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Utah State University, Office of Empowering Teaching Excellence
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INTRODUCTION

Jason Olsen, Ph.D.

Some of the realities of the last few years might seem too unbelievable to have made for a convincing work of science fiction. A world shut down by a virus that forced all of us to rethink the way we lived our lives? Technology capable of creating complicated and coherent texts out of thin air in seconds? Educators suddenly relearning how to teach their students seemingly from scratch? All of us trying to innovate to keep up with a world that moves more quickly than we could have ever thought possible? Well, maybe science fiction is the perfect guide for us as we traverse this brave new world—a place of unsettling familiarity, great unknowns, and remarkable possibilities.

Speaking of *A Brave New World*, a quote from Aldous Huxley’s science fiction classic comes to mind when considering our world and its constant change: “Every change is a menace to stability” (Chapter XVI). Of course, while stability can be an admirable goal, complacency isn’t, and if change can “menace” complacency, maybe that’s a way for instructors to remain effective. The world is changing, and the way our students learn is changing, too. Perhaps an overreliance on stability—especially in a world that pushes against it—will prevent educators from innovating in ways that will impact their students’ abilities to succeed.

Our articles in this issue of *Journal on Empowering Teaching Excellence* are far from fiction, but the methods and innovation on display are as creative and bold as anything you might find in more fanciful volumes. A changing world means the things that worked before simply can’t work in the same ways any longer. As Mary Shelley writes in the sci-fi masterpiece *Frankenstein*, “Nothing is so painful to the human mind as a great and sudden change. The sun might shine, or the clouds might lower: but nothing could appear to me as it had done the day before” (169). This realization of change shouldn’t be wholly negative—just because things have changed doesn’t mean they’re inherently worse. They just require a different mindset than what might have worked before.

That’s a driving force of “Adapting Interteaching to a Hybrid Format: A Framework for Implementation” by Carmen Farrell (University of South Carolina Beaufort). In this article, Dr. Farrell discusses ways of revisiting a pre-pandemic era teaching innovation (interteaching) into our new reality of myriad teaching deliveries at the university level (specifically in hybrid courses). Interteaching was envisioned as a method exclusive to in-person teaching, but that is no longer the norm, and this article reminds us that effective teaching strategies deserve adaptation.

Our next article shows us the importance of adapting to our ever-changing world by reminding future teachers of the importance of “relationships and lived experiences.” Crystal C. Loose (West Chester University of Pennsylvania) and Rose Jagielo-Manion bring us “Preservice Teacher Education Preparation: Implementation of Personalized Learning and Technology in the Fifth Industrial Revolution.” This study examines how well preservice teachers understand the concepts of personalized learning and how recent cultural developments in technology have required different classroom skills than previously required.

Brennan L. Bean’s (Utah State University) “Teaching Reproducibility to First Year College Students: Reflections From an Introductory Data Science Course” takes us directly into a science course to chart changes in methods in a world confronted by ChatGPT and other technological advancements that change what it means to be a student and an instructor. As Dr. Bean explains, “Computer programming is a form of modern writing that can be directly relatable in reproducible assignments,” thus showing the evolution of writing and language across disciplines.

“Evaluating Active Lecture and Traditional Lecture in Higher Education” by Kathleen Klein, Jennifer Calabrese, Adam Aguiar, Sunny Mathew, Kimoni Ajani, Sunny Mathew, Rania Almajid, and Jennifer Aarons (all of Stockton Uni-
University) deftly discusses active and traditional lecture methods in the classroom using data compiled from a study that compared these two methods. This article is valuable for understanding why active lectures (described in the article as “a teaching method based on a student-centered approach that encourages student engagement, interaction, and participation during lectures”) are such an effective strategy for our students and their constantly changing world (while discussing the potential merits and challenges of both lecture methods).

The issue’s content concludes with a book review of Geoff Marietta and Sky Marietta’s *Rural Education in America: What Works for Our Students, Teachers, and Communities*. The review, written by Sunshine L. Brosi (Utah State University Eastern), Marilyn M. Cuch (USU Uintah Basin), Spencer Spotted Elk (USU Blanding), Julie Stevens (USU Ephraim), Gustavo A. Ovando-Montejo (USU Blanding), is a thoughtful discussion of the book, framed by the fact that each of these reviewers teaches at a rural campus in the Utah State University Statewide system, giving them unique insight into the book’s investigation into rural education.

Finally, let’s end with a quote from another great sci-fi writer—Douglas Adams, who found plenty of levity in the world’s challenges. In *Dirk Gently’s Holistic Detective Agency*, Dirk says, “Let’s think the unthinkable, let’s do the undoable. Let us prepare to grapple with the ineffable itself, and see if we may not eff it after all” (188). We, fellow educators in higher ed, need to keep changing and evolving to serve our students and ourselves. It is often challenging and seldom easy, but it is necessary to educate our students in the ways they need and deserve. Sometimes our innovations will work brilliantly, and other times they will fail just as brilliantly, but if we consider our methods and what’s right for our classes, maybe we won’t, as Douglas says, “eff it after all.”

**References**


ADAPTING INTERTEACHING TO A HYBRID FORMAT:

A Framework for Implementation

Carmen Farrell, Ph.D.

Abstract

In the world of higher education, expectations of college-level instructors have shifted significantly in the last few years due to the COVID-19 global pandemic. Instructors were required to be more flexible than ever before, oftentimes across different modalities. This essay models an evidence-based teaching method, interteaching (IT), that was originally created for use in a traditional face-to-face classroom and suggests an adaptation of that method for a hybrid classroom. The theoretical framework of IT is explained and an adaptation of IT for hybrid classrooms is provided with a specific college-level course example of implementation. The advantages and challenges of this approach are also discussed in hopes that faculty will build off this idea and empirically test it as higher education continues to require more flexibility from its faculty members.

Keywords: interteaching, hybrid courses, higher education

Adapting Interteaching to a Hybrid Format: A Framework for Implementation

The COVID-19 pandemic has permanently changed how university instructors and their students are expected to engage (Xie et al., 2020). Early in the pandemic, when universities were forced to move all classes online, many instructors were thrown into the unknown with various online platforms, while still attempting to maintain teaching excellence and maximize student understanding. Even more than a year into the pandemic, instructors were still being asked to continuously flex in how they allowed students to attend their classes, whether due to limited classroom capacities or to students falling ill, as universities navigated whether to move back to fully online courses or try to remain in the classroom (Felson & Adamczyk, 2021).

As a result, numerous institutions have adapted or rapidly expanded their more flexible course modalities in order to engage the students who wanted to be on campus in their classes, but to also allow all students more flexibility with how they engage in coursework. Although hybrid and hybrid-flexible (hyflex) course models have been around for years (Beatty, 2006; 2007; McCray, 2000), the shifting landscape of higher education during the pandemic exacerbated the utilization of these modalities (Bashir et al., 2021; Xie et al., 2020). What these terms specifically mean can vary depending on the school and the context, but typically hybrid courses refer to when class instruction and engagement are provided by a combination of in-person and online learning, and hyflex refers to allowing students flexibility to choose what modality they want to engage with the hybrid course in (Beatty, 2006; 2007; McCray, 2000). Particularly at the beginning of the pandemic, these modalities were the first option to attempt to start getting students back in the classroom, and the
increased flexibility for students has become a much more consistent expectation as a result. Indeed, upper administration around the world now consistently promote these hybrid models of coursework as a necessity for engaging students across disciplines, and the number of hybrid courses being offered has increased significantly in the last few years (Bashir et al., 2021; Coates et al., 2021).

Allowing more flexibility for the student has its benefits, but it also requires instructors to utilize new technology, often in more complex ways than they had to prior to the pandemic. During this transitory period in higher education, instructors have started to share strategies and techniques to maximize student understanding (Ali, 2020). One way to be successful is to take concepts and pedagogies that are evidence-based and adapt them to work in a more flexible university environment. Interteaching (IT; Boyce & Hineline, 2002) is an instructional method that was systematically built to increase student engagement by immersing the student directly in the learning rather than the teacher passively instructing the student.

Boyce & Hineline originally created this method of IT as an application of behavior analysis techniques in the classroom with the hopes of improving student knowledge (2002). They were aiming to bridge the gap between behavior analysis techniques and the structure of the higher education classroom by allowing students to “interteach” with one another (described in detail below), give feedback to the instructor on what they need clarification on, and then have lectures tailored to their questions (Boyce & Hineline, 2002). Across the board, implementation of this technique shows improved student scores and retention of knowledge (for reviews, see Hurtado-Parrado et al., 2021; Sturmey et al., 2015). This essay argues for an adaptation of IT for a hybrid classroom, considering the increased expectation for these more flexible course models in higher education.

Due to the hybrid nature of the below description, there are elements in it that are similar to that of concepts like a “flipped classroom” in which students do work/reading/watch lectures on their own time and come to class to engage in active learning or problem solving to enhance their understanding of the content (Bergmann & Sams, 2012). However, with this implementation of IT, the instructor is still lecturing and utilizing some class time for direct instruction as well as peer discussion. So, while there are similar aspects, IT has additional elements that distinguish it beyond a “flipped classroom” format.

**Traditional IT Implementation and Results**

In a traditional face-to-face classroom environment, IT students would come to class having already read a chapter. Their class begins with a study guide that has questions on it pertaining to the materials they have already read (Boyce & Hineline, 2002). The main “interteaching” happens during class, when the students use 30-40 minutes with the study guide as the foundation of a group discussion, figuring out the answers to the questions and discussing what they have read in relation to the questions, as well as providing feedback to one another (Boyce & Hineline, 2002). The instructor walks around the room and supervises the conversations, jumping in to clarify or answer a question when appropriate. If students do well in their group discussion, they receive quality points towards their grade, as they have engaged well with both the course and its content (Boyce & Hineline, 2002).

At the end of the group discussion, the students are asked to rate their IT session and provide justification for what they did well or what could be improved. They are also asked to complete a record form indicating what topics they struggled with and what they would like to be reviewed in the lecture portion of class (Boyce & Hineline, 2002). The instructor then uses that feedback to tailor a clarifying lecture based on what the students most needed clarification on or wanted to better understand. From there, the students are expected to use reinforcement contingencies to fully complete their study guide based on what they learned in class (Boyce & Hineline, 2002). Throughout the term, students work with others at random during the IT sessions and develop competencies in what they are doing. Students demonstrate
their understanding by taking probes that extend beyond the study guides and assess the students in their knowledge and understanding. Boyce & Hineline (2002) suggest there should be a minimum of five probes per term.

IT has become more commonplace at universities, with various disciplines reporting success with the method in their classrooms (Sturmey et al., 2015). Across the board, IT shows consistently increased grades, engagement, and effectiveness compared to traditional lecture-based face-to-face courses (for reviews, see Hurtado-Parrado et al., 2021; Sturmey et al., 2015). More specifically, when comparing traditional lecture-based classes to IT classes, students showed improved examination scores, quiz scores, essay scores, and level of understanding (Cezeaux & Keyser, 2018; Edwards, 2008; Rieken et al., 2018; Scoboria & Pascual-Leone, 2009). Many of these studies also controlled for moderators, including variables like class size, aspects of IT implemented in class, student preference, and type of assessment. Even with those variables accounting for some of the variance in test scores, the boost in scores for IT students remained and the benefits of using this method in classrooms across disciplines are clear (for reviews, see Hurtado-Parrado et al., 2021; Sturmey et al., 2015).

**Online Implementation of IT and Results**

IT has primarily been used in a face-to-face classroom format, but due to the increase in online enrollment for universities (Xie et al., 2020), as well as the aforementioned need for flexibility due to the pandemic (Krebs et al., 2021), there has been expansion and exploration of IT in online environments (Krebs et al., 2021; Rieken et al., 2018; Soldner et al., 2017). Many of the components of original IT remain the same but are utilized differently in an online environment, and variations extend for both asynchronous and synchronous courses or a mixture of the two.

In one example, students were expected to read the content and prepare a study guide asynchronously. They were then asked their availability and were paired up with someone who had similar availability. Each pair then met virtually to do their paired IT discussion, rather than having everyone in one live synchronous class session (Rieken et al., 2018). TAs supervised the individual pairs in their group discussion and their feedback. The student record forms helped the instructor prepare a brief clarifying lecture that was posted asynchronously, on which the students were then probed in a variety of ways (Rieken et al., 2018). Another study had students prepare their study guide, read and watch the initial lecture asynchronously, and then had a synchronous time for all students to meet and pair up to complete their group discussion and record form (Krebs et al., 2021). The instructor then used that form to prepare and post an asynchronous clarifying lecture. Students in each of these studies who used the IT format scored higher grades and reported greater satisfaction with the IT method in comparison to others (Krebs et al., 2021; Rieken et al., 2018).

In one final example, students had an online synchronous class meeting once per week for 150 minutes (Soldner et al., 2017). Students were provided study guides prior to class, then either engaged in pair discussion via virtual breakout rooms or were placed in their own individual breakout rooms and were probed with quizzes at the end of that same class period (Soldner et al., 2017). The students in pairs were allowed quality points at the end of the probe, while those who were not paired were not. Results showed that there was a significant increase in scores for students who did paired discussion rather than individually reflecting on the study guides (Soldner et al., 2017). Students also expressed a greater preference for the paired discussion format (Soldner et al., 2017). All of these examples reinforce the idea that IT is a successful instructional technique that aids students in better understanding course content, even in an online environment.

These studies with online modalities maintain the same increase in performance that is seen in the more traditional face-to-face IT classes as described above (for a review, see Hurtado-Parrado et al., 2021). Thus, IT is consistently effective in getting students to learn the course material, whether they are online or in-person. Many of the authors of these online studies suggest that IT should be adapted and utilized in even more classroom formats, including hybrid and hyflex mod-
els (Krebs et al., 2021). The present essay intends to posit a hybrid adaptation of IT, as well as discuss the challenges and benefits of its implementation in hopes that this can be used as a foundation for future empirical study.

Hybrid IT Implementation

Course Selection

In considering when and how to implement IT in a hybrid classroom environment, the COVID-19 pandemic presented me with multiple opportunities to engage with this kind of format for several courses, including Introduction to Psychology and Life Span Developmental Psychology. As mentioned previously, universities can vary in how they define hybrid courses, so at my university, a hybrid course is defined as having one in-person class meeting a week for 75-minutes with additional asynchronous online work for the remainder of the week.

When it came to implementing IT in a hybrid course, I decided it would be best to attempt this in Life Span Developmental Psychology. Students taking that course had already taken Introduction to Psychology, so they have had some experience with classes in the field. It is also a required course for both psychology and nursing majors, and as those majors comprise a majority of most sections of the course, they take it seriously. At the time I utilized IT in my hybrid classroom, our university had also just launched an online-only degree completion program for psychology, so enrollment was growing exponentially, and there were not enough fully online courses being offered for the number of students we had. Thus, I was asked to modify my hybrid course so that the one live 75-minute class session a week could be attended in person by our traditional students and live-streamed synchronously online for our online-only students.

All of these factors impacted how I chose to implement IT into the one 75-minute live class session a week. It is also important to note that this hybrid version of IT was taught using Blackboard Collaborate Ultra Version 21 (Collaborate), which is where all course assignments and links to the online book were housed, as well as being the online platform for the synchronous students live streaming the class.

In this hybrid course, students were consistent in the modality with which they attended class, and attendance for the live class session each week was relatively high throughout the semester. For the traditional face-to-face students, they were technically allowed to livestream the class if they ever fell ill, but the face-to-face students engaged in the livestream modality less than 10% of the total class time. The online-only students did not ever change modalities. The students in the face-to-face group and the online-only group were self-selected, in that if they were enrolled in the online-only degree completion program, they had to be in the online-only group, and vice versa, which is a limitation of the current implementation.

Procedure

Each week throughout the semester, students were given a majority of the week to read a chapter of the book and complete reaction questions in short paragraph responses (similar to the study guide used in IT, see Boyce & Hineline, 2002) that were due the night before the live class meeting. These initial reaction responses were graded for completion, such that as long as the student made a genuine effort in answering each part of the reaction question (e.g., came up with logical possible answers to all of the questions), they would get full credit. This initial credit was worth half the amount of points of the corrected reactions, which are detailed after the explanation of the live class session. It was imperative for the students to have a full attempt of the study guide completed prior to entering the live class session that week. For an example of a study guide for this course, see Appendix A. With only 75-minutes of in-class instruction, none of that
time could be dedicated to completing the study guide. The students would get clarification in the live class session, but coming in with attempted answers was especially crucial for this hybrid format.

During the live class session, which was one 75-minute period each week, students attended either in-person or via livestream on Collaborate, depending on their degree modality. Each session started with breakout groups for the first 20-30 minutes of class time, actively engaging in IT’s group discussion. Those who attended in-person were split up into 3-4 person groups and those online were randomly placed into virtual breakout groups of 3-4 people via Collaborate. Roughly half of the class attended in person and half live-streamed the class session each week, and each section had around 35 students in total. The students had the first portion of class to discuss their reaction questions, share their answers with each other based on the reading, and complete a form to indicate what questions they wanted more clarification on (similar to the record form used in IT, see Boyce & Hineline, 2002). These forms were given to the instructor at the end of this group discussion time.

While the students were discussing, the instructor both walked around the room and virtually jumped into each breakout group periodically to make sure the students were on task and to intermittently answer questions or guide the group. While formal quality points (see Boyce & Hineline, 2002) were not given for each student, students knew active engagement was an expectation of the course. They were given warnings or point deductions at the instructor’s discretion for successive class sessions of either not attending or not actively participating in the discussion. For most students, a simple warning was sufficient to get them more engaged with and participating in the group discussions. All of the students were expected to attend class live for the 75-minute weekly session (whether online or in-person) unless they were ill or had a documented excuse for their absence. If they missed a significant number of live classes unexcused, that would also impact their quality points in the course.

Following discussion time, the instructor took the questions that students had asked and taught a clarifying lecture for the remainder of the class period on those topics. Prior to the class session, the instructor prepared lecture slides with videos and visual aids on the entire chapter’s content. During the group discussion time, based on both verbal feedback from the students and the record forms, the instructor structured the lecture to focus on what the students wanted a better understanding of. Typically, this structuring of the lecture took about 5 minutes as the students came back from their breakout groups and settled back into class.

During the lecture portion of class (the remaining ~45 minutes of class time), the instructor lectured and incorporated active learning strategies such as debating developmental issues, think-pair-shares, and scenarios. Following the live class period, the students were required asynchronously to revisit their guides, correct their initial reactions, and update them with what they learned from class. They were given 24 hours following the live class period to do this and resubmit for grading. These resubmissions were the corrected reactions that were graded for accuracy, which were worth twice the amount of points of the initial reactions, intending to have a similar effect as the reinforcement contingencies in traditional IT (see Boyce & Hineline, 2002). Prior research shows that having students go back and correct/improve their own work can be a useful way for them to better retain information they have learned in class (Fahimi & Rahimi, 2015; Zimmerman, 2002). Students then had the remainder of the week to asynchronously read the next chapter and complete their initial attempt at the next study guide, and the cycle repeated from there.

Two exams were used as probes for the students in the class, as they assessed the information the students learned in a comprehensive way by moving beyond the content of the study guides (Boyce & Hineline, 2002). Due to the nature of a hybrid course being once a week, and the wide breadth of content that is expected to be covered in a lifespan developmental psychology course, logistically, only two exam class periods fit into the structure of the course. Both of the exams were multiple choice and non-cumulative. Students took them through the Collaborate course website.

For this hybrid version of IT, the majority of the students’ course grades came from completing reaction questions via their study guide. They were given points for an initial attempt as well as double the points for a corrected version graded for accuracy as a reinforcement contingency. Late work was not accepted for the reactions due to the time-sensitivity of
being in class, but the students were allowed to miss one initial reaction and one corrected reaction over the course of the semester without any penalty to their grade. During the live class session each week, they engaged in group discussions where they completed record forms, were assessed on quality points, and then experienced a clarifying lecture. The students also had one midterm and one final examination, which were used as probes. These were multiple choice examinations. For a summary of the specific IT elements as well as their implementation in this hybrid format, see Table 1.

<table>
<thead>
<tr>
<th>Element of IT</th>
<th>Changes Implemented for Hybrid Classroom</th>
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<tr>
<td>Study Guide</td>
<td>Reaction questions initially completed prior to class time — graded for effort/completion</td>
</tr>
<tr>
<td>Group Discussion</td>
<td>Both virtual breakout groups and in-person and real-time</td>
</tr>
<tr>
<td>Record Form</td>
<td>Worksheet where they indicate where they need clarification</td>
</tr>
<tr>
<td>Quality Points</td>
<td>Students are observed in their participation, and if not present and/or not participating, points get taken off</td>
</tr>
<tr>
<td>Clarifying Lecture</td>
<td>Teacher comes prepared for everything, selects portions to cover in class based on feedback from students</td>
</tr>
<tr>
<td>Reinforcement Contingencies</td>
<td>Students go back and correct their initial reactions and submit them for accuracy</td>
</tr>
<tr>
<td>Probes</td>
<td>Students take multiple choice exams that go beyond the study guides in assessing their understanding</td>
</tr>
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**Challenges and Benefits**

Traditionally, IT is implemented in a fully in-person classroom and some instructors have also had success transitioning IT into online formats (Krebs et al., 2021; Rieken et al., 2018; Soldner et al., 2017). Thus, it seems logical that integrating IT into a hybrid classroom would also be a successful endeavor. One challenge of this method is the initial creation of all of the study guides and lectures. For the study guides, I prioritized making sure that enough of the course content was covered in applied and relevant scenario-based questions for the students to work with. Indeed, creation of the study guides was a time-consuming and continually edited part of the IT implementation process. However, those study guides also comprise the majority of the students’ grades, so it was a worthwhile investment of time.

Another challenge that is inherently present with a hybrid class structure is that the amount of live class time is limited, having one 75-minute live class session each week rather than two 75-minute or three 50-minute live class sessions each week. This is especially true for a subject like Life Span Developmental Psychology, where you are expected to cover development over the course of a full human life span in one semester. However, by using a chronological framework and ensuring that all three psychological domains of development (physical, cognitive, social-emotional) are covered, doing one period of the life span (e.g., adolescence) per week ended up working out quite well. In terms of hybrid IT implementation, the biggest area where the live class time constraints came up was in the usage of probing. In their original article, Boyce & Hineline (2002) suggest that a minimum of five probes should be assessed throughout the course of the semester. Due to the time constraints of one live session a week, I was only able to have two larger probes in the midterm and final exams. This decision was made because the study guides were a large amount of work for the students in their asynchronous time each week and assessing them weekly on top of having to correct their reactions after class was deter-
mined to be superfluous. In the future, instructors could explore the option of utilizing online quizzes or assessments in addition to the submission of the corrected reactions following the live class period.

Another factor to consider is that in traditional IT, students do their group discussion in pairs and the teacher walks around the room, jumping in as necessary to help guide or answer questions (Boyce & Hineline, 2002). In this hybrid model of IT, the groups were slightly larger – usually 3-4 students in a group – and the instructor had to both walk around the room as well as stand at the computer and jump into each virtual breakout room periodically. This also meant that the students who were online only discussed their reactions with others who were online, and vice-versa. Previous research does indicate that putting students in pairs rather than larger groups has a moderate effect on test scores (Hurtado-Parrado et al., 2021), so this is another limitation of this model. However, the logistics of the instructor having to navigate jumping in and out of virtual as well as in-person groups takes some time and practice, so having smaller groups in this case would have proven difficult.

Finally, because my university has an online-only degree completion program, students had to be self-selected into the two modality groups, based on what type of degree they were pursuing. This did not allow me to randomize the participants or have control over any extraneous variables that might also impact the students’ scores. This also made the group sizes unequal, based on the increased demand for the online-only program, which made running analyses on this data impossible. The hope is that this description of implementation can lead others to pursue randomized experimental work with this method.

Even with the various challenges associated with adapting IT into a hybrid classroom, there are numerous benefits as well. Research shows that using IT consistently improves test scores and student learning in both online and traditional classrooms (for reviews, see Hurtado-Parrado et al., 2021; Sturmey et al., 2015). Future research should utilize empirical data to support this structure with large sample sizes and test to confirm the same effects exist for a hybrid classroom. Researchers should also aim to obtain data on which way the students attended class, as well as other personal factors that might impact their grades. Anecdotally, the students rated the hybrid IT class extremely highly in both midterm and end-of-semester anonymous evaluations, and their grades were higher than the averages from previous non-IT life span developmental psychology classes. For example, students gave feedback like “I loved that we had the entire week to complete each assignment, and that we could discuss in class with our peers about our answers, and then correct them based on the class teachings” and “I found the format of the course (with weekly questions and then a thorough review and discussion) was a very effective learning format. There was also a lot of class engagement, which I found to be something great about this class.”

IT has the benefit of allowing the class to focus on exactly what the students need the most help with or clarification on, and this benefit is seen in the hybrid classroom format as well. It is also important to note that this specific example demonstrated success for students in two different modalities: those attending class in-person, as well as those who live-streamed the class synchronously. Regardless of the modality in which the student attended class, allowing them time to use each other as support systems is crucial, and having the instructor there to reinforce or clarify any remaining questions really helps to solidify the information for the students. One other factor to note is that this model of instruction was completed at a small regional public university, so implementation may have to be modified for universities with significantly larger class sizes. Logistically, for larger classes, it might be helpful to have TAs and/or peer mentors help to monitor the discussion portion of class.

**Conclusion**

The present essay offers a framework for implementation of IT, an evidence-based and mutually beneficial teaching method, in a hybrid classroom. The majority of the traditional IT framework can be implemented in a hybrid classroom,
with some adjustments due to the limited amount of live class time each week. Students received this hybrid IT format well, and this teaching method could increase accessibility and improve outcomes for students across modalities and disciplines in a hybrid classroom. This course has been taught this way for two years and will continue to be implemented in this hybrid format each spring semester moving forward. Over the last two years, small updates have been made to the reaction questions/study guides and the lecture slides/activities, but the overall structure of the IT implementation has remained the same. Due to the previously discussed unequal group sizes and group self-selection, formal analyses of data from this university are not possible. Therefore, future research should empirically test this framework.

References


**Appendix A**

**Example Study Guide – for Early Adulthood Module**

1. For physical development, your book discusses how early adulthood is the physiological peak for humans. What do they mean by this? Give two examples of how your body “peaks” at this time. After this peak, things start to decline. You book gives examples of how habits you establish in your twenties can greatly impact your later health. Explain how these habits can impact later health and then write at least two suggestions you might give a twenty year old on what healthy habits they should focus on at their age.

2. Your book discusses how people are choosing to get married and have children later in life than ever before. Give two reasons why you think that is. Then discuss what in vitro fertilization is and give one pro of using in vitro fertilization if you can’t conceive and one con. Are there other options for people who can’t conceive that aren’t discussed in this section? Then think about parenting. Define and give an example of at least 2 of Galinsky’s stages of parenting. Do you think families and parents look different now than they used to?

3. Do you agree with Perry’s scheme, that young adults move from dualism to multiplicity and relativism in their thinking? Explain why or why not, and then give an example of each (dualism, multiplicity, and relativism). Then after reading the section on education, discuss what skills learned in college best help students prepare for the workforce and why.

4. Marcia is someone who found her partner in college, got married the summer after graduation, and now is expecting her first child. Ashleigh did not find a partner in college, but instead has built wonderful strong connections with friends that she sees weekly even after graduating college. Did either Marcia or Ashleigh achieve intimacy versus isolation? Explain why or why not for each person.

5. What is emerging adulthood? What parts of Levinson’s theory are similar to this idea of early adulthood? Then describe at least 2 ways that emerging adults may differ across cultures, and write at least 2 sentences describing
each difference.

6. Which of the following do you think is most important in influencing attraction: similarity, proximity, familiarity, or reciprocity? Give at least 2 reasons why you think that is most important. Then do you agree with the triangular theory that there are six different types of love? Give an example of what 2 types of love might look like. Is it possible for someone to be happy without a significant other? Why or why not?
Abstract

It has been argued that we have moved into the age of personalization. One can see this while ordering drinks at a local Starbucks, where options are limitless. This personalization has been called the Fifth Industrial Revolution, a time noted for a deep, multi-level cooperation between people and machines. With emphasis on innovation, purpose, and inclusivity, this revolution calls for changes in the classroom setting to focus on relationships and lived experiences. So, how do we prepare our preservice teachers for this reality? Methods of instruction that create an engaging and collaborative learning community need to be considered when designing classroom experiences. The five facets of personalized learning will be examined through the lens of student research and application. These facets include assessments, instructional rigor, equity, study agency, and classroom culture. Qualitative data will be shared emphasizing student experiences as they engage in research and implementation of personalized learning tools during their field experiences. In addition to this, data from administrator and mentor teacher surveys regarding our teacher preparation program will be examined to better understand viewpoints from the schools that host our teacher candidates. Situated learning theory will be cited to emphasize the necessity of learning in context for preservice teachers.

Keywords: personalized learning, preservice teachers, Fifth Industrial Revolution, teacher preparation

Preservice Teacher Education Preparation: Implementation of Personalized Learning and Technology Integration in the Fifth Industrial Revolution

Challenges in education confronted during the pandemic have caused teachers and researchers to study the way we have been instructing students both present day and prior to the COVID-19 pandemic. Although the pandemic caused setbacks in academic achievements, lessons learned about the classroom environment continue to challenge current perspectives and future discussions about the way students learn. Connections made to recent realizations in the literature regarding personalized learning experiences, both the benefits and challenges, need to challenge educators and instructors in higher education to consider the classroom experiences necessary to prepare our students for the Fifth Industrial Revolution (FIR) (Voskoglou, 2020).

Over the course of the last century, we have moved from an industry focused on standardization and mechanical production to the influence of technology becoming an integrated and essential part of our lives. These shifts have created
a demand for learners who actively solve problems using creative thinking (Sudibjo et al., 2019; Voskoglou, 2020). The advent of the FIR takes the concept of the digitalization of our lives to one where all technology is used strategically to personalize products and services to meet the varied needs of individuals. (Paschek et al., 2019). Increases in collaboration between humans and technology have caused the need for different types of skills. With this in mind, undergraduate programs need to consider teacher training models with emphasis on technology-based teaching-learning models which encourage collaboration, creative and critical thinking, and problem-solving skills (Aslan, 2022).

With investment in improving teacher quality during teachers’ preservice training, it is essential that we study teacher preparation and the immediate impact on teacher comfort levels upon entering the workforce. Moreover, recent evidence suggests that the context of a teacher’s preservice teaching is associated with important consequences for their later employment outcomes (Goldhaber et al., 2017). High performing student teachers are more likely to stay in the profession. In recent years, school districts have begun to adopt schoolwide personalized learning (PL) models (Stuart et al., 2018). Personalized education has shown positive impacts on student education (Lee, 2014). However, to ensure student academic achievement, we need to better prepare preservice teachers with in-depth training and reflective experiences that consider the role of technology in promoting PL experiences for students as the FIR and technology have greatly enabled PL capacities (Kraft & Papay, 2014).

Responsibility for preparing preservice teachers to enter the world of education armed with the thinking, tools, and skills to teach their K-12 students rests on university teacher education programs. This paper will address background related to the FIR and PL and discuss how teacher education programs can use this knowledge to successfully prepare preservice teachers for classrooms of today and tomorrow. Furthermore, results of a two-year study on PL will be shared.

**Theoretical Framework: Adult Learning Principles**

In addition to considering research related to the FIR (Paschek et al., 2019) and PL (Lee, 2014), it was important for the authors to ascertain the challenges, needs, and goals of student learning with emphasis on adult learning principles. Recent needs and trends pointed to changing instruction to adapt to the new and most likely permanent place of virtual instruction, consideration of culturally diverse materials, the importance of transferring instruction to real-world experience, and on teaching in inclusive environments.

Adult learning principles were considered while prompting changes in instruction and classroom environments. Adult learning theory, or andragogy (Knowles, 1975), highlights the importance of students being in control of their own learning. Adult learners are self-directed and self-dependent, they assume a problem-centered approach to learning and, consequently, are typically internally motivated (Knowles, 1975). In fact, active adult learners who take initiative in learning tend to learn more and learn better than passive learners (Loeng, 2020). Research also supports self-directed learning as a vehicle for critical awareness (Freire, 1970; Loeng, 2020). Andragogy fuses nicely with all aspects of PL as learners are asked to participate in self-directed learning to explore and expand upon topics of interest to them. Situated learning theory (SLT) gives meaning to learning in context and views learning as a recursive process that occurs through participation in a collaborative environment where adults act in and with context and tools (Lave & Wenger, 1991). SLT informs learning that is not only context-dependent but also rooted in the situation in which a person participates with support and guidance (Loose, 2020). The authors provided authentic learning experiences to support learners as they tried new pedagogical tools to support PL in the classroom during their student teaching field experience. With emphasis on SLT, students were instructed on how to incorporate new instructional strategies by using the platforms in a classroom directed by their instructors.
Literature Review

Fifth Industrial Revolution

Rapid technological advances, as well as continuing changes in industry, shape the way we live. These shifts impact our lives in all ways and influence how we live, work, and behave (Sudibjo et al., 2019; Voskoglou, 2020). Historically, schools and other learning institutions have been slow to shift and respond, often being accused of not adequately preparing individuals for the demands of the life and job market they will face.

These shifts require educators to think critically about the ways they create learning experiences that provide students with opportunities to develop creative thinking and problem-solving skills. As indicated in the World Economic Forum, graduates need to be prepared with soft skills such as teamwork and independent thinking (Davos-Klosters, 2018). Many graduates are prepared with the academic knowledge necessary for the workplace but lack interpersonal skills and practical experience (Ginting et al., 2020; Prinsley & Baranyai, 2015; Sarfraz et al., 2018). A recent survey showed that employers perceived a lack of appropriate skills as the biggest barrier to employing graduates. These skills, among others, include time management, teamwork, and interpersonal skills (Lisa et al., 2021; Swafford, 2017). This has led to transformation in HE, particularly in assessment practices that foster teamwork and effective feedback practices (Ashford-Rowe et al., 2014; Sarfraz et al., 2018). This shift from traditional assessments, such as multiple-choice questions, to more authentic opportunities has created further scope for soft skill usage (Gulikers et al., 2008).

Teacher training programs should be organized, taking into account collaborative learning and research-oriented opportunities that support technology integration as they develop their skills to support student learning in a classroom environment that is more personalized and embellished with technology integration.

Personalized Learning in the Classroom

Personalization is not a novel approach but rather the goal of education. The FIR and use of technology have greatly enabled PL as educators to reimagine their curriculum post-pandemic to address not only social justice and empathy but also include opportunities that allow for personal voice, choice, and active engagement. PL reconsiders the traditional classroom setting with increased personalization based on student achievement, interest, and learning styles (Patrick et al., 2017).

Findings from recent research confirm that optimal learning conditions include environments that give students choice, ownership, and voice through authentic learning experience (Thibodeaux et al., 2019). This environment will be discussed through a lens that is applicable to higher education preservice teacher preparation programs. Through immersion in PL techniques within higher education courses, students not only learn the meaning but experience methods that they can utilize in real-life circumstances. PL environments reconsider the use of assessments and data, instructional rigor, student agency, project-based learning, and technology to support student learning paths while cultivating creative learning experiences (Thibodeaux et al., 2019).

For the intent of this paper, the authors have considered five facets of PL, including classroom culture, assessments, instructional rigor, equity in education, and student agency. Each of these areas were studied by preservice teachers (PST) with emphasis on implementation in the classroom and contextual design. First, creating a classroom culture that inspires learning is the goal of education, as without a safe environment, learning will not transpire. A student-driven model of education should empower learners to pursue their goals, investigate problems, design solutions, and develop curiosities that foster creative thinking and dialogue. These are all essential ingredients of a setting conducive to the FIR. Second, the design of such a space should support peer accountability and self-assessment. Personalized assessments can
be developed to support authentic learning opportunities through project-based learning and feedback loops. Third, rigor is standard in all classroom environments, but for personalization to be impactful, student interest, learning styles, and academic needs should be considered. Fourth, fostering an environment of collaboration means that not only is the group benefiting from each other, but there is awareness of how to support one another when there are trials. This environment encourages equity in education with dialogue that fosters an understanding of cultures and varying viewpoints. Finally, through self-directed learning, personalization is supported as students recognize their own interests and best methods for learning. Student agency is a natural offset of personalization as they learn through activities that are meaningful and relevant to their own interests. This type of ecosystem is not possible without the establishment of trust, where it is understood that it is okay to make and learn from mistakes.

**Intentional Use of Technology to Engage and Prepare**

The role of digital learning in promoting PL cannot be overlooked. When considering the FIR (Paschek et al., 2019), PL (Lee, 2014), andragogy (Knowles, 1975), SLT (Lave & Wenger, 1991) and what this means for the classroom context, the authors confronted the question of how instructors can leverage technology as a tool to not only engage, but to also foster innovation, purpose, collaboration, and critical awareness (Young & Nichols, 2017). To maximize student learning, instructors must make intentional decisions related to learning outcomes and develop “constructive” and “interactive” learning activities involving the use of technology for engagement, problem-solving, and/or collaboration (Sailer et al., 2021, pp. 4-5). Moreover, in contemplating which specific technological tools might be most effective, factors such as anonymity of participant responses, opportunities for individual reflection and/or collaborative thinking, sharing of varying perspectives and/or experiences, and whether a process- or product-driven use of technology is best, must also be addressed. Responses to these questions allow the instructor to create opportunities that maximize engagement and learning, all the while preparing them for classroom environments at the conclusion of the teacher education program.

Prior research on teacher preparation programs examined learning experience designs to prepare first-year teachers, technology incorporation during field experiences, and reflection to promote success in the classroom setting (Brown & Englehardt, 2017; Kang & Windschitl, 2018; Shelley, 2019). However, there is minimal research on action research experiences of preservice teachers with emphasis on personalized learning techniques for classroom application and preparation for FIR. Through intentional and focused uses of technology, the instructors were able to blend principles related to PL, andragogy, and the FIR while also addressing career preparation in the classroom setting. As research suggests, these learning experiences were designed to meet the specific needs of students in personal, engaging, and collaborative ways to expand the competencies required for their future careers (Mogas et al., 2021; Zhao & Watterston, 2021).

The purpose of this study on PL was to first increase preservice teacher (PT) knowledge regarding PL through the development of PL modules and secondly, to measure comfort levels in the classroom setting. Follow up focus groups and surveys administered to K-8 mentor teachers and administrators provided the researchers with an opportunity for further study of preservice teacher skill sets and the effectiveness of higher education teacher preparation programs to prepare students to instruct in classrooms on the cusp of the FIR. Thus, this study had four research questions: (1) What do preservice teachers know about personalized learning? (2) Does participation in research improve preservice teachers’ knowledge and awareness of personalized learning? (3) Does preparation in personalized learning influence the relationship between the mentor and preservice teacher? and (4) To what extent can preparation in personalized learning impact teacher preparation and comfort level in the classroom setting?
**Methodology**

This research used qualitative action research to examine PT perspectives and the perspectives of mentor teachers, as well as administrators in the buildings that hosted PT during their field experiences. The objectives of this study were to 1) evaluate PT knowledge of personalized learning using survey data; 2) develop modules along with the PT revolving around personalized learning; 3) collect data on PT comfort levels of PL through the answers to open-ended questions on the survey; 4) explore the impact of the modules on PT performance in the classroom.

**Participants**

There were three different cohorts of participants in this multi-part study. Cohorts of participants included 25 Early and Middle Grades Education PT enrolled at a suburban public university in Pennsylvania. They participated in seminar cohorts designed by the student teaching supervisor during which they shared field experiences and learned about PL topics pertaining to career readiness. These PT, making up three different cohorts, were recruited to participate in the creation and utilization of research modules. Additionally, K-8 mentor teachers and administrators in schools and districts that hosted university PT as student teachers during the 2021-2022 school year served as survey respondents. Lastly, focus group participants included 24 K-8 mentor teachers and/or administrators in schools/districts hosting student teachers. There were 16 participants in the Fall 2021 focus group meeting and 8 participants in the Fall 2022 focus group meeting.

**Procedures**

This qualitative action research study immersed PT participants in the research process with direct classroom applications in a five-phase process. PT participants self-selected topics pertaining to PL, researched this topic by gathering artifacts, testing technology tools, and reading peer-reviewed journal articles. Participants then implemented newly learned knowledge during their field experiences in their classrooms. Participant data was collected using surveys and reflection journals. Mentor teachers and administrators were also surveyed and focus group meetings took place at the end of the 15-week implementation.

The focus of Phase 1 was to assess PT knowledge and introduce the PL modules to PT. PT completed a digital pre-survey of their understanding of PL and its application to classroom environments and technology usage. Information gained from this survey was utilized to create modules for PT to extend their existing knowledge and to address gaps in their understanding of PL practices.

During Phase 2, the instructors developed training materials on the PL topics, including classroom culture, assessments, instructional rigor, equity in education, and student agency. This material was shared with PT during weekly seminars at the beginning of the 15-week semester. PT chose a topic that appealed to them and added to each module as they researched the topic. Each PT had a partner that they worked with to research their topic. Presentations were developed for each topic and each PT group was provided feedback after their presentations were shared during weekly seminars over the course of the 15-week semester.

In Phase 3, PT implemented the modules they created in their classroom settings, engaging in action research throughout this process. The action research experience allowed PT to apply their PL focus area during their field experience. After researching their chosen topic with a group or partner, PT designed and implemented lessons that included elements of PL practices. PT utilized reflective journals to reflect on their new learning in the field and during seminar course experiences related to PL.
Phase 4 focused on gathering feedback from mentor teachers and administrators in schools that hosted PT at the end of the 15-week semester. A focus group of mentor teachers and administrators then met over Zoom to discuss the impact of PL and technology training. The Zoom meeting was recorded and transcribed. PT data was also once again collected using a digital post-survey.

In the last phase, Phase 5, data from the PT surveys, K-8 mentor teacher and administrator surveys, focus group meetings, and PT reflective journals were analyzed for PT understanding and application of PL and elements of technology.

**Data Collection**

This study used four data collection tools across the three different participant groups. PT participants completed surveys and reflective journals. Surveys were also administered to mentor teachers and administrators. Notes from focus group meetings with mentor teachers and administrators also served as data collection instruments.

**PT Pre- and Post-Surveys**

A digital pre-survey pertaining to knowledge of PL and PT comfort levels was distributed to PT during the first student-teacher seminar using Survey Monkey. The same survey was administered as a post-survey during the final PT seminar at the end of the 15-week semester. The survey included open-ended questions such as, “What is your comfort level of technology usage in the classroom?” and “What changes do you expect to see in education as a result of the COVID-19 pandemic?” Ten survey questions utilized a four-point Likert scale rating in response to statements such as “I understand how PL can be applied to the classroom through authentic, rigorous, and relevant assessments” and “My comfort level in the classroom setting is influenced by training in PL.” Likert scale ratings ranged from strongly agree to strongly disagree.

**PT Reflective Journals**

PT participants were asked to keep a reflective journal pertaining to their perspectives of being a researcher, comfort levels in their classroom placement, and knowledge gained regarding PL during the 15-week semester. Prompts were used at the beginning and end of each seminar to encourage PT reflection. Reflective journal prompts included questions such as: How is online learning impacting student instruction? Do you see PL happening in your placement? What have you done to influence classroom culture in your Zoom classroom? How do you support student agency? How are racial, ethnic, and cultural backgrounds represented in the classroom and in student output? Did preparation in PL influence your relationship between your mentor teacher and yourself? Did researching PL improve your understanding of it? How did preparation in PL influence your comfort level in the classroom setting? In addition to this, PT were encouraged to journal about their PL experiences during the field placement. This type of journaling was unprompted and based on each participant’s experiences in the field.

**Survey for K-8 Administration and Mentor Teachers**

In order to explore the impact of the modules on PT performance in the classroom, a digital survey was distributed to K-8 mentor teachers and building administrators that hosted PT during the 2021-2022 school year. Participants for the survey were selected based on their involvement with our PT. Surveys were distributed at the end of the 15-week semester in 2021 and 2022. This three-question survey was created using Qualtrics. Two questions included a list of options
where respondents could check responses that applied. These questions were: (1) Thinking of the PT that you have worked with, which of the following would you consider are strengths that they have exhibited? (2) What areas should we focus on in strengthening our candidates’ preparation? Possible options to check included competency using instructional technology, competency with data-driven instruction, ability to think creatively, etc. The third question was open-ended and asked respondents what trends in the field the university should be aware of when preparing WCU teacher candidates. These questions were expanded upon in the focus group meetings to gather more data on ways to improve our teacher preparation program.

Focus Group Meetings with K-8 Administration and Mentor Teachers

Two focus group meetings were held in Fall 2021 and Fall 2022 as an additional source of data related to PT application of modules to their teaching practice. These meetings aimed to delve more deeply into the survey results and to gather additional information used to guide program decisions in effectively preparing PT to enter the profession. Researcher notes during the focus group meetings served as the additional data source.

Data Analysis

Thematic analysis was used to identify and interpret patterns and themes in qualitative data from the digital journals, open-ended survey questions, and focus group interviews. The researchers used a constant comparative data analysis method (Fram, 2013). This method of analysis requires that all data be systematically compared with the other data in the data set. This method ensures that the data collected will be evaluated rather than possibly disregarded on thematic grounds. Using coding methods, the researchers examined the data, looking for patterns in the reflective journals, open-ended survey questions, and focus group interviews. The researchers completed a multi-step process of coding the data to capture participant perspectives. Descriptive coding was used to surface the main topics represented in the data. During the second-cycle coding process, color coding strategies were used to refine understanding of patterns emerging throughout the first-cycle coding process. Pattern coding was utilized to group first-cycle codes into larger categories with associated subtopics. Focused coding helped us determine the most frequent codes within and across data sets. Elaborate coding allowed us to deductively code using a priori concepts drawn from the research literature (e.g., personalized learning and assessments). Structural coding allowed us to use our research questions to guide data analysis directly. The coding and analysis of qualitative data is strengthened by triangulation through a variety of data sources. Any weaknesses in data can be compensated for by the strengths of multiple sources of data, thereby increasing the validity and reliability of the results.

The 10-question digital survey, including questions to be answered using a four-point Likert Scale, was used for data analysis. The Likert scale ranged from disagree strongly to agree strongly. Using Survey Monkey tools, data was grouped using tables and percentages. This allowed us to examine PT responses before and after their experiences with training in PL. The administrator and mentor teacher survey was implemented using Qualtrics to gather input on PT preparedness. The questions and answers from these surveys were designed to provide information for future seminar design.

Results

The results of this study informed researchers’ understanding of current trends in education and the challenges currently present in teacher preparation programs. It is important to realize that Cohort 3 had a different experience than Cohorts
Due to the COVID-19 pandemic of 2020-2021, the first two cohorts of PT experienced teaching using Zoom or other remote learning platforms for part or all of their student teaching experience. This caused students to view learning from different perspectives. Most interesting were the journals after COVID-19 restrictions. Cohort 3 put more emphasis on writing their thoughts than previous cohorts. Their desire to write and reflect for longer periods of time resulted in lengthy passages for each journal prompt. The research questions will be examined and explained below through analysis of the four data collection tools.

Preservice Teachers’ Knowledge of PL

The first research question, *What do preservice teachers know about personalized learning*, aimed to discover PT assumptions about PL. Survey findings indicated that PT assumed initial understanding of PL. 66% of participants indicated that they felt secure in their understanding of PL topics during initial survey completion. The topics that PT felt confident in were using relevant and rigorous assessments, feedback cycles, and rigorous learning experiences. After seminar study and field experience application of PL topics, 90% of PT felt secure in their understanding. At the onset of this study, PT assumed that they understood the meaning of PL in the classroom environment. After learning more about the topic of PL and how to embed this in the classroom, PT’s open-ended responses suggested that they wished they knew more about student profiles, lesson planning, curriculum components at various grade levels, and the difference between differentiated instruction and PL.

The use of journals in this action research project allowed for the documentation of PT participants’ involvement in the research, understanding, and application of PL. Three cohorts of PT participated in the use of reflective journals after being exposed to presentations on PL and then through their own research and application of topics pertaining to PL in the classroom. Journal reflection and open-ended question analysis showed that PT comfort levels increased because of PL module study and authentic learning experiences through application of content learned in seminars in their own classrooms. Upon further analysis, it was evident there was some initial misinterpretation of what PL looked like in the classroom setting. For example, after a journal prompt, “How do you personalize learning in the classroom?” PT assumed that differentiated instruction and PL were the same. There were also assumptions that using technology programs for K-8 students was a way to personalize learning. The in-depth study of each area of PL, including classroom culture, assessments, instructional rigor, equity in education, and student agency, created a culture for learning in PT seminars and assisted with misinterpretations that would have impacted PT classroom performance and evaluation. Review of journals revealed words associated with each area of PL after instruction in PL. During a seminar session, PT were prompted to list words that summarized their understanding of each PL topic. Analysis of this prompt resulted in two recurring words associated with PL as indicated in Table 1.

<table>
<thead>
<tr>
<th>Facet of PL</th>
<th>Word 1</th>
<th>Word 2</th>
</tr>
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<tbody>
<tr>
<td>Instructional Rigor</td>
<td>Challenging Students</td>
<td>Enrichment</td>
</tr>
<tr>
<td>Equity</td>
<td>Fairness</td>
<td>Empathy</td>
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<tr>
<td>Assessment</td>
<td>Variety</td>
<td>Fair</td>
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<tr>
<td>Classroom Culture</td>
<td>Inclusion</td>
<td>Community</td>
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<td>Student Agency</td>
<td>Choice</td>
<td>Responsibility</td>
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PT were asked to answer the journal prompt “How do you personalize learning?” in their reflective journals at the conclusion of their action research experience. The following responses were recorded in the PT responses: classroom seating, sociogram, choice in writing topics, choice in how to learn material, self-assessments, and gearing instruction towards interests/abilities. Furthermore, analysis of responses showed that classroom culture was emphasized through shared experiences, cultural days for holidays, and representation through books, videos, and art. Classroom culture was also explained through what PT observed based on overall classroom environments, including positive reinforcement, accountability in and out of the classroom, respect, growth mindset, and activation of prior knowledge. Finally, student agency was written about with emphasis on the use of packets to provide independent work time. Online resources were also suggested as a method to encourage student agency. The researchers would argue that this is a misinterpretation of student agency as packets do not provide authentic learning opportunities for students to apply what they have learned. It was evident that PT initially misinterpreted several areas of PL and that in-depth discussion during seminars and field experiences allowed them to grow in their understanding.

This is further explained through the second research question: Does participation in research improve PT knowledge and awareness of personalized learning? Post-survey results indicated that PT awareness improved in some areas after training and application in the field. The most noted areas of improvement included authentic assessments with 100% indicating improvement on how to use PL to create authentic, rigorous, and relevant assessments. PT demonstrated their understanding by promoting the use of assessments that offered real-world experiences rather than only multiple-choice assessments. An example of a higher-level assignment included presenting to a community audience on the creation of a dog park. 100% of PT indicated that they understand how PL can be applied to the classroom through authentic, rigorous, and relevant learning experiences. This was demonstrated when they designed a variety of learning experiences that offered opportunities for transfer of knowledge in authentic ways. This included project-based learning, using adaptive software, group collaboration, and inquiry-based learning. However, 40% of PT did not feel confident using PL in the classroom to support a classroom environment emphasizing reflection, student-led accountability, and feedback cycles. PT were still learning how to provide learners with multiple opportunities to express their interests through practices that allow students to advocate for themselves. PT were still learning how to promote student usage of long- and short-term goals. PT were also still learning how to support feedback cycles by establishing systems for giving, receiving, acting upon, and tracking feedback. Surveys also indicated that when PL planned lessons, they were able to use PL to create opportunities for flexible learning choices that recognized student strengths. Flexible learning choices were not leveled but offered a variety of choices to complete assignment expectations. 20% of PL did not feel confident in the ability to use learner profiles and 40% did not tailor lessons to personalized learning paths.

Student agency, development of classroom culture, and creating environments to foster equity were areas that PT felt least comfortable during their field experience. It was evident that they were unsure how to accomplish this in the classroom setting. Although PT became more aware of PL topics, they were not always able to capitalize on this awareness because of mandated curriculum found in K-8 education. It was difficult for PT to create personalized pathways and utilize student learning profiles to support accomplishment of academic goals because each student had to satisfy mandated curricular components. Therefore, students were mostly completing the same activities at the same time rather than activities customized to reflect individual or group needs.

Analysis of themes from journals and open-ended post-survey questions indicated that after training on PL, PT reported a lack of PL opportunities for students in K-8 public education. They saw more differentiated instruction for students that were academically below grade level but not for those that were above grade level. They witnessed a one-size-fits-all assessment approach that connected to scripted programs. Although PT were trained and aware of PL techniques, there were times that they felt tied to a curriculum that did not encourage creativity and problem-solving skills.

Findings revealed that PT were able to apply newly learned knowledge of PL techniques to improve elements of classroom culture and student agency. For example, it was noted that K-8 students were able to take charge of how they
learned material at times. Team-oriented learning was used to support various abilities, interests, and talents. Online resources were used to support the student agency through interaction with self-paced academic programs. Classroom culture was emphasized through lessons on growth mindset and activation of prior knowledge, which was different for each student. Real-life experiences were incorporated through lessons designed to represent different cultures.

Feedback from the surveys of K-8 mentor teachers and administrators revealed that even though PT show strengths in the areas of instructional technology usage, lesson planning, and flexibility in their teaching, they need to grow in the areas of culturally responsive teaching, social-emotional learning strategies, use of data-driven instruction, managing classroom behaviors, and thinking creatively. Additional educational trends noted on the surveys that should be addressed in the teacher preparation program included the following: varied uses of technology in virtual, hybrid, and in-person settings to meet all students’ needs, equity, the science of reading, and responsive, differentiated instruction. Focus group discussions also pointed to needs in the areas of PT lesson planning that involve creative lessons geared to K-8 student needs, even when scripted curricula are provided. PT questioning and student engagement were noted as areas in need of growth as well.

The Influence of PL on Mentor Teacher and Preservice Teacher Relationship

The third research question aimed to discover, Does preparation in personalized learning influence the relationship between the mentor and student teacher? Findings indicated that PT felt inspired by the learned material and having opportunities to share PL topics with their mentor teacher. However, scripted programs often found in K-8 education limited application of PL in areas of assessment creation and instructional rigor. PT felt tied to mandated district assessments and often designed lessons, so students were successful with assessments, rather than appealing to student interest and learning styles. The time required to learn district programs, content, and classroom management skills took time away from the implementation of PL strategies.

However, PT reflective journals indicated that there was increased dialogue with the mentor teacher on topics outside the school agenda and curriculum pertaining to their study of PL topics. PT felt confident in discussing their chosen PL topics with their mentor teachers and this created a collaborative space early on during their field experience. During the first and second weeks of student teaching, it was evident that PT felt more confident in their ability to suggest PL techniques. One PT wrote, “I was nervous to begin my student teaching experience because I was unfamiliar with the grade level curriculum. Since it was a grade 1 classroom, I could easily see PL happening in the classroom through choice boards that supported student agency and choice. It also impacted student rigor since choice boards were leveled. It gave me an opportunity to talk to my mentor about PL happening in her classroom.”

Thematic analysis also suggested that conversations with mentor teachers supported the development of creative assignments supporting PL. Several PT mentioned that their study of PL led to increased creativity when designing lessons and assessments. The use of technology, authentic assessments, and flexible project choices were a result of their research in PL.

Impact of Preparation in PL on Teacher Comfort Level and Preparation

This study also endeavored to answer the question, To what extent can preparation in personalized learning impact teacher preparation and comfort level in the classroom setting? Analysis of initial survey data indicated that only 20% of PT felt their comfort level in the classroom setting was influenced by training in PL compared to 100% after training. Upon completion of PL modules and research application, PT used words to explain their experiences, including the necessity
of instructional rigor and challenging content, the support of equity and empathy, the creation of varied assessments, designing a classroom that fosters inclusion and collaboration, and supporting student agency through choice. Supporting student-led accountability through feedback cycles was one of the most challenging areas for PT to facilitate in the classroom. Utilizing student reflection was a second area that scored lower on post-surveys.

Initially, PT used technology as an instructional tool to convey information, but not for PL. PT felt extremely comfortable using technology in the classroom overall but felt less prepared to find new ways to incorporate that into the classroom to increase PL experiences for students. A portion of field experiences took place online, so students were required to be on computers during this hybrid learning experience. This impacted PT capacities to personalize instruction, however it forced them to utilize the technology that was available to them. Upon the return of K-8 students to the classroom setting from virtual classroom experiences, PT noted a lack of motivation and academic struggles. Despite this roadblock, their training in PL prepared them for more interactive technology activities in the classroom.

Results from mentor-teacher and administrator surveys and focus group meetings substantiate PT limited use of technology in the classroom and lack of creativity in lesson design/implementation. Although PT felt comfortable integrating technology, findings clearly showed that teacher preparation programs can better support PT in learning ways to not only utilize technology as a resource for personalized learning, but also as a tool to be responsive to students’ needs, whether academic, social, or emotional. PT would also benefit from learning how to use technology to foster K-8 student engagement which will hopefully result in better, more inclusive learning environments, stronger classroom management and comfort levels for PT, and, ultimately, better learning outcomes for students.

Responses on PT post-surveys corroborate these recommendations from mentor teachers and administrators regarding support in how to integrate technology and PL into K-8 classrooms. When asked what professional learning sessions they would be interested in attending on the post-survey PT’s responses pointed to topics such as how to successfully blend PL and the required district-wide assessments and how to integrate PL into specific content areas such as math.

Discussion

Transforming teacher education programs to cultivate seminar environments that encourage self-directed learning on topics that support educational demands today will support PT as they transition to the classroom setting during their full-time student teaching semester. Topics need to support in-depth study of PL environments, including assessment, instructional rigor, technology, equity, engagement, and cultural awareness. However, results of this study clearly demonstrate that, while helpful, PL is not enough to effectively teach students in the FIR. As higher education classrooms take steps to create classroom settings that support authentic learning experiences, PT will be prepared to better transition to their own classrooms upon graduation. Considering the necessary changes to support learner needs for the FIR and beyond, initiatives should include the identification of practices that teacher training facilitators can and should use to develop learners’ skills in thinking creatively (Nahavandi, 2019). This gives educators an opportunity to reimagine what and how they teach (Zhao & Watterston, 2021).

To best prepare learners to thrive in this new environment, we must engage students and teachers in critical dialogue about how and why we use technology, focusing on how it helps to support or meet a need (Mogas et al., 2021; Sudibjo et al., 2019; Voskoglou, 2020). PT must be taught how to move from the use of technology as a tool for direct substitution and more for creation and transformation purposes with K-8 learners. Additionally, teacher education programs should demonstrate and have PT practice ways that they can leverage technology to address the individual needs and personalize instruction where K-8 students create, collaborate, communicate, and use critical thinking skills. Inviting technology and/or instructional coaches/coordinators from local school district partners to facilitate training for PT prior to their
student teaching semester would be advantageous. These changes or additions to teacher preparation programs will help to bring meaning to the use and application of technology in classroom environments.

Moreover, designing teacher education programs to prepare PT with ways to adapt scripted programs often found in K-6 classrooms, will require revision of higher education curriculum with more emphasis on PL techniques and strategies for promoting active student engagement. Teacher preparation programs must also focus on teaching their PT how to create equitable, culturally responsive learning environments that foster K-8 student creativity and engagement, as these are critical skills for the future. For example, as situated learning theory dictates, teacher education courses should provide opportunities for PT to practice designing lessons with scripted curriculum that maximize student engagement with instructor support and guidance (Lave & Wenger, 1991; Loose, 2020). In this way, PT will enter classrooms during their student teaching experience better prepared.

Future research should address ways to support PT in fostering engagement in classrooms with pedagogical approaches in addition to PL, such as inquiry- or problem-based learning and design thinking. A follow up study that focuses on a systematic, collaborative, and reflective process for guiding student teachers through lesson plan design and implementation in their specific classroom context would be worthwhile in better preparing the PT of today for the classrooms of tomorrow.

Limitations

The results of this were obtained from three cohorts. Each cohort offered unique perspectives that could not be controlled. For example, cohorts 1 and 2 had mixed-field experiences that included all or some of their placement online using Zoom or Office to interact with students due to COVID-19 restrictions. This offered unique challenges and experiences that differed from Cohort 3. The impact of these experiences cannot be fully explained given various confounding variables. For example, because cohorts 1 and 2 had to utilize technology to instruct students, this may have impacted their comfort levels in the classroom. This forced technology experience could have influenced PT opinions regarding technology usage as noted by one student who indicated that using Zoom and the Smart Board at the same time was a lot. Cohort 3 had very different experiences because their entire field experience was in a classroom setting. This group approached journal writing differently and spent considerably more time reflecting on prompts provided during seminars. Another limitation of this research is the lack of quantitative data. In later studies, better survey tools and data analysis methods will be considered. Finally, generalizations from this study are assumed based on research completed in higher education within the Pennsylvania State School System. Lastly, researcher bias must be considered as the researchers served as instructors for the PT during seminar sessions.

Conclusion

This research has shown that exposure to PL strategies influences PT comfort levels in the classroom in the areas of instructional rigor and assessment utilization. PT felt extremely comfortable using technology in the classroom overall but felt less prepared to find new ways to incorporate that into the classroom to increase PL experiences for students. Supporting student-led accountability through feedback cycles was one of the most challenging areas for PT to facilitate in the classroom. Utilizing student reflection was a second area that scored lower on post-surveys. Research results in these areas may have been influenced by experiences during the COVID-19 pandemic.

As indicated by administrator and teacher focus groups and surveys, PT need to be better equipped to use technology as a hybrid method of instruction or to differentiate instruction. It was also evident that PT need better training regard-
ing scripted curricular programs encountered in many school districts in the United States and how to add creativity to enhance these programs. Going forward, it will be necessary to complete research on mentor relationships and how they influence PT creativity in the classroom. There are many burdens placed on teachers today and this may impact their time available to cultivate creative opportunities in the classroom. Allowing educators time to build a curriculum around their students’ interests or customize their lessons to maximize their engagement could influence student productivity. This needs to be examined to meet the needs of the FIR.

References


TEACHING REPRODUCIBILITY TO FIRST YEAR COLLEGE STUDENTS:
Reflections From an Introductory Data Science Course

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Abstract

Modern technology threatens traditional modes of classroom assessment by providing students with automated ways to write essays and take exams. At the same time, modern technology continues to expand the accessibility of computational tools that promise to increase the potential scope and quality of class projects. This paper presents a case study where students are asked to complete a “reproducible” final project in an introductory data science course using the R programming language. A reproducible project is one where an instructor can easily regenerate the results and conclusions from the submitted materials. Experiences in two small sections of this introductory class suggest that reproducible projects are feasible to implement with only a little increase in assessment difficulty. The sample assignment presented in this paper, along with some proposed adaptations for non-data science classes, provide a pattern for directly assessing a student’s analysis, rather than just the final results.

Keywords: data science, reproducibility, programming, assessment

1 Introduction

Academic progress relies on the ability to build upon existing knowledge. This concept is reinforced in classrooms where instructors challenge their students to demonstrate their understanding of course information in a final report, experiment, or presentation. However, effectiveness of classroom assessments is reduced when students are unable to replicate or reproduce their submitted results. Unfortunately, issues with reproducibility are common. For example, Baker (2016) reported from a survey of 1,576 scientific researchers that:

• 90% felt that there was a slight to significant “reproducibility crises” in the sciences,
• 70% have tried, and failed, to reproduce (i.e. replicate) another scientist’s experiments,
• more than 50% have failed to reproduce their own experiments.

The widespread difficulty with scientific reproducibility has resulted in multiple instances of high profile researchers building careers on falsified/altered data (Dahlberg, 2018; Kim, 2023). While Fanelli (2018) argues these reported difficulties in reproducibility fall short of a crises, these statistics and stories highlight the importance of teaching our students how to conduct analyses that can be reproduced and/or replicated by others.

The notion of reproducibility is sometimes conflated with the terms repeatability and/or replicability. The National Academies of Sciences Engineering and Medicine (NASEM, 2019) distinguish these terms as:
• **Reproducibility**: obtaining consistent results using the same input data; computational steps, methods and code; and conditions of analysis.

• **Replicability**: obtaining consistent results across studies aimed at answering the same scientific questions, each of which has obtained its own data.

The NASEM definition of reproducibility motivates a classroom-centric definition of reproducibility:

• **Classroom Reproducibility**: the ability of an instructor to easily regenerate the results and conclusions of a student report from the submitted materials.

Use of the term “easily” in this definition suggests that the student has appropriately organized the submitted materials so that little manual or computational effort is required on the part of the instructor to regenerate the results. The definition implies that the instructor is able to evaluate both the final report, as well as the analysis that preceded it. The need for reproducibility in classroom assignments stems from recent technological advances that threaten traditional norms of assessment. To illustrate this, Figure 1 proposes a model of classroom assessment that is adapted from many of analysis workflows that exist in data science (Stodden, 2020; Wing, 2019; Keller et al., 2020; Boenig-Liptsin et al., 2022) and mathematical modeling literature (Doerr et al., 2017; Anhalt et al., 2018). This includes a mathematical modeling workflow in the Common Core State Standards for Mathematics (CCSSM, 2010).

Figure 1 is a workflow designed to apply across disciplines and assessment types. For example, many students use course materials (information) and feedback on previous assignments (experience) to evaluate exam question prompts (analysis) and provide final answers (insight). On term projects, students couple course materials (information) with their personal interests (experience) to propose and answer a research question (analysis) as documented in a final report (insight). Two key components of the workflow are that (1) analysis (i.e., learning) is more than a simple regurgitation of information and (2) analysis and insight are related, yet separate and distinct, steps in the workflow. Ideally, the communicated insight from the project will provide the student and others with new information and experiences that will benefit future analyses.

Most classroom assessments focus on evaluating student insight. Such assessments implicitly assume that the communicated insight is directly reflective of the analysis that preceded it. However, online resources and modern technology obscure the relationship between analysis and insight. For example, ChatGPT (openAI, 2023) has already proven to perform better than average on tests across many disciplines (Lo, 2023) and has been used to write student essays (Stokel-Walker, 2022) and scientific research papers (Stokel-Walker, 2023). While modern artificial intelligence (AI) systems may provide correct answers to assessments, those answers do not imply an understanding of the material being assessed. This fact is admitted by ChatGPT itself in a reply to the query “Do you understand the meaning of the things that you tell me?”:

> As an AI language model, I don’t possess subjective experiences or consciousness, so I don’t have personal understanding or awareness in the same way humans do. (June 16, 2023 using May 24 version of ChatGPT)

When the connection between analysis and insight is lost, so is the efficacy of traditional classroom assessment. That in mind, there is evidence to suggest that AI has potential to improve learning and educational outcomes (Chen, Jensen,
Albert, Gupta, & Lee, 2023). This includes the use of AI systems to teach computer programming syntax (Perkel, 2023). Rather than ban AI use in the classroom, this paper proposes modes of assessment that more directly assess a student’s analysis, rather than just the communicated insight. This paper illustrates the feasibility of this approach in an introductory data science course, where students are able to create a reproducible final project in the R programming language.

This paper proceeds with a brief history on the notion of reproducible reports along with a summary of existing software tools that facilitate the creation of such reports. This is followed by a description of a reproducible final project as administered in an introductory data science course at Utah State University (USU). This paper concludes with a reflection on the potential opportunities, adaptations, and limitations of expanding and generalizing reproducible assignments to other courses. The article demonstrates the feasibility of incorporating reproducibility into assignments with only small adjustments to traditional assessment approaches.

2 Literature

Discussions regarding computational reproducibility have been ongoing since at least the mid-1990s, when Knuth (1992) used the term literate programming to describe a combination of computer code and text as a way of making a computational analysis easier for humans to read and understand. This was followed by Buckheit and Donoho (1995), who described really reproducible research as one in which the software environment and code would be made widely available for others to inspect, modify, and apply. Gentleman and Lang (2007) built upon these ideas when they proposed the idea of a research compendium, which is a combination of data, software and dynamic documents that allow others to reproduce all research results. It is the idea of the research compendium that motivates the final project described later in this paper.

Dynamic documents contain text, code, and data that can be quickly recalculated each time the document is generated. Perhaps the most popular example of software for creating dynamic documents is Jupyter Notebooks (Jupyter, 2023). These notebooks allow users to integrate text with code from over 40 different programming languages that can be run interactively. Another popular dynamic document software is Rmarkdown (Allaire et al., 2023), which is designed to work with the Rstudio Integrated Development Environment (IDE) (Posit, 2023b) for the R programming language (R Core Team, 2023). (Please see Chapter 40 of (Irizarry, 2022) for additional details about using Rmarkdown in reproducible data analysis projects.) There are also several extensions/companions of Rmarkdown designed for creating dynamically generated slides and lecture notes for teaching (Dogucu & Çetinkaya Rundel, 2022). Continual improvements to these and other software implementations make these dynamic document generating tools increasingly accessi-

![Figure 1: A generalized data analysis workflow adapted for classroom learning.](image-url)
ble to larger and larger audiences. For example, Bryant et al. (2019) demonstrated the successful use of Jupyter Notebooks to teach programming to middle school students with little prior programming experience.

Modern technological advances continue to increase the accessibility of dynamic document software while simultaneously reducing the computation time necessary to render them. This increased accessibility prompted Somers (2018) to call the scientific paper “obsolete” in favor of a future world filled with dynamic documents that communicate research results interactively. Some academic journals have partially caught hold of this idea by now insisting that the results of submitted papers be reproducible (Nature, 2018; JASA, 2022; R Journal, 2023). However, a review of the literature suggests that the push for reproducibility in both research and teaching has been concentrated in statistics, data science, and computer science. This may be due to the perceived difficulty of incorporating computer programming into non-computer programming courses. Section 3 of this paper aims to illustrate that the implementation of reproducible reports in an introductory course may be more accessible to both students and instructors than might be initially perceived.

3 Case Study: Stat 1080 Final Projects

STAT 1080: Foundations of Data Science is a course that satisfies USU’s quantitative literacy (QL) general education requirement. The course is designed to be accessible to students of all majors with minimal prerequisites beyond remedial mathematics. The course uses R programming to teach key concepts of statistics and data science. The final project described in this paper has been administered to two small sections of this course—one taught in the Fall 2022 semester (eight students) and another in the Spring 2023 semester (five students). Student backgrounds have varied significantly—from first semester freshman and/or students with little programming or statistics experience, to last semester seniors with extensive statistics and/or programming experience.

Throughout the semester, students complete four homework assignments where they demonstrate the ability to clean, shape, visualize, and analyze data. All data that are necessary to complete homework assignments are made available either in the dslabs (Irizarry & Gill, 2021) R package, available on the Comprehensive R Archive Network (CRAN, 2023), or the stat1080r package (Bean, 2022), which is a software package available at https://github.com/beanb2/stat1080r. Students install this software on their machine and answer prompts in an Rmarkdown (.Rmd) file, which renders an .html report. Figure 2 (top) shows a snippet of a .Rmd file as opened in the Rstudio IDE, while Figure 2 (bottom) shows the corresponding .html output. Notice that the computer code in Figure 2 includes comments that are preceded by a #. Code comments provide students with an opportunity to provide verbal explanations of their code or links to references where they obtained sample code. The key feature of the .Rmd file is the ability of the student to provide the code used for analysis alongside their written insight in a single document.
Students are required to submit the completed .Rmd file on Canvas, which is USU’s current Learning Management System (LMS). The instructor then downloads the .Rmd files and renders each file to its corresponding .html output prior to assessment. The rendering from .Rmd to .html by the instructor ensures that all the code submitted by each student is fully executable. Students are assessed on both the correctness of their text responses along with the validity of the
executed code. For homework assignments, 10% of the assignment points are awarded based on the proper formatting and successful execution of the .Rmd document.

The biggest difference between a .Rmd submission and a more traditional Canvas submission is the need for the instructor to download and regenerate the .html report on their own computer. This prevents the instructor from using the convenient document preview features that are common in many LMSs, which may increase grading time. This potential increase in grading time is offset by the natural way that the .Rmd file gives the instructor to evaluate the work of the student, which is especially useful for partial credit assessments.

### 3.1 Final Project Description

The homework assignments are designed to prepare students for the reproducible final projects, which are completed in groups of 3–4 students. Students are asked to analyze an external dataset of their choosing, often found on websites such as Kaggle (https://www.kaggle.com/). Students first submit a project proposal that briefly describes their dataset along with the questions they intend to explore. The proposal ensures that students select data sources already organized in tables, with rows representing observations and columns representing variables. This avoids handling more complicated data forms, (e.g. images and sound) that tend to have much larger file sizes and require analysis techniques that fall beyond the scope of an introductory course. Students are also encouraged to analyze datasets with 10,000 observations or less in order to reduce the logistical difficulties of uploading and downloading large file sizes on the LMS. These recommendations could be relaxed in smaller, more advanced, courses with students who have prior experience with database management.

Students are encouraged to follow the general principles of a research compendium (Gentleman & Lang, 2007) using the ever-improving software tools available in R (Marwick, Boettiger, & Mullen, 2018). Students are expected to pattern their submissions after the example available at the following link: https://github.com/beanb2/stat1080 final project example

For convenience, Figure 3 provides a screenshot of this repository. Students are encouraged, though not required, to adopt identical folder names for their projects. A brief summary of each file/folder is provided below. Note that this proposed file organization is simpler than other file organization structures proposed for use in course/workshop projects using R (Mehta & Moore, 2022; Ball et al., 2022).

- **data-raw/** This folder contains all original data files relevant to the final project report. Students are discouraged from making any alterations to the original data files besides those that are scripted in the .Rmd code. For data that requires significant cleaning prior to use, students may elect to write a separate .R script that creates a clean version of the data for use in their markdown file.

- **scripts/** As previously mentioned, large datasets and complicated analyses are discouraged for use in STAT 1080 projects. That in mind, there is still the possibility that students need to perform computations that take a long time to run. In more advanced courses, students may also need to write custom programming functions to accomplish tasks. The scripts folder provides a space for students to include code that is too computationally intensive to include in the .Rmd report. Any interim datasets that are created by .R files in this folder should be saved in the **data-raw** folder.
• **final_project_report.Rmd/html** These files constitute the final report that will be regenerated by the instructor at the time of grading. As illustrated in Figure 2, the .Rmd file contains the text and code while the .html file contains the output of the executed .Rmd file. In order for the analysis to be reproducible, the instructor should be able to run the .Rmd file and regenerate the .html without having to alter any of the files.

• **stat1080 final project example.Rproj** This file is for convenience in working with projects involving R code. Opening a .Rproj file creates a new R Studio IDE session with the working directory set to the location of the .Rproj file. This file is not necessary, however, as Rstudio always uses the location of the .Rmd file as the working directory when rendering the .html file.

The specification of a working directory via the .Rproj file allows for the use of relative file paths when reading and writing other files within the project. Unlike full file paths, which are unique for every computer and user, relative file paths do not need to be altered when the project is moved to another computer. For example, the R code for reading in a data file from the example project on any computer using relative file paths would simply be

```r
read.csv("data-raw/kc_house_data.csv").
```

Additional details on file paths can be found in Chapter 5 of Irizarry (2022).

### 3.2 Final Project Assessment

Students are required to submit a compressed folder (.zip) of their final project on the LMS. The LMS restricts the file upload type to ensure that students do not only submit a single file. The instructor then completes the following steps:
1. Download and decompress the submitted zip folder.
2. Open the .Rproj file.
3. Open the .Rmd file within the R project.
4. Run an automatic check for proper code formatting using the lintr package (Hester et al., 2022).
5. Render the .html file from the .Rmd file.
6. Assess the .html file like any other final report.

Steps 1–5 take less than one minute to complete, making the increased grading time minimal compared to a more traditional assessment workflow that starts at Step 6. This process could be easily adapted to other dynamic document types, such as Jupyter notebooks. Proper formatting of the project and successful rendering of the code constitutes 10% of the final project grade. The submitted code, along with any errors generated when the instructor attempts to run the code, provide a record of student effort that aids the instructor when assessing the appropriateness of the analysis and drafting a detailed instructor review.

The instructor review follows the pattern used for peer-reviewed journals, where students are required to articulate what changes they made to each instructor comment using a different colored font. Students are provided with a template review response document that includes the following instructions and example:

```
You will be given the opportunity to resubmit your assignment for full points if you address my comments. Please include this response to review document inside of your R project when you resubmit. You should provide a response, colored in red, outlining how you addressed each comment. Here is a generic example of how this might look (this comment is not specific to any submission):

The interpretation of your p-value in your “Methods” section is not fully correct. The p-value is NOT the probability that the null hypothesis is true. Please revise.

The p-value interpretation has been revised to indicate that it represents the probability of observing something as far (or farther) away from the assumed average.
```

Students who sufficiently improve their project submissions based on instructor feedback and appropriately respond to review receive full points on the final project. The approach of assigning full points after a successful response to review is inspired by the “ungrading” ideas outlined in (Blum, 2020), though a full discussion of this approach to assessment falls outside the scope of this paper.

### 4 Reflections, Limitations, and Adaptions

So far in STAT 1080, the management and assessment of the reproducible final projects has proceeded with almost no difficulty beyond what would be typical for a regular final project report. All students have been able to successfully create reproducible final projects with little intervention on the part of the instructor. This success highlights the ability of students to effectively learn how to organize and execute a reproducible analysis. Further, the submission format for both final project and homework assignments has proven beneficial for assigning partial credit to student responses. This
is because the work (i.e. computer program) underlying each answer must be provided by the student. This allows the instructor to quickly pinpoint an error in student work by interactively running portions of the submitted code. This type of interactive error checking is something that would not be possible if students only reported on the final output. However, assessment can be difficult in instances where the student’s .Rmd files fail to properly render to an .html file, as this requires the instructor to identify and remove the error-prone code before evaluating the remainder of the document.

One limitation of the reproducible final projects is the need for students to know or learn basic computer programming. That in mind, many software programs, such as SAS Enterprise Guide (Hemedinger & McDaniel, 2005), provide ways to generate computer code based on point-and-click actions taken by the user. Another potential way to circumvent this issue is to use more common software systems, such as Microsoft Excel, for analysis. The final project example described in Section 3.1 provides an example of an excel workbook in the data-raw that includes a visual similar to one of the visuals in the rendered .html file. The six steps of assessment presented in Section 3.2 would be nearly identical for an Excel submission, except that students would need to provide an already “rendered” .docx or .pdf document that copies/pastes the visuals provided in the excel file into the final report. Keep in mind that any assignment using Excel as the primary means of analysis would be at risk of the all-too-common copy/paste errors associated with point-and-click software systems (Horton, Alexander, Parker, Piekut, & Rundel, 2022; Perkel, 2022).

A third way this project could be adapted would be to have the student provide an analysis journal. An analysis journal is similar to the idea of using an electronic portfolio as a means of assessment (Buzzetto-More, 2010) and may include:

- transcripts of any ChatGPT inquiries and output related to the project,
- a step-by-step description of all changes that were made to the original data using point-and-click software,
- a daily or weekly project log where students describe key moments in their research progress over time,
- a review response document where students outline the changes they made to their final draft based on feedback from a writing tutor or peer.

The assessment of the analysis journal would be similar to assessing any other technical writing. Emphasis would be placed on writing that clearly communicates the student’s progression from initial idea to final product. Instructors may choose to relax formatting requirements for these documents as long as the formatting does not distract from the student’s articulation of their research steps. The critical element of any reproducible project adaptation is a way for the student to clearly communicate the process by which the final report was developed though the submission of secondary files.

Another potential issue with reproducible final projects is that such projects require that students and instructors use the same software versions. While many programming languages and their associated IDE’s are freely available, there is the potential for an increased burden on the part of the instructor to troubleshoot specific student installation issues. Hopefully, these issues would be concentrated in the first two weeks of the semester. One way to overcome this issue is to use cloud-based computing platforms, such as those as employed by the introductory data science class at the University of California, Berkeley (UCB, 2023). For R users, one convenient option is Posit cloud, which includes an instructor-level subscription service (Posit, 2023a).

One final limitation of reproducible final projects specific to STAT 1080 is the prevailing culture of making data science projects publicly accessible, also called open-source. While open-source projects accelerate learning and research, they also mean there are many community contributed analysis examples that students could try to copy for their final projects. One potential solution to this problem is to have students collect and use their own data, perhaps collected throughout the semester, for their final projects. For example, STAT 1080 includes a personal data collection project based on the
Feltron Annual Reports (e.g. http://feltron.com/FAR13.html) that could potentially be expanded into a reproducible assessment that replaces the current final projects in the course.

5 Conclusions

Several scholars have expressed the idea that “writing is thinking” (McCullough, 2002; Mintz, 2021). This paper argues that computer programming is a form of modern writing that can be directly evaluated in reproducible assignments. This is not to suggest that all students need to be expert programmers, but simply that all students should learn basic skills in project organization, and perhaps computer programming, that allows their ideas to be reproduced and enhanced by others. Experience in STAT 1080 suggests that students can quickly capitalize on the many tools that make reproducibility feasible with minimal training. This paper has described the implementation of a final project in an introductory data science class that fosters reproducibility and proposed adaptations to the implementation to work for non-programming audiences. The proposed adaptations only require minor adjustments by the instructor for grading, namely downloading and decompressing a zip folder instead of using a LMS document preview feature. In so doing, this paper has demonstrated the feasibility with which reproducibility can be taught and assessed in undergraduate courses. It seems inevitable that the societies and economies of tomorrow will be increasingly characterized by AI, automation, and computation. No academic discipline will be immune to the increased demands for computational ability from their graduates. Small steps, such as the teaching of basic computer programming skills for the purpose of creating reproducible projects, will teach students critical skills in project organization and management that will prepare them to thrive within the computational systems shaping modern life. Further, such assignments will improve our ability to evaluate student learning in a technology-saturated world that blurs the line between output and understanding.

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EVALUATING ACTIVE LECTURE AND TRADITIONAL LECTURE IN HIGHER EDUCATION

Kathleen Klein; Jennifer Calabrese, OTD; Adam Aguiar, Ph.D.; Sunny Mathew, Ph.D.; Kimoni Ajani, Ph.D.; Rania Almajid, Ph.D.; and Jennifer Aarons, Ed.D.

Abstract

The purpose of this study was to evaluate the effectiveness of traditional and active lecture methods in higher-education courses. A multiple group convergent parallel mixed method design was used, with measurement of learning, attention, and student preference for active or traditional lecture methods. Six faculty at a public university in the northeast region of the United States engaged 178 undergraduate and graduate students in a traditional lecture session and an active lecture session during the Spring 2022 semester. Results indicated effectiveness of active and traditional lecture approaches (p < .05). Analysis of qualitative and quantitative data in the study provides additional information regarding student preference for active lecture based on perceptions of increased learning benefits, interaction/engagement, attention, activities, discussion, and the use of multimedia. In implementing both traditional and active lecture sessions this study employed pre-lecture and post-lecture quizzes that students found to be very beneficial to learning.

Keywords: active lecture, traditional lecture, active learning, student engagement

Introduction

Lecture, as a teaching method, remains one of the most common and enduring course delivery methods in higher education (Deslauriers et al., 2011; Henderson & Dancy, 2007; Sadeghi et al., 2014; Schmidt et al., 2015; Stains et al., 2018). Active lecture is a teaching method based on a student-centered approach that encourages student engagement, interaction, and participation during lectures. Traditional lecture is a passive approach where students listen without active engagement or significant participation. In higher education, the use of active lecture has numerous benefits compared to traditional lecture (Freeman et al., 2014; Kay et al., 2019; McCullough & Munro, 2018; Murphy et al., 2021).

One major advantage of active lecture is increased student engagement and participation (Bradford et al., 2016; Bidadi et al., 2016). With active involvement in the learning process, students are more likely to experience increased understanding and retention of course content. Active lectures encourage students to think critically, ask questions, and participate in discussions in a manner that more fully engages students with the subject matter (Chi & Wylie, 2014; Connell et al., 2016; Freeman et al., 2014; Silva et al., 2022; Yarmohammadi et al., 2023). Active lecture also promotes the development of important skills such as teamwork, communication, and problem-solving (Farashahi & Tajeddin, 2018; Knight & Wood, 2005). Group activities and discussions may be incorporated into active lectures, providing students the opportunity to work together and develop communication skills. Another benefit of active lecture is the reduction of the achievement gap between students as active lecture provides equity opportunities, encouraging all students to participate and engage in the learning process, regardless of background or prior knowledge (Clark, 2023; Haak et al., 2011; Theobald et al., 2020).
In contrast, traditional lectures draw criticism for focusing on the instructor instead of the student. It may be difficult for students to stay engaged and focused during a long lecture, resulting in a struggle to retain information (Alaagib et al., 2019; Sudarmika et al., 2020; Zeng et al., 2020). Traditional lecture relies heavily on memorization rather than critical thinking and problem-solving skills (Schmidt et al., 2015). In a meta-analysis study conducted by Freeman et al. (2014), it was observed that students in traditional lecture courses were more likely to fail compared to students in active lecture courses. Traditional lectures remain a convenient method for delivering vast amounts of information and may be well received when presented by an engaging lecturer in a systematic and organized manner (Kay et al., 2019).

While traditional lecture is a common approach to teaching in higher education, active lecture is shown to be more effective in promoting student engagement, participation, and learning (Deslauriers et al., 2011; Freeman et al., 2014; Kay et al., 2019; Murphy et al., 2021). By incorporating active lectures, educators help students master course content, develop important skills, promote equity in the classroom, and improve overall learning outcomes.

This study was designed to apply and evaluate the existing literature findings. The faculty researchers were curious about assessing the impact of active lectures compared to traditional lectures with graduate and undergraduate students in their classrooms. The systematic evaluation of active and traditional lecture methods serves several purposes, all of which contribute to understanding the influence of lecture teaching methods on learning outcomes.

The specific objectives of this mixed-methods research study include:

- Determining if active and traditional lecture methods contribute to improved learning outcomes, as measured by knowledge retention quizzes and student perceptions.
- Investigating whether active lectures increase student attention and participation compared to traditional lectures, indicating heightened student engagement and motivation.
- Assessing students’ preference for active and traditional lecture methods.

In addition to these study objectives, the faculty researchers were eager to evaluate the effectiveness of their personal classroom lecture approaches and to acquire skills related to the scholarship of teaching and learning. Faculty were interested in determining the generalizability of research literature findings to different subject areas and student demographics. This study served as part of a continuous improvement process, highlighting best practices and areas for enhancement. The investigation of these two lecture methods allowed faculty to consider aligning their teaching strategies with specific student learning outcomes based on analysis of the impact of the lecture method in the classroom.

**Method**

**Participants**

Participants were 178 undergraduate and graduate students attending a public university in the northeast region of the United States. As indicated in Table 1, two courses were graduate courses, representing 58 of the 178 students in the study. The other four courses were undergraduate courses, with 120 undergraduate students participating in the study. Student participation in the study was voluntary. Students were enrolled in at least one of six participating courses in Spring 2022, as indicated in Table 1.
Table 1. Student Participants

<table>
<thead>
<tr>
<th>Course Subject</th>
<th>Number of Students</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afrikan Studies</td>
<td>35</td>
<td>undergraduate</td>
</tr>
<tr>
<td>Biology</td>
<td>22</td>
<td>undergraduate</td>
</tr>
<tr>
<td>Hospitality</td>
<td>12</td>
<td>undergraduate</td>
</tr>
<tr>
<td>Occupational Therapy</td>
<td>28</td>
<td>graduate</td>
</tr>
<tr>
<td>Physical Therapy</td>
<td>30</td>
<td>graduate</td>
</tr>
<tr>
<td>Social Work</td>
<td>51</td>
<td>undergraduate</td>
</tr>
</tbody>
</table>

All participants provided consent and were clearly informed that participation in this research study had no impact on the course grade. In accordance with ethical guidelines, this study received approval from the University’s Institutional Review Board (IRB) under protocol number 2022-025.

**Research Design**

A multiple group convergent parallel mixed method design was used to compare traditional and active lecture approaches. In this approach, quantitative and qualitative data are analyzed with analysis merged into a singular interpretation. This design permits enhanced understanding of quantitative data based on qualitative findings (Creswell & Plano Clark, 2011).

The research questions addressed for this study are (1) To what extent does active lecturing impact student learning compared to traditional lecturing? and (2) Does active lecturing increase student engagement as measured by students’ self-reported perceptions?

Students enrolled in one of six courses taught by six different faculty members were provided with a class session that involved traditional lecture and a separate class session that involved active lecture as defined in a protocol developed for the study and submitted as part of the IRB process. The protocol provided specific information for faculty to employ active and traditional lectures in the classroom. Prior to implementing the lectures, the faculty involved in this study were grouped into pairs. Each pair reviewed their planned active and traditional lectures prior to lecture delivery to ensure fidelity to the definition of active and traditional lecturing.

For this study, a traditional lecture is course content delivered via instructor’s spoken word and didactic feedback restricted to answering student questions only. An active lecture for this research study is defined by Kay et al. (2019) as a “...student-centered approach where instructors and students collaborate, engage and interact with course content” (p. 449). Specifically, Freeman et al. (2014) described active lecture as an experience that “engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work” (p. 8413-14). Faculty members in this study determined an appropriate class session in their Spring 2022 course for each lecture approach with consideration of making the content challenge level equivalent between the two course sessions.

Both traditional and active lectures presented students with clear learning objectives/outcomes and reviews to ensure that students had sufficient knowledge or skills necessary to succeed in mastering the course content. The active lectures presented students with materials/activities designed to promote active learning, suitable technology to facilitate continual engagement and interaction, and/or supplementary materials for student-focused active learning (Freeman et al., 2014; Pickering & Roberts, 2018; Kay et al., 2019).
In this study, each faculty selected active learning activities best suited to the specific class session. Active learning activities included small group work, think-pair-share activities, polling, worksheets, case studies, jigsaw, YouTube video activities, and discussions. Faculty engaged with student groups/pairs during the activities to facilitate student learning and utilized questioning/polling and other interactive methods to assess student understanding of concepts and provide real-time feedback to correct any errors when learning course content.

Participating faculty formed partner groups allowing a faculty partner to review planned lectures, course content, and quizzes to determine whether lecture, course activities, and pre-lecture and post-lecture quizzes met study criteria before delivering the active or traditional lecture session. This process helped to determine that course content and quizzes used in the various courses and lecture methods were as equivalent as possible. If additional guidance on fidelity was desired, the faculty contacted the primary investigator for clarification. In three courses (50%), the traditional lecture session preceded the active lecture session during the semester. In the other three courses, the active lecture session preceded the traditional lecture session. Although complete control of confounding variables was not possible, careful matching of content within each course and appropriate statistical analysis was implemented to enhance the validity of the findings of this study.

Instruments

Quantitative and qualitative student data was collected after each active lecture and traditional lecture course session with a Qualtrics survey developed by the researchers. The survey was completed anonymously by students immediately following the session. The survey questions are listed below.

Qualtrics Survey Questions

1. IRB-approved text statement providing informed consent.
2. Did today’s lecture help you to learn and understand the course content presented?
3. How did the lecture help you learn the content? What specifically was the strength of this lecture?
4. What specifically prevented you from learning content during this lecture?
5. Did the lecture maintain your attention during the class?
   a. If YES, how did the lecture help?
   b. If NO, why not?
6. I would prefer __ percent (%) of our classes to use today’s lecture method. 0=none of our classes; 100=all our classes
7. Please suggest activities that would increase your learning and participation in this class.
8. Please include any additional comments/suggestions regarding lectures like the one in today’s class.

Student learning of course content was measured with an eight to eleven-question pre-lecture and post-lecture quiz developed and administered by each course faculty member. The quiz grades did not impact the student’s grade in five of six courses. In one course, lecture quizzes were scored activities and the scoring did not change when the quiz was used for the study. Mean quiz scores were compared to measure student mastery of course content (learning).
Results

Learning Quizzes

Pre-lecture and post-lecture quizzes were used to assess student learning of course content. Any change in student quiz scores from before the lecture to after the lecture was used to measure student learning of course content. The quiz scores were assessed with paired t-tests. Statistical analysis indicates students’ learning of course content increased in both active and traditional lectures.

A paired t-test was conducted to compare the mean quiz scores before \((M = 54.11, SD = 25.83)\) and after \((M = 72.55, SD = 22.25)\) active lecture classroom sessions. The results showed a statistically significant increase in quiz scores following the active lecture, \(t = -11.27, p = .000, d = 0.51\), indicating a medium effect size. The standard deviation of the differences between paired observations was 21.38. Likewise, the paired t-test conducted to compare the mean quiz scores before \((M = 42.21, SD = 19.28)\) and after \((M = 67.17, SD = 24.02)\) traditional lecture classroom sessions showed a statistically significant increase in quiz scores following the traditional lecture, \(t = -11.86, p = .000, d = 0.4\), indicating a small to medium effect size. The standard deviation of the differences between paired observations was 26.98.

The analysis of learning measured by pre-lecture and post-lecture quizzes indicates that student learning increased with both traditional and active lectures. However, the effect sizes suggest that the improvement was moderate for active lectures and smaller for traditional lectures. In the active lecture quizzes, the standard deviation of 21.38 suggests some variability in the improvement of students’ quiz scores after the lecture. In the traditional lecture quizzes, the standard deviation of 26.98 indicates a slightly higher level of variability, suggesting that quiz score improvements varied more among students in traditional lecture sessions.

The researchers opted for a multiple-group convergent parallel mixed-method design, which facilitates the analysis of quantitative data in tandem with qualitative survey findings, as outlined by Creswell and Plano Clark (2011). This approach enables exploration of the student learning experience in active lecture classes compared to traditional lecture classes, going beyond the limits of relying solely on analysis of quiz scores.

Survey

Students anonymously completed a Qualtrics survey after active learning class sessions \((n=178)\) and again after traditional lecture class sessions \((n=177)\). The survey provided quantitative and qualitative data to be analyzed concurrently to assist the researchers with a unified interpretation of data regarding the student learning experience during active or traditional lectures.

Survey responses regarding students’ perceptions of learning course content and maintaining attention are summarized in Table 2. A higher percentage of students reported learning more from active lectures (94%) compared to traditional lectures (85%). The 9% difference suggests that active lectures were perceived as slightly more effective in terms of content learning. When reporting on attention levels, which are associated with engagement and motivation (Gamo, 2022), a significantly higher percentage of students felt more attentive during active lectures (93%) compared to traditional lectures (69%). The 24% difference suggests that active lectures were more successful in maintaining student attention.
Table 2. Summary of Student Yes/No Responses to Survey Questions 2 & 5

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Q2 Number of respondents</th>
<th>Q2 Percentage of respondents</th>
<th>Q5 Number of respondents</th>
<th>Q5 Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active Lecture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Yes</td>
<td>167</td>
<td>94%</td>
<td>154</td>
<td>93%</td>
</tr>
<tr>
<td>1 – No</td>
<td>11</td>
<td>6%</td>
<td>11</td>
<td>7%</td>
</tr>
<tr>
<td>No Answer</td>
<td>0</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>178</td>
<td>100%</td>
<td>178</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Traditional Lecture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Yes</td>
<td>151</td>
<td>85%</td>
<td>105</td>
<td>69%</td>
</tr>
<tr>
<td>1 – No</td>
<td>26</td>
<td>15%</td>
<td>47</td>
<td>31%</td>
</tr>
<tr>
<td>No Answer</td>
<td>0</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>177</td>
<td>100%</td>
<td>177</td>
<td>100%</td>
</tr>
</tbody>
</table>

A chi-square test for independence was conducted to examine the relationship between student perception of effectiveness (learning course content and maintaining attention) and active lecture. The results revealed a significant association between effectiveness and active lecturing, $\chi^2 (1, N = 178) = 16.87, p < 0.0001$. These results indicate a statistically significant association between student perception of the course’s effectiveness in learning content and maintaining attention during active lecturing.

A chi-square test for independence was conducted to examine the relationship between student perception of effectiveness (learning subject material and maintaining attention) and traditional lecture. The results revealed a significant association between effectiveness and traditional lecturing, $\chi^2 (1, N = 177) = 35.32, p < 0.0001$. The chi-square test found a significant association between students’ perceptions of the effectiveness of traditional lectures in terms of learning subject material and maintaining attention.

The results of the chi-square analysis suggest that students perceive their learning as effective, irrespective of the lecture method. The choice of teaching method (active or traditional lecturing) may impact students’ perceptions of the course’s effectiveness, highlighting the importance of considering student feedback and preferences when selecting the most suitable lecture approach.

The quantitative comparison of quiz scores and analysis of student survey data presented so far offer support for active and traditional lectures, with students indicating higher levels of attention during active lectures and a slight perception of increased learning during active lectures. Additional interpretation of the quantitative data is aligned to the qualitative findings from student surveys. The researchers note that these findings are based on students’ self-reported perceptions of their learning and attention and these perceptions may be influenced by various factors, including personal preferences and biases.

In evaluating how often students would prefer active versus traditional lecture sessions as a specific percentage of a course, students reported a preference for a larger portion of active lecture compared to traditional lecture, as indicated in Table 3. Student survey mean responses provided in Table 3 indicate a preference for a larger percentage of the class to incorporate an active lecture method (71%) compared to traditional lecture (51%).
Table 3. Summary of Student Responses to Survey Question 6

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Q6 Mean</th>
<th>Q6 Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Lecture</td>
<td>71</td>
<td>64-98</td>
</tr>
<tr>
<td>Traditional Lecture</td>
<td>51</td>
<td>12-77</td>
</tr>
</tbody>
</table>

The mean preference score for active lectures is higher than that for traditional lectures (71% vs. 51%). Many students indicate a preference for active lectures, which consist of interactive and engaged learning. The wide range of preferences indicated in Table 3 suggests that there is significant variability among students in terms of their preferences for instructional lecture methods. These findings, along with empirical evidence, suggest that incorporating active learning strategies aligns with student preferences. In doing so, faculty recognize that student preferences may be influenced by various factors, including their prior experiences, learning styles, and the content of a specific course.

Qualitative Data for Traditional Lectures.

In the analysis of qualitative data pertaining to traditional lectures, we aimed to complement the quantitative findings with a deeper understanding of student preferences. Among the 151 students (85%) who responded positively to the effectiveness of traditional lectures in aiding their learning of course content (as indicated in Table 2), we selectively examined survey questions three and four. These questions allowed students to elaborate on the strengths (question three) or weaknesses (question four) of the traditional lecture method. Of the respondents, 150 students representing all six courses provided additional comments, shedding light on the perceived strengths of traditional lectures.

One prominent theme identified was the value of quizzes in enhancing the learning experience. Many students expressed appreciation for the pre-lecture quiz, which provided a basic overview of what to expect and helped them focus on specific areas during the lecture. Furthermore, the process of taking both pre- and post-lecture quizzes was seen as effective in assessing knowledge and reinforcing learning. Reiteration of key points and clear definitions within the pre-lecture quizzes contributed to a better understanding of the content. Interestingly, some students even noted that the presence of quizzes, including knowledge of a post lecture quiz, helped maintain their attention during the lecture.

Another strength frequently highlighted was the structured learning aided by well-organized PowerPoint presentation slides. Students found these slides instrumental in systematically presenting lecture content. Visual aids, such as pictures, diagrams, and charts, were considered helpful for illustrating complex concepts and enhancing comprehension. Additionally, the incorporation of real-life examples, historical context, and statistical data within traditional lectures facilitated students in relating to and understanding the subject matter.

Furthermore, traditional lectures were praised for their clear, understandable, and detailed presentation style. Students appreciated lectures that were concise, well-organized, and focused on key points, as they found it easier to grasp information in such formats. Lectures that delved into topics with depth and provided comprehensive information were also valued for their thoroughness and detailed explanations. Some students found value in the passive learning style that traditional lectures offered, where they could receive information without excessive interaction.

However, it is important to acknowledge that not all students perceived traditional lectures as effective. In three out of the six courses examined, 25 students provided comments indicating that the traditional lecture format did not support their learning of the course content. These students reported difficulties related to engagement, maintaining attention, and information overload. Terms like “monotonous,” “boring/dry,” and “not engaging” were used to describe the lecture experience. A lack of variation in presentation style, faculty engagement, and student participation in discussions or
interactive activities contributed to students deeming traditional lectures as ineffective for their learning. Additionally, challenges with notetaking and maintaining attention hindered their understanding of lecture content. These qualitative insights provide a comprehensive view of the strengths and weaknesses associated with traditional lecture methods.

Qualitative Data for Active Lectures.

In the analysis of qualitative data related to active lectures, we aimed to gain a deeper insight into student preferences, aligning these qualitative findings with the quantitative results. As shown in Table 2, a significant majority of students (94%, or 167 students) reported that active lecturing positively contributed to their learning of course content. To further explore the reasons behind this perception, we selectively examined survey questions three and four, which allowed students to elaborate on the strengths (question three) or weaknesses (question four) of the active lecture method. Among the respondents, 87% (154 students) from all six courses provided comments to indicate the strengths and weaknesses of active lectures.

One prominent theme emerging from the analysis was the value of cooperative group learning and peer interaction during active lectures. Students expressed appreciation for the opportunities to collaborate with their peers and engage in discussions related to course content. Comments such as “I like to hear my peers’ point of view, or what they thought about the text that we were assigned. I like to compare “key takeaways” and find out if we focused on the same aspects” highlighted the perceived benefits of group learning. Peer interaction and the exchange of perspectives were seen as valuable aspects of active lectures, enhancing students’ learning, and benefiting from the insights of both faculty and peers.

Furthermore, many students emphasized the beneficial contributions of quizzes, both before and after the lecture. They found these quizzes valuable for maintaining focus and retaining the course content covered in the lecture. Comments such as “This lecture helped me learn because the pretest had me thinking about the material that I did not know then when we were lecturing I understood the correct answers to the questions on the pretest and the post-test reinforced my learning/knowledge” expressed student appreciation for the quizzes. It is noteworthy that almost 25% of student survey responses specifically noted the value of quiz administration in enhancing attention and knowledge retention, even though quizzing was not an inherent feature of active or traditional lectures.

Another important theme highlighted the significance of interactive elements within active lectures. Students reported that class activities and student participation were highly effective in maintaining attention, focus, and enhancing knowledge retention. Incorporating questions, polling, learning activities, in-class projects, and discussions during the active lecture encouraged active involvement in the learning process, which students believed increased their attention and overall learning.

The analysis also emphasized the effectiveness of a variety of active learning strategies employed in active lectures. These methods were commended for making lectures more engaging and memorable. Students expressed appreciation for well-designed active lectures, which included multimedia materials, personal stories, and engaging examples of course content. They found these elements helpful in breaking down complex information and aiding comprehension. Moreover, students praised the clear connection between course content and its real-world relevance in active lectures, which added depth to their learning and made the content more meaningful.

However, it is important to acknowledge that, in some cases, a few students did not find active lectures effective for their learning. In three of the six courses assessed, one student in each course indicated that the active lecture was not useful but did not provide specific comments. In one course, nine students (18%) reported that the active lecture was not useful, with seven students providing brief comments. Two of the comments identified perceived ineffectiveness of the active lecture in conveying information. One student stated a preference for traditional lectures. Other students expressed confusion about group work, finding it challenging to understand the work assigned.
The results section presents a thorough examination of the study’s findings, employing quantitative and qualitative measures to evaluate active and traditional lecture methods. The analysis of quiz scores demonstrates that active and traditional methods led to increased student learning, with active lectures yielding a moderate improvement and traditional lectures a slightly smaller one. Student surveys reveal a preference for active lectures due to their engagement and ability to maintain attention, group interactions, and presentation interactive elements. It is noted that students found value in well-organized traditional lectures as familiar, organized, and presenting information systematically. Of special interest are student comments related to the benefits of pre-lecture and post-lecture quizzes that were related to the study and not representative of traditional or active lectures. The study underscores the importance of considering student feedback and preferences when selecting lecture methods and the need to further investigate aspects of lecture methods and knowledge assessment measured by quizzing.

Implications for Future Research

The results of this study should be considered in the context of several limitations, including the generalizability of students representing a diverse range of educational levels from a variety of academic fields of study at one public university. The higher-order creativity and skills required in graduate professional courses, as well as the understanding and comprehension expected in foundational courses, may have impacted the study outcomes (Venton et al., 2021).

Additional limitations include non-standardized researcher-generated surveys and quizzes. Future studies could incorporate more objective measures of learning. Limited student comments indicate that changing student expectations when instructors deviated from more familiar teaching methods may have influenced student responses when the instructors offered a traditional lecture and active lecture session for this study. Likewise, activities and approaches to traditional and active lectures were not standardized, although a protocol and peer review provided guidelines for the lecture methods.

This study suggests several avenues for further research within the context of lecture approaches in higher education. There is a need for ongoing longitudinal studies to assess the enduring effects of various lecture methods on student learning and engagement (Gamo, 2022). Such longitudinal studies could prove valuable in identifying shifts in student characteristics and evolving learning preferences over time. Also, future research may aim to evaluate the influence of instructor characteristics on the effective delivery of traditional and active lectures. Given that lecture methods have been a subject of scholarly investigation for many years, researchers may use this study’s findings to advance our comprehension of lecture method effectiveness in higher education. Notably, this study reveals students’ appreciation for pre-lecture and post-lecture quizzes as tools that enhance focus on lecture content and facilitate self-assessment of learning. This presents an intriguing potential area for future research exploration.

Conclusion

This study delved into the comparative effectiveness of active and traditional lecture approaches in higher education, shedding light on their impact on student learning and engagement. Active lecture, characterized by its student-centered approach and emphasis on engagement and interaction, was found to offer some advantages over traditional lecture methods. The significant benefits of active lectures described in the literature and confirmed by students in this study include increased attention and engagement, a stronger preference for active lectures compared to traditional lectures, and increased learning as measured by student report and the slightly larger effect size in pre-lecture and post-lecture
quizzes. Active lecture group activities, discussions, and other activities that promoted peer interaction were valued by students.

In contrast, traditional lectures, while convenient for delivering vast amounts of information, were critiqued by students for their potential to disengage students and faculty. Students reported struggling to maintain focus during traditional lectures, resulting in decreased information retention. Student comments indicate information overload and boredom during traditional lectures. In this study, student scores increased from pre-lecture to post-lecture quizzing. Chi-square analysis indicated effective learning (maintaining attention and learning subject material) irrespective of the lecture method. Empirical evidence indicates that students in traditional lecture courses are more likely to experience failure compared to their counterparts in active lecture courses.

This study indicates that students perceive traditional lectures to be valuable when presented systematically and engagingly by instructors. Clear organization, visual aids, and well-defined objectives contributed to making traditional lectures more effective. Nevertheless, the overall findings suggested that active lectures held an advantage in terms of promoting student engagement, attention, and learning gains measured by pre-lecture and post-lecture quizzes.

The study’s objectives encompassed assessing the impact of lecture methods on learning outcomes, investigating student engagement and preferences, and contributing to faculty’s ongoing improvement in teaching practices. It revealed that students tended to learn more effectively in active lecture settings and perceived higher levels of attention and engagement during these sessions. Furthermore, students expressed a preference for incorporating active lectures in a higher proportion of their courses.

The multiple group convergent parallel mixed method research design enabled a comprehensive exploration of both quantitative quiz score data and qualitative student survey responses. While the quiz scores confirmed the positive impact of both active and traditional lectures on student learning, the survey responses illuminated the nuances of student experiences and preferences.

However, this study does have limitations, including the non-standardized nature of the surveys and quizzes, the specificity of the university and its student demographics, and potential student bias due to deviations from familiar teaching methods. Future research in this area could benefit from more standardized measures, larger and more diverse participant pools, and a deeper exploration of the impact of instructor characteristics on lecture effectiveness.

In conclusion, this study describes the value of incorporating active lectures in higher education settings and offers insight on student perceived benefits of active and traditional lectures. It offers valuable insights regarding the influence of lecture methods on student learning and attention, highlighting the need for continued exploration in this area and the potential for enhancing teaching practices to align with student preferences and improve overall learning outcomes.

References


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Abstract


*Keywords:* rural, community, STEM, diversity, education

Overview

We, the reviewers, live, work, and teach as educators in rural communities in Utah as part of Utah State University’s Statewide Campuses. Our teachers’ and students’ demographic include rural students, who are often marginalized and considered a uniform “other.” Drs. Marietta and Marietta explore the complexities of the rural experience in their new book focused on action items in education to meet the needs of these diverse and resilient communities. The structure of the book begins with framing and defining rural communities, discusses the unique needs and successful initiatives in rural areas, and concludes with actions, including successful strategies and recommendations for educational initiatives. The authors, both from and living in rural America, present an *emic* approach to rural education in contrast to vast *etic* research. Their expertise includes research and experiences on the Navajo Nation in New Mexico and in various schools in rural Eastern Kentucky.

Context

The rural-urban divide is an ongoing issue in the United States, amplified by headlines about moving state lines to divide rural sections of states from urban ones in diverse geographies of Oregon, North Carolina, and Maryland. Rural is often defined as the opposite of urban, with an emphasis on the rural-urban divide and a rural monolith of white poverty, resource extraction, and social conservatism. This dichotomy and simplification results in the mischaracterization of many communities by agencies, including the Census Bureau, Office of Management and Budget, and the National Cen-
ter for Education Statistics (NCES). In the context of this book, rural is defined by the distance from major cities and amenities (such as major airports), population densities, community ties, and a deep sense of place.

In urban settings, opportunities to attend different schools often result in socioeconomic and racial disparities with unique urban problems and urban-focused educational strategies. To further the book’s point about the complexities of rural communities, new alternative charter schools are now an option in the Black Belt region of rural Alabama (Marshal et al., 2022). Some might argue for the application of work from poor urban areas to poverty-stricken rural communities. For instance, research in urban schools in the greater Washington, D.C. area found effective strategies for increasing retention included laundry services in the school and bus passes (Williams, 2019). Though these two solutions directly target urban students, other interventions found could easily be applied to rural populations, including a food and toiletry pantry, building positive relationships, providing safety nets and counseling, and focusing on post-secondary plans (Williams, 2019). The complexities of issues and direct interventions aimed specifically at rural schools are often underfunded and overlooked by academic communities.

The authors explicitly respond to the notion of educating children away from their rural communities as a source of outmigration. Though many programs focus on education as a way to move children away from their struggling rural economies, the authors stress the inherent urban bias of encouraged outmigration and note that most adults in the United States live where they grew up regardless of geography. These programs are often from the perspectives of outsiders, and urbanites are not expected to relocate. One such program, with an unapologetically named “Pathways Off the Res” student handbook, was part of the University of New Mexico’s Native American Studies Academic and Retention and Intervention (NASARI) program from the Fall of 1990-1996, funded by the New Mexico State Legislature (Belgarde & Lore, 2007).

The book does not ignore the inherent economic challenges of rural landscapes, including resource-extraction-based jobs, diminished infrastructure, disproportional opioid-epidemic impacts, and impacted healthcare and education systems. These real challenges, however, are often overemphasized at the expense of the benefits of rural locations, including a deep sense of place which is embedded in place-based and identity-based education with benefits to the larger community and strong community ties. The authors also discuss the socioeconomic, racial, and political diversities and intersectionalities that exist in rural communities with an emphasis on Native American, African American, and LatinX communities throughout rural America. Schools that embrace social mobility and create opportunity are described by bell hooks as “The classroom with all its limitations remains a location of possibility . . . we collectively imagine ways to move beyond boundaries, to transgress. This is education is a practice of freedom.” (hooks, 2014).

The strengths of rural communities are highlighted in the book, focusing on many of the characteristics that tie us to our own rural communities in Utah: “deep sense of place, strong community and kinship bonds, innate understanding and appreciation of the natural world, development of selflessness, and the central role schools play in communities with few other resources” (p. 35, Marietta & Marietta 2021). In addition, independence and resilience to natural disasters, the Covid-19 epidemic, and other positive traits are described thoroughly in the book. It is noted that Utah is ranked second in inequitable school funding in the U.S. (Farrie et al., 2019). USU’s statewide campus system reaches our rural students as proximity to a University has large impacts on post-baccalaureate degree attainment.

**Needs of Rural Students**

Striking a particularly relevant point was the discussion of literacy and state language tests. The authors’ example is of 4th-grade Navajo students who were asked comprehension questions about a reading passage on the New York City subway system fares and schedules. These students knew “Subway” as a sandwich shop sixty miles away and trains as above-ground cargo containers. The lived experiences of the students had tremendous bearing on how they interacted with
the text, emphasizing the need for culturally relevant instruction and a need to tap into existing rural storytelling knowledge. Focusing on relevant context is especially important for those of us who teach via interactive broadcast, bringing our examples relevant to the locations of our students. New methods such as augmented reality (AR) show promise to enhance discovery for place-based education in rural areas (Gordon-Messer et al., 2022).

In addition to standardized testing bias towards urban identities, programs directed specifically at rural students have resulted in a distrust of the educational system. Settlement schools and boarding schools, specifically for Native American students, focused on teaching students away from communities and their traditions. Many of us and our students are just one or two generations away from these atrocities, resulting not only in severed cultural and community ties but also in transgenerational epigenetics of traumatic stress (Jawaid et al. 2018).

The book focuses on specific needs, including early childhood education, literary programs, STEM and STEAM programs, and college and career readiness. The authors highlight the vast amount of research on the benefit of all-day pre-K options, which are scarce to non-existent in rural Utah. For example, rural literacy programs, including Dolly Parton’s Imagination Library, which is available in five countries, are undersubscribed in the Western U.S. and especially on Tribal Lands. The authors highlight the impacts of University Extension partnerships, 4-H, and FFA for promoting science education but also emphasize the digital divide due to lack of broadband internet options. A highlight of the book focuses on why fewer rural students graduate from college than their urban and suburban peers. Solutions presented in the book include concurrent enrollment, career and technical education, post-secondary certificates, and university and community interactions which address cultural mismatches.

**Recommendations**

A strength of the book is a focus on actions for parity in rural college attainment. The authors outline specific steps to take, including understanding the social and cultural history of your school, identifying forces shaping your context, identifying community strengths and assets, and evaluating programs you have in place. In understanding the history, we find it imperative to acknowledge historical traumas that have occurred under the guise of education in our communities and openly address those traumas that have impacted our Native American students, communities of color, and our two-spirited siblings. Data-driven actions required determining for your community items like the number of children who live with a grandparent, are homeless, and preschool attendance rates. In addition, we find it helpful to work with our local high schools to determine the number of high school seniors who are credit-deficient for graduation, an issue that summer dual enrollment can address. Additional tools outlined in the book include an asset map and sample rubrics for evaluating your programs.

A weakness in the book was an overemphasis on Appalachian communities, which have their own inherent issues and often specific strong sources of funding not found in other parts of the United States or in other countries. Though the need for research on rural education was mentioned several times in the book, we are left wondering about the main themes of this type of research and where to begin when focusing research on rural educational needs. Another limitation of the book is its review of the importance of rural education centers and hubs in identifying, supporting, and disseminating funding related to rural education. These centers, found in many states and related conglomerate organizations, are bastions for intellectual and financial support for solving distinct rural issues. A section on these resources would have improved the book by providing concrete resources for specific future actions.

Though the book is focused on optimism, the underlying conditions of communities disproportionately impacted by climate change, facing additional losses of natural resource-related jobs, and continued rural-urban divides are evident and looming. A statewide rural education center would allow us to systematically address several of the issues outlined in the book. If you are new to thinking about rural communities, or if you are a scholar of rural identities, this book offers
insights into common misconceptions, focuses on rural communities’ strengths that are often overlooked, and provides strategies for improving rural education from emic perspectives of researchers committed to rural areas. We encourage you to sit on your back porch, your condo’s balcony, or wherever life finds you, listen to the birds sing, and read about where we call home.

References


Acknowledgments

Utah State University campuses and centers reside and operate on the territories of the eight tribes of Utah, who have been living, working, and residing on this land from time immemorial. These tribes are the Confederated Tribes of the Goshute Indians, Navajo Nation, Ute Indian Tribe, Northwestern Band of Shoshone, Paiute Indian Tribe of Utah, San Juan Southern Paiute, Skull Valley Band of Goshute, and White Mesa Band of the Ute Mountain Ute. We acknowledge these lands carry the stories of these Nations and their struggles for survival and identity. We recognize Elders past and present as peoples who have cared for, and continue to care for, the land. We affirm Indigenous self-governance history, experiences, and resiliency of the Native people who are still here today.

We acknowledge the land and our mothers as our first teachers.

Drs. Sunshine Brosi and Sky Marietta are sisters who grew up together in rural Eastern Kentucky in a family of seven children.