Instructors' Use of Student Projects in Postsecondary Quantitative Reasoning Courses in Ohio

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Student projects in a postsecondary Quantitative Reasoning (QR) course can encourage students to think deeply about connections between a real-world situation and the corresponding mathematical or statistical model. These projects can help students collaborate and improve their 21st-century skills, such as critical thinking and oral and written communication. This paper reports how 13 QR instructors across two studies at 11 public postsecondary institutions in Ohio implemented student projects. We analyzed the course syllabus for each participating instructor, conducted at least one semi-structured interview, and observed their teaching using six Instructional Quality Assessment rubrics. Data revealed substantial variation in the implementation of student projects, resulting in varying opportunities for student learning. Our findings indicate that student projects are a critical variable in Quantitative Reasoning.

Keywords: Quantitative Reasoning, student projects, and project-based learning and assessment.

An entry-level postsecondary (gateway) QR course includes nontraditional mathematical goals for students (e.g., collaboration and oral and written communication using quantitative arguments) that aim to prepare them to solve problems in everyday and professional contexts (Mathematical Association of America [MAA], 1996; Stump, 2017). Policy documents and professional opinions call for methods of instruction and assessment that build the student QR competencies of interpretation, representation, calculation, analysis, assumptions, and communication (e.g., AAC&U, 2009; Boersma et al., 2011). They also emphasize the need for students to think deeply and critically about real-world phenomena and link them to relevant mathematics and statistics (Foley & Wachira, 2021).

QR instruction is relatively common to include projects requiring students to solve real-world problems and construct associated knowledge and skills (Lutsky, 2008; MAA, 1996). Learning via such projects provides constructivist and collaborative opportunities for students to grow academically and nonacademically (Harwood, 2018; Virtue & Hinnant-Crawford, 2019). Traditional mathematics assessments—quizzes, tests, and exams—do not address students' engagement in and learning through the projects and typically do not emphasize bona fide real-world problem-solving, collaboration, or communication. Professionals, including Virtue and Hinnant-Crawford, argue that students' learning in a nontraditional course that relies on projects can only be appropriately assessed through their engagement in similar opportunities, that is, project-based assessment.

Student Projects in Quantitative Reasoning

Project-based learning (PBL) and project-based assessment (PBA) address issues related to implementing several formative assessment strategies in mathematics courses, which may be challenging to implement in a typical mathematics course (Chanpet et al., 2020). PBL and PBA tasks include several nontraditional instructional and assessment tools, such as observation, performance tasks, portfolios, presentations, taxonomies of experts, reflection writing, and peer- and self-assessment in different contexts (Noonan & Duncan, 2005; Tal et al., 2000). These tools also allow students to enhance and demonstrate their understanding of mathematical relationships in several real-world phenomena.

Quantitative Reasoning courses and *project-based learning and assessment* (PBLA) share many things, including implementing real-world tasks to help students solve problems from their everyday contexts. Using rich tasks in projects for instruction and assessment in QR courses can help instructors understand a student's misconceptions and determine a student's learning gaps (Kish, 2017). QR and PBLA constitute a social constructivist approach requiring students' active engagement and critical inquiry into genuine phenomena. Students' coordination, collaboration, and communication are their essential components. Several recent studies have identified group projects as a critical variable for QR instruction and assessment (Budhathoki, 2022; Budhathoki et al., 2024; Foley et al., 2023). Therefore, PBLA can be instrumental in enhancing and assessing student learning in QR courses.

National and state-level recommendations (e.g., Leitzel, 2014; MAA, 1996) emphasize active student engagement and the critical inquiry of real-world phenomena. However, little or nothing is said about assessing student learning or using projects. Moreover, most gateway mathematics instructors lack experience using projects in their teaching. QR instructors in Ohio (the research contexts reported in this paper) and at the national level often say their unawareness about the types of projects to select, the number of projects to implement during a semester, ways to engage students in a project, and learning outcomes to focus on through such projects. Consequently, there are varied QR instructional and assessment practices in Ohio.

This paper reports the combined findings of two studies conducted to explore the formative assessment practices of QR instructors in Ohio public postsecondary institutions; the first was a pilot study, and the second a dissertation study. However, this paper focuses on reporting only QR instructors' implementation of student projects. The findings reported here may be significant to novice and experienced instructors who strive to implement projects in their QR teaching and similar other freshman-level mathematics courses.

Multiple Case Study and Cross-Case Analyses

The Ohio Department of Higher Education (ODHE) created common student learning outcomes and transferability across its 36 public community colleges and universities for all gateway mathematics courses, including QR (ODHE, 2015). Foley and Wachira (2021) and Leitzel (2014) have touted QR as the most appropriate gateway mathematics course for non-STEM majors. To earn transferability, the ODHE (2015) requires that critical thinking be the centerpiece of QR, that a QR course develops the competencies of interpretation, representation, calculation, analysis, assumptions, and communication, and that a QR course focuses on three main content areas: numeracy, probability and statistics, and mathematical modeling. However, the ODHE (2015) does not specify how to assess students' achievement of such learning outcomes. However, this is a part of the process for a given institution to have its QR course certified to be transferable across the state.

The researcher employed a multiple case study in both examinations. He defined a case in the pilot study as an instructor who taught at least one section of QR courses in public postsecondary institutions in Ohio during data collection, which he narrowed to the instructor teaching at least one section of Ohio Transfer 36-approved QR courses for the dissertation study. The researcher employed a purposeful selection of cases to recruit 6 instructors (3 male and 3 female) from 2 universities and 3 two-year colleges during the Spring of 2020 for the pilot study and 8 instructors (2 male and 6 female) from 3 universities and 5 two-year colleges during the Summer and Fall of 2021. However, 1 female instructor from a two-year college dropped off from continuing her participation, still giving consent to use the data thus far. Also, 1 male instructor from a two-year college participated in both studies, totaling 13 QR instructors from 11 public postsecondary institutions in Ohio. The instructors had a wide range of positions and experience; they ranged from graduate students to full professors. Their experiences in QR teaching ranged between one semester and six years. Also, some of them were working as course coordinators at their institutions.

The researcher conducted one qualitative interview with each instructor and analyzed their course syllabus in the pilot study. However, he conducted at least two virtual or in-person interviews for the dissertation study, analyzed course documents including course syllabus and teachers' artifacts, and observed two consecutive classes using 6 IQA rubrics (a) *Rigor of teachers' questions*, (b) *Accountable talk*, (c) *Clarity and detail of expectations*, (d) *Communications of expectations*, (e) *Teachers' press,* and (f) *Students providing* (Boston, 2019).

The data reported in this paper mainly include that obtained from the instructors' course syllabi analyses. The researcher categorized the instructors' project-related data into several categories, like the number of projects implemented during a semester, weights to the total course grade that instructors provided for projects and associated presentations, the content domains covered through the projects, whether the projects were individual or group assignments and the time they assigned the projects to students. The researcher transcribed the verbal data for the interview data and created codes using value coding focusing on the instructors' intrapersonal and interpersonal perceptions and experiences in implementing projects in this course (Saldana, 2016). Then, he developed themes by merging similar and related codes. He used the cross-case analysis technique to explore commonalities and differences in the instructors' actions, activities, and processes regarding project implementation (Stake, 2006).

Results and Discussions

The data analyses revealed exciting information about the instructors' use of student projects in teaching QR. Though all 13 instructors included projects in their course syllabi, they had mixed perceptions about using projects and associated presentations in this course. They also had a great deal of variation in their types, the number of projects, and how to implement them. Table 1 and Table 2 represent information obtained from the analysis of the course syllabi from the pilot study and the dissertation study, respectively. Both tables consist of the instructors' plans

Table 1: Use of Student Projects by Instructors in the Pilot Study

Instructors	Number of Projects	Weights for Projects	Content Domains	Individual or Group	Time of Implementation
Amanda	3	45%	Financial literacy Statistics Modeling	Group	One at each third of the semester
Cole	1	10%	Media literacy	Individual	The second half of the semester
Dani	3	40%	Business math Statistics Modeling	Group	One at each third of the semester
Evan	1	10%	Statistics	Individual	End of the semester
Fawn	1	4%	Comprehensive	Group	End of the semester
Zach	1	10%	Media literacy	Individual	The second half of the semester

for implementing projects, including the frequency of the projects; weights given to projects to determine student grades; content domains emphasized through the projects; nature of the projects; and the implementation time. Zach is included on both tables as he participated in both studies. Still, Zach had different project implementations during the two semesters of his participation; an increment in his number of projects and associated weights to the course grades may indicate QR instructors' increasing use of student projects in public postsecondary institutions in Ohio.

Wide Range of Number, Weights, and Time of Implementation

The instructors provided a wide range of importance to student projects and associated presentations in their course syllabi. The weights of student projects and presentations to the total course grades ranged between 4% and 75% through 1 to 8 projects a semester; the average number of projects a semester was 13, with an average weightage of 33%. However, as discussed above, this data may change based on their implementation; in his dissertation study, the researcher discovered that the average weight for student projects based on the 8 instructors' implementation decreased from 28.8% of total course grades to 27%, but with an increase in student presentation weights, from 12% to 15%. Out of 13 instructors reported in this study, 2 instructors (Evan & Fawn) provided a little weight to their projects to determine the course grades; they employed only one project during the semester and, like a traditional homework problem, required students to solve the given problems with the provided information. On the contrary, the other 2 instructors (Julie & Kande) used 8 and 6 projects in a semester, offering 40% and 75% weights to the total course grades. Still, these two instructors also implemented their projects like a traditional homework problem, emphasizing students' abilities to solve the problem, not the QR competencies like interpretation, representation, analysis, assumptions, and explanation. These 4 instructors did not have firm beliefs about using student projects in this

Table 2: Use of Student Projects by the Instructors in the Dissertation Study

Instructors	Number of Projects	Weights for Projects	Content Domains	Individual or Group	Time of Implementation
Ashley	1	30%	Student choice	Group	Over the semester
Clara	3	40%	Personal finance, Statistical modeling	Group	One at each third of the semester
Gordon	2	30%	Financial Literacy, Statistical modeling	Group	One in each half of the semester
Julie	8	40%	Recent topics	Individual	Every other week.
Kande	6	75%	Recently topics	Individual	Every other week
Susan	4	50%	Numeracy, Statistics, Modeling, Comprehensive	Group	One in about a month.
Yara	4	60%	Financial literacy, Statistics, Media literacy, Modeling	Two individual, two group	One in about a month.
Zach	2	20%	Media literacy, Personal Finance	Individual	One in each half of the semester.

course, but they had to put them in their syllabi as the Ohio Department of Higher Education required. However, some instructors heavily relied on student projects to determine course grades even though they did not have much weight on student projects. For example, Ashley and Susan from the dissertation study heavily relied on student projects. Though they had exams and quizzes in their course syllabi, they implemented such assignments as open, take-home group projects. They stated that they had to put exams and quizzes in their course syllabi as the mathematics departments in their institutions were traditionally required and required them to use exams and quizzes at least in some manner.

The instructors also had variations in the time they implemented the student projects, mainly depending on the number of projects during the semester. The instructors using multiple student projects generally divided the whole semester duration by their number of projects and used the results as the duration for each project. However, Evan and Fawn implemented their only one project at the end of the semester, like a test for a content domain or comprehensive exam. It is worth restating that these two instructors did not rely much on student projects. Likewise, though Julie and Kande implemented one project every other week, they used their projects as different names for their unit homework.

Content Domains

Even though the 13 instructors had variations in the number of, weights to, and time of implementation of their student projects, they had some commonalities in the content domains their projects covered. Notably, only 9 of the 13 instructors required students to work on any given quantitative situation, identify the available quantitative information, choose appropriate mathematical processes to solve the problems, make necessary assumptions, and derive conclusions. They provided open-ended quantitative situations, embracing the three content domains the Ohio Department of Higher Education suggested—*numeracy*, *probability and statistics*, and *mathematical modeling.* Their practices embrace all or any of the six QR competencies—*interpretation, representation, calculation, analysis, assumptions,* and *explanation* in the projects. The commonalities in content domains were more among the instructors who used more than one project during a semester. Notably, 7 instructors used more than one project during a semester, excluding the two who claimed to implement projects in each content domain. They all assigned a project in numeracy, budgeting, or personal finance. The statistical project was another popular choice; 6 of 7 instructors assigned multiple projects and 1 assigned only one project implemented statistical projects, requiring students to calculate and reason with statistics.

Similarly, 4 among the 13 instructors assigned mathematical modeling projects to students. In addition, 4 instructors included media literacy in their projects. In addition, 2 instructors, who had only one project, either let students choose any project they found interesting or provided a comprehensive worksheet; they also had chances to highlight some or all of the content domains discussed above.

The other 4 instructors, who implemented their projects like a traditional worksheet problem, generally emphasized students' ability to use recently learned mathematical knowledge and skills to solve problems. They usually provided all the required information, suggested appropriate mathematical steps, and required students to calculate answers. Their practices mainly emphasized 3 of 6 QR competencies—*interpretation, representation, and calculation.*

Collaboration and Communication

The majority of the 13 QR instructors emphasized student collaboration through their projects. Notably, 8 of the 13 instructors assigned some or all projects in groups and emphasized that students work together to understand quantitative situations, collect data, prepare reports, and present findings and conclusions. The instructors used various innovative approaches to ensure collaboration among students. Some instructors collected effort grade forms from each to determine how the team members contributed to the projects. Likewise, some required each member to submit individual reports, reserving rights to grade only one paper per group and assign grades to the whole group.

All QR instructors required students to submit a written report from their projects, but only 7 incorporated oral presentations. Depending on the nature of their projects, the instructors required students to prepare a detailed report individually or in a group or submit the worksheet. However, Cole and Zach needed students to prepare a report, develop QR activities out of their media literacy projects, and exchange with peers to seek mutual feedback.

The instructors' student presentation implementation was closely related to the nature of their projects, group or individual. Seven instructors implemented student presentations, and they all assigned group projects. Only the instructor who implemented group projects but not student presentations was the one who did not believe much in student projects. Still, there was a significant variation in the instructors' implementation of student presentations. While other instructors required students to present their project findings and conclusions, Gordan allowed students to present any interesting quantitative context. The four instructors who did not require students to present included the 4 instructors using their projects as worksheet problems and the 2 instructors from the same two-year college, Cole and Zach. Many of these 6 instructors argued that adding a presentation would add anxiety to students. They stated that students in QR courses often have low confidence in their mathematical abilities, and requiring them to present on a mathematical topic may adversely affect their learning.

Group Projects as a Critical Variable for Formative Assessment in QR

The dissertation study discovered group projects as a critical variable for formative assessment in Quantitative Reasoning courses. The 8 instructors in this study generally relied on group projects for students' learning with collaborative and collective endeavor; their average weight for group projects was 20.5%, which was 56.5% of their average collaborative assessments. They also had a strong positive association between collaborative assessments and group projects, $r = .87$. Five (5) of the 8 instructors used group projects, highlighting students' holistic development and ability to use the mathematical content in real-world problems through their group projects. They mostly used open-ended, ill-defined, and high cognitively demanding tasks in their group projects, emphasizing the reasoning competencies of QR, like analysis, assumption, and communication. They mostly gave less instruction and support and sought students' collaboration and communication to accomplish the projects. The group projects also had a close connection with student presentations. Only the instructors who assigned group projects required their students to present the findings and conclusions of the projects.

Group projects were also associated with the instructors' formative assessment strategies. Only the instructors using group projects asked a series of checking and advancing questions to check students' understanding, seek clarification, connect ideas, and further their learning and understanding, usually in a whole class setting. Likewise, only such instructors had sophisticated feedback practices; they provided formative feedback while students worked on their group projects and in-class activities, emphasizing clarifying students' misconceptions, furthering understanding, and fostering self-esteem and confidence. Likewise, the instructors generally orchestrated students' peer- and self-assessment only in the group projects and presentations. The peer- and self-assessment also highlighted the students' collaboration, communication, and reflective understanding abilities.

The group projects also connected to the instructors' scores in the IQA rubrics. Instructors who employed group projects scored higher than those who used only individual projects. For the 7 instructors in the dissertation study, the average score on the 6 IQA rubrics was 3.08 out of a possible 4, with at least 3 in each rubric, but the Accountable Talk. This study also suggested collaboration and communication as the premise and results for the group projects.

Conclusions

A Quantitative Reasoning course aims to develop students' quantitative and reasoning abilities to solve problems in their everyday and professional contexts. A typical QR instruction uses projects that include real-world tasks and performs as constructive and collaborative platforms where students work individually or in groups to foster their QR competencies. Therefore, many professional communities and policy documents explicitly or implicitly suggest instructors use projects as both instruction and assessment in QR courses.

Quantitative Reasoning instructors in public postsecondary institutions in Ohio greatly varied their plans for and implementation of student projects. They mainly varied in the number of projects they used in a semester, associated weights to determine course grades, the content domains covered by the projects, and the implementation, individual or in groups. There were significant differences among the instructors who used one project versus multiple projects in the semester. Likewise, in implementation, the instructors varied when they assigned student projects, the nature of such projects, opportunities for students to collaborate while working on projects, instructors and peer feedback practices, and the learning competencies emphasized through the projects. The instructors' student presentation and formative assessment practices mainly depend on the nature of their projects; only the instructors who employed group projects required students to present their findings and conclusions. The instructors' variations in their project implementation provided different learning opportunities for their students. Such variations may challenge the transferability of this course. Ten among 11 institutions represented here offered the *Ohio Transfer-36* approved QR courses. However, the instructors mostly used fermi projects, mainly covering the three content domains the state authority suggested–*numeracy, probability and statistics,* and *mathematical modeling.*

The discussion in this paper restated several findings of the first researcher's dissertation study: (i) a great deal of variation in QR instructors' use of student projects in public institutions in Ohio, (ii) group projects as a critical variable for formative assessment in QR. The group projects, supported by instructor autonomy, create opportunities for students to solve real-world problems, fostering their six QR competencies—*interpretation, representation, calculation, analysis, assumption,* and *communication* (AAC&U, 2009; Boersma et al. 2011), and (iii) collaboration and communication as the premise for and results from the group projects.

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