International Journal of Contemporary Education
Vol. 6, No. 2; October 2023
ISSN 2575-3177 E-ISSN 2575-3185
Published by Redfame Publishing
URL: http://ijce.redfame.com

A Preliminary Report on Students' Reflections about Their Learning in an Active Learning Classroom

Su Liang[1], Tina Vega[1]

[1]University of Texas, San Antonio, USA

Correspondence: Su Liang, University of Texas, San Antonio, USA.

Received: August 8, 2023 Accepted: September 11, 2023 Online Published: September 14, 2023

doi:10.11114/ijce.v6i2.6393 URL: https://doi.org/10.11114/ijce.v6i2.6393

Abstract

In the past decades, College Algebra has become a big hurdle for students to graduate or further pursue STEM or related careers. For most of the student population, College Algebra is a terminal course and only a small portion of students take it for further mathematics courses. The traditional content of College Algebra does not serve either group of students well (Mathematical Association of America, 2004; Mathematical Association of America & National Council of Teachers of Mathematics, 2012). In recent years, at a large Hispanic-serving university, the course design for liberal arts students has been changed. An active-learning curriculum has been implemented, namely Quantitative Reasoning. This curriculum engages students with opportunities to learn math concepts from relevant everyday sources and even their own personally collected data. Students build their own understanding of mathematics by relevant data-based situations experienced through preview activities designed to prepare students for class, collaboration in class discussion and discovery through relevant problem situations, and practice activities extending learning after each lesson. The purpose of this study was to investigate student perceptions of their learning outcomes from an active-learning structured course. That is, what impact does a course design with pre-assignment tasks, authentic problem solving through collaboration in class, and practice assignments after lessons have on diverse student populations in a quantitative reasoning course?

Keywords: quantitative reasoning, Post-secondary education, active-learning, collaborative learning, critical reflection, undergraduate mathematics

1. Introduction of the Active-learning Curriculum

The study was based on the course – Quantitative Reasoning. We adopted the textbook - *Quantitative Reasoning* (2016) for this course. The textbook was available as an In-Class Notebook and students had access to the pre-class and post-class activities online. The pre-class activities were provided for students to do before each class and introduce the context of the in-class work. For example, students were given a set of 10 quiz scores for a sample student that were erratic. Students were then provided with step-by-step directions of averaging three scores at a time to introduce the idea of moving averages. This prepared students for the context of their in-class exploration and in-class activity that extended to creating weighted moving averages for a similar set of quizzes and for a future mini-project on mean household income over time in the United States. Another pre-assignment presents students with a rabbit population growth example, that is attributed to a puzzle posed by Fibonacci. In this pre-class assignment students create a time-series model of population growth over time setting the stage for the class investigation discovering what characterizes exponential growth. Basically, the pre-class work allows students to engage in relevant real contexts that will be used in class, as well as activating pre-knowledge for the mathematical content to be explored in class.

The in-class activities engaged students in solving real life problems. In example, students were asked to collect data on their daily water consumption for 10 days and then used dot plots of class population (all students' 10 days of water consumption data) and means of each student's consumption to study the central limit theorem and standard deviation. In another activity, students were provided several scenarios and then based on the conditions given worked to determine which job offer he/she should take. These sample activities are shown below. In-class work activities are done collaboratively through small group discussion.

1. Sample of asking the students to collect data for analysis.

   Collect your data on daily water consumption for the next 10 days on the Daily Water Consumption Data Recording Table below. You will need this information for a later lesson.

Daily Water Consumption Data Recording Table

Day	1	2	3	4	5	6	7	8	9	10
Number of cups of water consumed per day										

2. You have been offered three full-time jobs, each in different cities and with different salaries. Other than salary and city, the job responsibilities are exactly the same.
    1) The first job offers an annual salary of $65,000 and is in Austin, TX.
    2) The second job offers an annual salary of $60,000 and is in Big Rapids, MI.
    3) The third job offers an annual salary of $100,000 and is in Thousand Oaks, CA.

How would you decide which job to accept?

Background Information: In this lesson, we focus on the purchasing power of the dollars in. each city, rather than other factors (such as climate, proximity to family, etc.) that could impact the decision about. accepting the job.

After-class activities provide practice and extension to mathematical concepts explored in class. In example, students are presented with population data and determine whether the set should be modeled exponentially or logistically by the patterns found in percentage growth. Later students work with data that has populations of species interacting (predator/prey) that are modeled periodically and in the after-class assignments work to determine conclusions about populations as parameters change.

2. Research Perspectives

Research has reached a consensus that an active learning approach is a much more effective teaching strategy than a traditional way of teacher-centered lecture (e.g., Deslauriers, Schelew, & Wieman, 2011; Freeman et al., 2014; Kogan & Laursen, 2014; Deslauriers et al, 2019; Ribeiro-Silva et al., 2022). Active learning benefits students' learning from numerous perspectives including: motivating students to learn (Harmin, 1996; Lugosi & Uribe, 2022), creating a learning community (Boyer, 2002), stimulating students' thinking (Anthony, 1996; Vogel, 2005), promoting collaborative learning (Artzt & Newman, 1997), constructing ability of communicating mathematical ideas (National Research Council, 2000; Sammons, 2018), recognizing the ownership of learning (Mikalayeva, 2015), learning with understanding (Anthony, 1996; Carvalho & West, 2011), and building confident and with a positive attitude (Dogan, 2012).

3. The Existing Issues

Although existing research in the literature indicate that active learning approaches such as inquiry-based learning and problem-based learning have positive impact on students' learning, traditional lecture still dominates school teaching and learning overall (Liang, 2019). Both teachers and students face challenges in an active learning classroom. Historically, most of us grew up learning through teachers' lectures. Teachers who are used to having total control of class when giving a traditional lecture, may feel like they are losing control of the classroom and may not be comfortable when giving the floor to students, specifically when many unexpected questions are raised by students in discussions. Additionally, students who always passively listen to what a teacher told them to do in traditional classrooms, may perceive that a teacher who lets students teach themselves is not teaching appropriately when being encouraged to do mathematics or discuss with peers. In teaching evaluations, it was not uncommon that students commented that the teacher is lazy or the teacher hates teaching when a teacher implements an active learning approach (Liang, 2019). A recent study found that students in an active learning classroom assessed their learning lower than their peers did in a traditional classroom even though the active-learning class students indeed learned more than the students in the traditional classroom (Deslauriers et al., 2019). On the one hand, active learning has a significant positive impact on students' learning; on the other hand, less effective traditional way of teaching still dominates the school teaching. Misperceptions on active learning have been hindering the implementation in teaching practice.

4. The Research Question

In the research field, there exists a gap between the theory of active learning and the effective practice of active learning, especially in post-secondary education. The purpose of this study was to bridge theory and practice through analyzing students' reflections on their learning and our observations as instructors, while teaching the quantitative reasoning course for college liberal arts students utilizing an active learning approach. What we have learned from the implementation of an active learning approach will not only help us improve and develop better practice strategies for ourselves, but also provide new knowledge for better implementation of active learning in college mathematics teaching. Through this study we want to address the following research question: How does an active structured mathematics course affect students' learning experience and outcomes based on their self-reported reflections?

5. Theoretical Framework

Human beings learn from reflecting on what they have done. According to Dewey (1933), it is not experiencing itself but reflective thinking on experience that generates learning. Teachers learn how to improve teaching by constantly reflecting on their teaching practice. We learn how to improve mathematics education using our collective wisdom generated from critical reflections. Critical reflection is a high level of the reflective thinking process to look for the meaning of experience. This process involves assessing, inquiring, analyzing, synthesizing, and making connections between related factors (Ash & Clayton, 2009; Brookfield, 2017; Dewey, 1933, 1963; McKnight, 2002; Ryan & Cooper, 2000). Through this intellectual process, we add depth and width to our understanding of some phenomenon we experienced or observed; and we change intrinsically for the better. David Kolb, in 1984, developed a holistic model of the experiential learning cycle taking the original intellectual experiential work from educational theorists such as Piaget and Dewey. Kolb's model demonstrates the learning process cycle, starting with a concrete experience, followed by reflective observation, abstract conceptualization, active experimentation, and finally back to the starting point (Kolb, 1984; Kolb & Kolb, 2013). We adapted Kolb's learning cycle to frame this study (please see the framework diagram). The study process involved the cycle of collecting data from teaching, reflecting critically on the collected data, generating new knowledge on teaching practice. We collected the students' reflections from the four sections of the course and then the two authors reflected critically on the collected student reflections to generate the emerging findings for related new knowledge. The process of critical reflection involved systematic coding, peer check, and verification of the common themes.

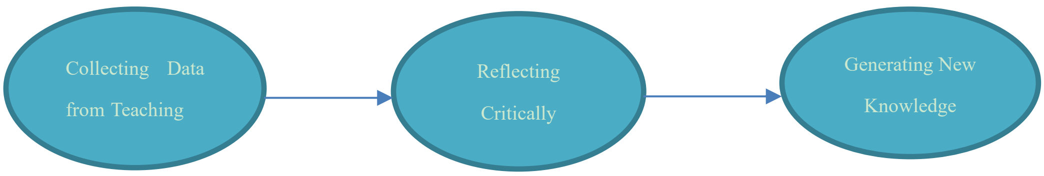

Figure 1. The Framework Diagram

6. Research Methodology

Qualitative methods are more appropriate for a more rich-descriptive study. This study describes the results of analyzing the students' end-semester reflections following qualitative research process. The students' reflections were collected from a quantitative reasoning course. The two researchers are the two instructors of this course. The students enrolled in four sections (Sections 1, 2, 3, and 7 in table below) were invited to participate in this study and 52 students submitted the reflections on their learning at the end of semester with student success data from all 149 students enrolled reported. The reflection protocol (See the Appendix) was provided for students to follow as a guide in order to remind them of the focus in their reflections. In the protocol, students were told that they should include but was not limited to the eleven protocol questions. 5 extra credit points were awarded to add the final exam scores for the students to submit their reflections. The final exam carried 20% of the final course grade.

The collected reflections were coded by the two researchers separately at first and then discussed to verify the common themes discovered by them. The study generates the findings based on the researchers' critically reflecting on students' reflections and overall students' course success.

7. Findings/Results

The passing rate for the sections that participated in this study was better than the traditional College Algebra courses which had a 27% DFW (Drop, Fail, Withdraw) rate in the same semester. All sections for this study ranged from 90%-100% of students gaining credit for the course except one subsection that had 16 out of 20 students successfully gain credit. Additionally, three sections had students who were co-enrolled (B*sections) in a support class due to not being college ready and those subsections had an average pass rate of 90%. The table below shows the course success in detail.

Table 1. Course Success Data

Section (*indicates not college ready, co-enrolled)	Total students (gradable)	Students with B or higher	Total students gained credit for course	Percentage passing	Percent B or higher
1A	24	17	22	92%	71%
1B*	13	9	13	100%	69%
2A	23	10	21	91%	43%
2B*	20	6	16	80%	30%
3A	17	8	16	94%	47%
3B*	17	9	17	100%	53%
7A	35	26	32	91%	74%

Analysis of student reflection data revealed that the course had positive impacts on students' mathematical learning and their personal growth, including:

- *Changing students' perceptions on mathematics from negative to positive.*

  Almost every student in their reflection mentioned that math was a subject they disliked. because previous math courses were not relevant to them, but this course allowed them to see that mathematics is relevant to their everyday life. Quoting the example comments: "This course has changed my attitude about learning math by making it more interesting and easy to understand. I never felt as what I was learning was difficult or pointless. I was always excited to learn in this course and I have never felt that in any other math class. Math has always been a subject I tend to dread learning about, but this semester has changed my feelings about the subject. After taking this course I now feel excited to learn about similar topics like the ones in our in class notes, they were all very unique and I wonder what other topics involve math."

- *Learning the content with understanding.*

  One student wrote: "I think I actually learned the concepts rather than memorize to do something for the exam and forgot it afterwards." Another student wrote: "Each new chapter had preliminary questions that related to real world situations which introduced us to the new math concept we would be learning. I think that learning a real-world situation that I could understand before actually learning the math concept aided my learning significantly."

- *Learning how to learn (manage time wisely; use all available resources).*

  Quoting the example comments: "Some important lessons that I learned in Quantitative Reasoning are organization, time management and the importance of self-teaching".

- *Learning technology (Excel).*

  Quoting the example comments: "It was great to learn new things in excel while also using the real-world applications of math. That was probably the most helpful aspect of the class, my knowledge for working excel has greatly improved."

- *Engaging more in learning inside and outside the classes.*

  Students appreciated the preview assignments before each class. One example is: "The preview assignments helped me in the class due to the fact that I already knew what was going to be discussed in the class beforehand, allowing myself being more prepared for the specific class." Many students mentioned that they engaged in classes more actively than before. Quoting the example comments here: "I feel like due to this learning environment; I was more eager to pay attention in class and excited to learn new subjects presented to us with each different chapter".

- *Gaining confidence.*

  Quoting the example comments here: "A huge take-away that I have is a lot more confidence in myself and confidence in using math. A lot of this confidence has stemmed from the amount of practice this course gives you, and the format of the learning in class."; "I am fairly confident in my ability to do math after taking this course and am looking forward to doing this kind of math later in life".

- *Learning from one another in groups.*

> Students appreciated collaborating with their peers in class. Quoting one example comment: "During class we typically work in small groups to work through the lesson. This format allows for a lot of great learning and problem solving……This, along with the students working together, allowed for a very successful learning environment that I feel helped the students thrive."

8. Conclusion

"Students' success in college is greatly influenced by the mathematics they learn, how they learn it, and how they see themselves as a learner and doer of mathematics" (Hartzler and Blair (Eds.), 2019, p. 102). The way how we engage our student in learning mathematics is crucial for improving their learning experience and outcomes. Utilizing non-traditional learning models such as active learning "promotes discussion of mathematics between students and teachers and among students themselves, all the while applying mathematics to real world situations" (Vega, 2011, p.11). Based on students' reflection on their learning from the course, and our own reflection on teaching the course, we have learned that it is necessary to support students' learning by a consistent, well-structured course design that engages students in learning both inside and outside classroom. Only inside-class engagement is not enough for a better learning outcome. Relevant content, active engagement inside and outside classroom, and learning support make a better math learning experience for math-struggling students. The course involved students with relevant content and multi-dimensional engagement through pre-class preview assignments, in-class activities, after-class practice assignments, mini-projects, and attending tutoring sessions. In students' reflections, many students mentioned that the course was structured in a way that they were forced to engage in learning inside and outside classroom and they learned to be responsible for their own learning. Students seemed to believe that the structure of the course helped them not only learn better but also learn how to learn and form good study habits. Although this study focused on how an active structured mathematics course affected students' learning experience and outcomes, the findings can be applied to other STEM or non-STEM disciplines.

9. Limitation of the Study

This preliminary study report has limitations, that is, the sample size was small, and the instructors are also the researchers. We will continue collecting data and recruit more students enrolled in this course from other instructors' sections in the future. A longitudinal study will be conducted to help us see a more complete picture and generate new knowledge about the impact of an active structured course on student learning outcomes at the post-secondary level.

Appendix

Course Reflection Protocol

Write a 2-page reflection on your learning from MAT 1043. The paper should be formatted as line space 1.5, Times New Roman, and font size 11. Your reflection can include but is not limited to:

1. What is your important take-aways and why? Be specific.
2. How did the preview assignments affect your learning? Be specific.
3. How did the class activities affect your learning? Be specific
4. How do you like the course content? Give an example or two.
5. How do you think the course content is relevant to your everyday life?
6. Has this course changed your attitude about learning mathematics? In what way?
7. Do you think the content of this course will be useful for your future? Why?
8. How could this course be improved to help you learn better?
9. Do you feel you actively engaged in learning when taking the course and why?
10. Do you think you learned a lot or very little? Give your reason.
11. Do you think you gained confidence in learning math? Give your reason.

You will earn extra credit for turning in your course reflection (5 points will be added to your final exam).

References

Anthony, G. (1996). Active learning in a constructivist framework. *Educational Studies in Mathematics*, *31*(4), 349-369. https://doi.org/10.1007/BF00369153

Artzt, A. F., & Newman, C. M. (1997). *How to use cooperative learning in the mathematics class* (2nd ed.). National Council of Teachers of Mathematics.

Ash, S. L., & Clayton, P. H. (2009). Generating, deepening, and documenting learning: The power of critical reflection in applied learning. *Journal of Applied Learning in Higher Education*, *1*, 25. https://doi.org/10.57186/jalhe_2009_v1a2p25-48

Boyer, K. R. (2002). Using active learning strategies to motivate students. *Mathematics Teaching in the Middle School*, *8*(1), 48-51. https://doi.org/10.5951/MTMS.8.1.0048

Brookfield, S. (2017). *Becoming a critically reflective teacher* (Second edition. ed.). Jossey-Bass.

Carvalho, H., & West, C. A. (2011). Voluntary participation in an active learning exercise leads to a better understanding of physiology. *Advances in Physiology Education*, *35*(1), 53-58. https://doi.org/10.1152/advan.00011.2010

Deslauriers, L., McCarty, L. S., Miller, K., Callaghan, K., & Kestin, G. (2019). Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences*, *116*(39), 19251. https://doi.org/10.1073/pnas.1821936116

Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science*, *332*(6031), 862-864. https://doi.org/10.1126/science.1201783

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. D. C. Heath and company.

Dewey, J. (1963). *Experience and education*. Collier Books.

Dogan, H. (2012). Emotion, confidence, perception and expectation case of mathematics. *International Journal of Science and Mathematics Education*, *10*(1), 49-69. https://doi.org/10.1007/s10763-011-9277-0

Emerging issues in mathematics pathways: Case studies, scans of the field, and recommendations. (2019). (R. Hartzler & R. Blair, Eds.). Charles A. Dana Center at The University of Texas at Austin.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410. https://doi.org/10.1073/pnas.1319030111

Harmin, M. (1996). *Strategies to inspire active learning: Complete handbook*. Christopher-Gordon Pub.

Kogan, M., & Laursen, S. L. (2014). Assessing long-term effects of inquiry-based learning: A case study from college mathematics. *Innovative higher education*, *39*(3), 183-199. https://doi.org/10.1007/s10755-013-9269-9

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Kolb, D. A., & Kolb, A. Y. (2013). *The Kolb learning style inventory 4.0: Guide to theory, psychometrics, research & applications*. Experience Based Learning Systems, Inc.

Liang, S. (2019). Inquiry-based learning in college mathematics education: Theory and practice. The Mathematics Education for the Future Project.

Lugosi, E., & Uribe, G. (2022). Active learning strategies with positive effects on students' achievements in undergraduate mathematics education. *International journal of mathematical education in science and technology*, *53*(2), 403-424. https://doi.org/10.1080/0020739X.2020.1773555

Mathematical Association of America, & National Council of Teachers of Mathematics. (2012). *Calculus: A joint position statement of the Mathematical Association of America and the National Council of Teachers of Mathematics*. https://www.nctm.org/uploadedFiles/Standards_and_Positions/Position_Statements/Calculus%20MAA%20NCTM%20Joint%20Statement.pdf

Mathematical Association of America. (2004). *Undergraduate programs and courses in the mathematical sciences: CUPM curriculum guide 2004*. Mathematical Association of America.

McKnight, D. (2002). *Field experience handbook: A guide for the teacher intern and mentor teacher*. College Park.

Mikalayeva, L. (2015). Motivation, ownership, and the role of the instructor in active learning. *International Studies Perspectives*, *17*(2), 214-229. https://doi.org/10.1093/isp/ekv001

National Research Council. (2000). *How people learn: Brain, mind, experience, and school* (J. D. Bransford, A. L. Brown, & R. R. Cocking, Eds.). National Academy Press.

Quantitative Reasoning. (2016). Charles A. Dana Center. www.utdanacenter.org

Ribeiro-Silva, E., Amorim, C., Aparicio-Herguedas, J. L., & Batista, P. (2022). Trends of active learning in higher education and students' well-being: A literature review. *Frontiers in psychology*, *13,* 844236-844236. https://doi.org/10.3389/fpsyg.2022.844236

Ryan, K., & Cooper, J. M. (2000). *Those who can, teach* (9th ed.). Houghton Mifflin Co.

Sammons, L. (2018). *Teaching students to communicate mathematically*. Association for Supervision & Curriculum Development. http://ebookcentral.proquest.com/lib/utsa/detail.action?docID=5343204

Vega, T., & Travis, B. (2011). An investigation of the effectiveness of reform mathematics curricula analyzed by ethnicity, socio-economic status, and limited English proficiency. *Mathematics and computer education*, *45*(2), 10.

Vogel, R. (2005). Patterns--a fundamental idea of mathematical thinking and learning. *ZDM : The International Journal on Mathematics Education*, *37*(5), 445. https://doi.org/10.1007/s11858-005-0035-z