effect holds with Statistics N = 44 and Chemistry N = 44

Figure 5

The percentage of withdraws in inverted classes were significantly smaller than traditional classrooms (see figure 6)

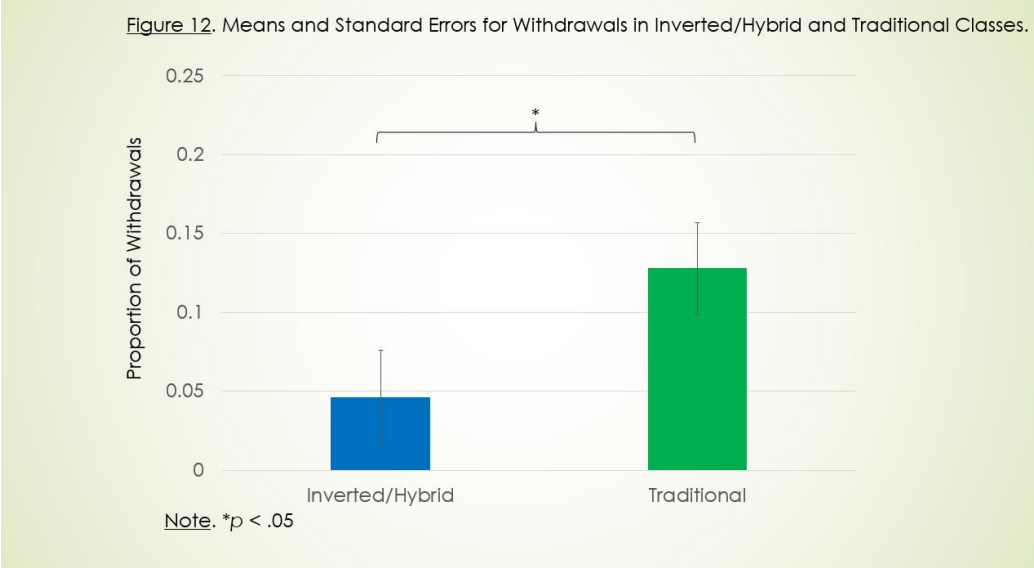


Figure 6

The technology effects

Videos for inverted classrooms are a given and are not considered as technology. We decided to consider use of software, online homework and instructional tools such as Kahoot and clickers as technology. Since all statistics classes used the same software and almost all biology classes did not utilize any software, we will consider the use of technology in chemistry classes where we noticed a more pronounced and diverse use of technology. As table 1 shows there is not a clear difference between chemistry classes which used technology versus those who did not.

Measure: MEASURE_1

Technology	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
None	1	.308	.013	.283	.334
	2	.431	.015	.401	.462
Daily or Weekly	1	.320	.013	.294	.346
	2	.409	.016	.378	.441

Table 1

Let's look at the three sections of one introductory chemistry class where Kahoot was used by some and not used by others. Figure 7 clearly shows a significant difference between the improvement (difference between pre-test, blue line, and post-test, green line).

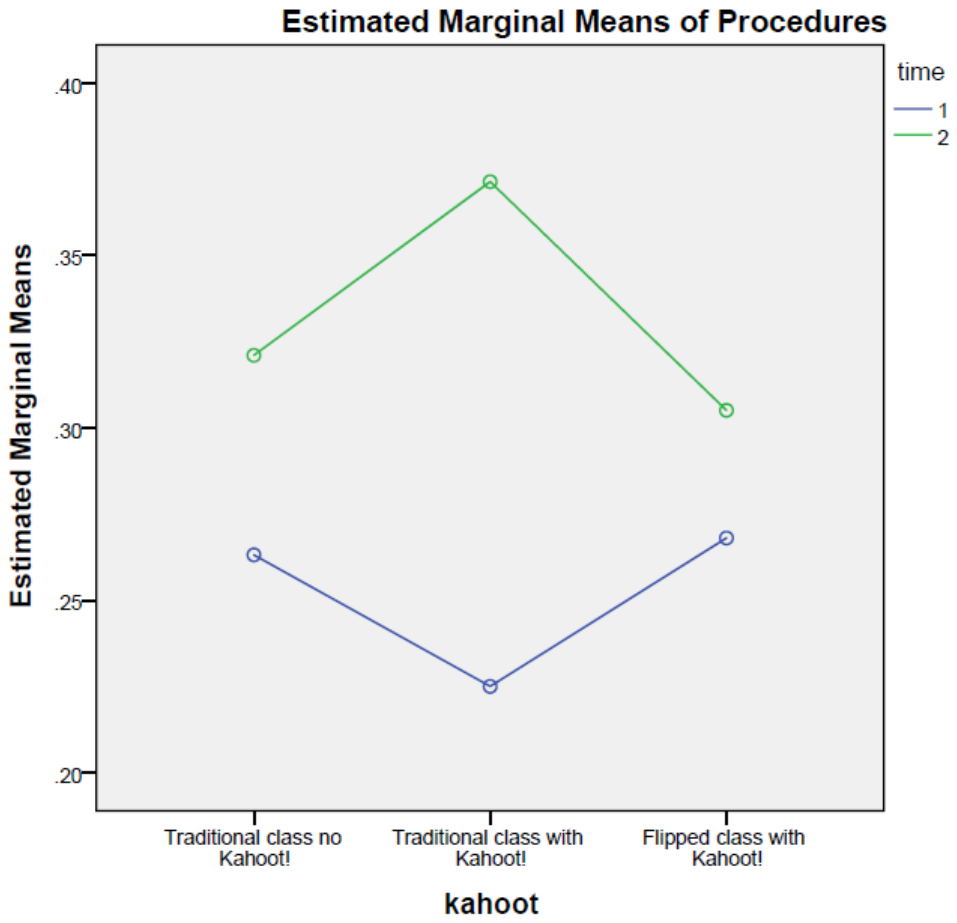


Figure 7

In a related observation, we noticed an effect we call the ”video saturation.” Preliminary analysis of the data shows that higher video saturation classes compared to low video saturation classes were associated with increased post-test performance on Facts but not beneficial on Content and Procedure.

The importance of “high stake” post-test, an unpleasant surprise

In our preliminary analysis, we looked at the percentage of students who performed worse in post-test than the pre-test. We expected that number to be small. However, we noticed an unusually high percentage among chemistry students. A cross tabulation (contingency table) analysis showed that indeed the chemistry students had a higher than expected drop in scores from pre to post-test as shown in Table 2. Investigation revealed that, unlike statistics classes, in chemistry classes the post-test either was: not part of the final exam or accounted for a very small portion of the students’ grade and the exam was given in a lab period prior to the final exams. This result shows the importance of “high stake” post-test.

What are the stakes on the post test?

			totchangesplit		
			.00	1.00	Total
Discipline2	Biology	Count	9	38	47
		Expected Count	6.0	41.0	47.0
	Chemistry	Count	24	97	121
		Expected Count	15.4	105.6	121.0
	Statistics	Count	8	146	154
		Expected Count	19.6	134.4	154.0
	Physics	Count	2	13	15
		Expected Count	1.9	13.1	15.0
Total		Count	43	294	337
		Expected Count	43.0	294.0	337.0

Table 2

Conclusions

We did not find a significant difference between the performance of students in inverted and traditional classes. One benefit of inverted classes appears to be decreased with-drawals from inverted/hybrid classes which warrants further attention. Higher grades in Spring 2018 for inverted/hybrid classes also warrant further study. In terms of the use of technology, we found no significant difference between overall class performance with or without technology. We believe the type of technology and its application will prove to be significant but further study is needed We cannot rule out potential impact of professor (although some of the findings collapse across professors, and across disciplines)
The degree to which the class was hybrid or inverted could influence the results. It be-came obvious to us that for meaningful results post-test must be high stakes.

Future work

i. Examine transfer of learning in sequential classes (e.g., STAT 374 – STAT 375)
ii. Further examination of faculty surveys on the number, type, and length of the instructional videos
iii. Examine content that is inverted vs. traditional in the same classes (to control for potential effects of professor)
iv. Further examine the role of technology
v. Examine the student survey for influence of attitudes
vi. Look at other factors, i.e. classroom activities, number and type of group projects, percent of class time spent on lecture in inverted models, etc.

Acknowledgements

We would like to thank NSF for the generous funding, all the participating faculty in this grant (Drs. Sauncy, Czuchry, Ruane, Jonas, Hijazi, Fauchs, Lievens and Wang) and our colleagues at Texas Lutheran University for their support. Special thanks goes to Mike Czuchry , professor of psychology at Texas Lutheran University for the analysis of the data.

References

1. Maureen Lage, Glenn Platt, Michael Treglia (2000), Inverting the Classroom: *A gateway to Creating an Inclusive Learning Environment*, Journal of Economic Education
2. A. Kaw, M. Hess (2007). *Comparing Effectiveness of Instructional Delivery Modalities in an Engineering Course* Autar, International Journal of Engineering Education, Vol. 23, No. 3, pp. 508-516
3. Bergmann, J., & Sams, A. (2012). *Flip your classroom: reach every student in every class every day.* Washington, DC: International Society for Technology in Education
4. Reza Abbasian & John Sieben (2013)*"Creating an Inverted Classroom",* ICTCM , Boston, MA
5. Reza Abbasian & John Sieben (2013) *"Inverted Classrooms: the What, the Why, the How"*, Annual MAA-Texas Section, Lubbock, TX, April 2013.
6. Reza Abbasian and John Sieben*" Inverted classroms: Videos, Sofware, Hardware, Class Activities and Best Practices*, TLU pedagogy conference
7.Reza Abbasian and Mike Czuchry (2018), *Inverted classrooms in STEM Disciplines: A preliminary Report*, TLU Pedagogy Conference
8.Reza Abbasian , Mike Czuchry , John Sieben (2018) , *Investigation of Inverted and Active Pedagogies in STEM Disciplines: A Preliminary Report*, Mathfest, Denver