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The effect of student engagement strategies in online instruction for data management skills

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Abstract

Evaluating the effectiveness of teaching methods for synchronous online instruction is integral to fostering student engagement and maximizing student learning, particularly in one-time workshops or seminars. Using the lens of social constructivism theory, this study investigated the effect of different approaches of synchronous online instruction on the development of graduate students' research data management (RDM) skills during the post-pandemic era. One experimental group received teacher-centered instruction primarily via lecture and the second experimental group received student-centered instruction with active learning activities. A one-way ANCOVA was used to compare the post-test RDM scores between one control group and the two experimental groups, while controlling for the impact of their pre-test RDM scores. Both experimental groups who received online RDM instruction scored higher than participants from the control group who received no instruction. Additionally, our results indicated that learners who were exposed to more engaged and collaborative instruction demonstrated higher learning outcomes than students who received teacher-centered instruction. These findings suggest that interactive teaching that actively engages the audience is essential for successful synchronous online learning. Simply transferring a lecture-based approach to online teaching will not result in optimal student engagement and learning. The interactive online instructional strategies used in this study (e.g., collective note-taking, Google Jamboard activities) can be applied to any instructional content to engage learners and enhance student learning.

Keywords Research data management · Online instruction · Social constructivism · Student-centered learning

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1 Introduction

Research data management (RDM) plays a crucial role in making all outcomes of research projects findable and reusable to share knowledge, to meet funding agencies' requirements, and to maintain transparency. RDM instruction is a central part of RDM services in academic libraries (Si et al., 2015). In order to prepare future generations of researchers, academic libraries need to extend their RDM instruction to the student population (Xu, Zhou, Kogut & Watts, 2022). A powerful RDM instruction program that combines current RDM best practices and standards to meet the target audience's needs is essential (Poole, 2015). As the demand for RDM instruction has increased, considerable numbers of academic librarians have acknowledged the importance of an appropriate combination of data management competencies and professional skills training (Goben & Nelson, 2018). Hence, during the past decade, academic libraries have expanded the scope of their RDM efforts and provided RDM-related training activities in various approaches including one-time workshops, seminar series, and/or credit courses (Xu, Zhou, Kogut & Watts, 2022). Each of these approaches to instruction involves various instructional formats and strategies.

Instructional technology supports instructors in providing extensive interaction between instructors and their students (Shank & Dewald, 2003; Edmunds et al., 2021). The rapid advancement of technologies provides instructors in academic libraries with options for providing online instruction to meet stakeholders' needs in learning RDM-related knowledge and skills. Research shows that online instructional delivery benefits students' learning to the same extent as traditional in-class instruction, and most learners are satisfied with online instruction (Germain et al., 2000; Nichols et al., 2003). However, different formats of online instruction might lead to different effects due to the use of different online instructional strategies. For example, instructors in the teacher-centered online instruction model function as presenters that tell information to the students, and students are expected to passively receive the knowledge being presented; while in the student-centered approach, teachers function like a facilitator so that learners are involved in more active and collaborative learning (Rogers & Freiberg, 1994). The student-centered approach focuses on meaningful inquiry and active, honest engagement (Rogers & Freiberg, 1994).

Although the academic library instruction literature has focused on providing online synchronous learning during and after the pandemic, little research has compared the effectiveness of instructional strategies for improving student learning and engagement. The aim of the present study was to investigate the impact of a synchronous online RDM workshop on graduate students' RDM skills improvement and to compare the changes in students' RDM knowledge and skills between two different online instructional conditions (teacher-centered vs. student-centered).

2 Theoretical framework & literature review

2.1 Social constructivism and collaborative learning theory

Social constructivism claims that people form meaning and understanding through the engagement of one another and their interactions with surroundings. Social constructivism is closely related to Vygotsky, Bruner, and Bandura's social cognitive theory (Kim, 2001). The social contexts that learners bring to their learning environment and the setting in which learning takes place are both important to social constructivists. Learning is seen as a social process (Kim, 2001). Meaningful learning occurs when individuals are engaged in social activities (McMahon & Zyngier, 2009).

Learning by active engagement is embedded in the Social Constructivism concept rooted in Vygotsky's (1978) work. Vygotsky's Zone of Proximal Development (1978) serves as the foundation for collaborative learning. It emphasizes that critical thinking skills must be developed collaboratively, and research suggests that group activities help students remember knowledge better. Peer-to-peer learning is a key component of the collaborative learning theory (Vygotsky, 1978), which promotes critical thinking in the classroom.

Collaborative participation helps learners construct understanding together that would not be possible alone (Greeno et al., 1996). Students engage in social learning activities that involve hands-on project-based methods and utilization of discipline-based cognitive tools (Gredler, 1997; Rosen & Salomon, 2007). Together they produce a product and, as a group, impose meaning on it through the social learning process. According to Vygotsky (1978), group learning aids in the development of students' leadership, self-management, oral communication, and higher-level cognitive abilities.

2.2 Online instruction in RDM

Online education has developed as an alternative to traditional face-to-face classroom instruction. Research points out that online instruction has been shown to increase the retention of information and is less time-consuming. Online instruction provides learners with flexibility in location and time, and it also provides instructors and students with flexibility in instructional delivery methods (Li & Akins, 2005). Research has emphasized that online instruction's unique dimensions and rewarding experiences do not always appear in traditional instructional delivery conditions (Conceição, 2006; Robertson et al., 2005). Many higher education institutions perceive online instruction as a promising approach to providing quality instruction (Crawford-Ferre & Wiest, 2012).

After the COVID-19 pandemic, school closures and in-person class cancellations were widespread at higher education institutions in the US. For example, a recent report showed that 41% of higher education institutions developed fully or primarily online instruction, and 20% used a hybrid model to respond to the COVID-19 global crisis in 2021 (College Crisis Initiative, n.d.). As technology has quickly developed, academic libraries have integrated educational technologies into the delivery of instruction. Academic librarians also shifted from providing traditional face-to-face instruction to providing online instruction due to the COVID-19 pandemic (Stimpson, 2020).

Researchers are increasingly expected to meet RDM requirements by funding agencies and journals. As a result, the need for RDM instruction in academic libraries has grown significantly in recent years (Xu, 2022). Online instruction is one way to provide quality instruction and meet the demand for RDM training. A study reported that, during the past decades, about 35% of RDM instruction in existing studies was provided in a traditional face-to-face format, whereas 28% of RDM instruction in current studies was provided in online or hybrid formats (Xu, Zhou, Kogut & Watts, 2022). This study also noted that there might be more RDM instruction provided in an online or hybrid format, especially under the circumstances of COVID-19 (Xu, Zhou, Kogut & Watts, 2022).

Literature shows that libraries are already providing RDM instruction synchronously and fully online (Read, Koos et al., 2019). For instance, in 2014 the University of Houston Libraries offered a workshop, which was open to all graduate and professional students on campus, in order to meet the need for graduate students' data management responsibilities and equip them for future academic careers (Peters & Vaughn, 2014). The participants' feedback indicated that they were satisfied overall with the online workshop but improvements for the future included less time for instruction and modifying the topics and materials to be more general for an audience from various discipline areas. Similarly, Read, Larson, et al., (2019) created web-based modules to develop researchers' skills in RDM. Modules addressed RDM best practices, resources and regulations, and the culture and practice in the biomedical research field. The online modules offered crucial context that allowed librarians to overcome the barriers between librarians and researchers. The audience expressed satisfaction with the instruction and demonstrated that the online modules positively affected their RDM knowledge and skills.

Moreover, academic libraries have successfully provided hybrid RDM instruction. For example, a study revealed how the librarians and researchers planned and implemented an RDM-related workshop during an ACRL 2015 pre-conference (Conrad et al., 2017). This seven-hour workshop combined face-to-face chunked lectures and follow-up webinars accompanied by interactive activities, such as panel discussions and a role-play activity. The workshop feedback showed that more robust RDM instruction on specific topics with shorter time lengths, such as webcasts, may seem counterintuitive but effective in meeting audience needs. Similarly, Verbakel and Grootverld (2016) reported a hybrid RDM course aimed at equipping participants with various skills and knowledge that would enable them to take the initial actions to help researchers in storing, managing, archiving and sharing their research data. Active online interactions among the students were embedded throughout the training. The online forum of this program led to lively discussions on various aspects of data management and helped students get different perspectives and approaches for receiving feedback from their coaches.

2.3 Comparisons of two teaching approaches for online RDM instruction

In the library instruction literature, few studies have compared the effectiveness of the teaching methods to increase engagement and student learning in synchronous online learning. Using a quasi-experimental design to compare student learning between a traditional face-to-face session and a synchronous online session, Lantzy (2016) found that both modes were effective in teaching the health information content. However, Lantzy (2016) looked only at the difference between online and in-person instruction, not at the level of teaching techniques. A systematic review examining graduate and professional library instruction concluded with a call to conduct more studies in hybrid and online instruction contexts with this population (Grabowsky & Weisbrod, 2020).

Student engagement refers to meaningful cognitive, behavioral, and emotional engagement throughout the learning environment (Fredricks et al., 2004). According to social constructivists, collaborative elaboration helps learners construct understanding together that would not be possible alone (Greeno et al., 1996). Synchronous online instruction, however, due to the shift to remote learning during the COVID-19 pandemic highlighted the issue of "Zoom fatigue." "Zoom fatigue" is the exhaustion that comes from engaging in videoconferences for multiple hours a day (Bailenson, 2021). Factors contributing to Zoom fatigue with online learning include an increase in distractions and multitasking, technology not working, lack of nonverbal communication, intermittent feedback from other participants, inability to see facial cues due to cameras being turned off, and constantly viewing oneself (Bailenson, 2021; Palmer et al., 2022; Peper et al., 2021). Therefore, online synchronous sessions require "an increased effort to maintain students' attention" (Fuller et al., 2021, p. 107) and more cognitive efforts to engage learners (Fauville et al., 2021). In other words, an increase in student engagement in online teaching is needed in order to remedy "Zoom fatigue" and improve student outcomes.

While "Zoom fatigue" is primarily caused by the complexity of the interpersonal interactions restrained in the typical spatial dynamics taking place in the virtual context (Nadler, 2020), certain instructional strategies can ease "Zoom fatigue" and promote student engagement in online synchronous learning. Compared with teacher-centered instruction, student-centered synchronous online instruction provides the instructor with the chance to promote discussions in the course and draw links between ideas with online activities and resources, without giving lengthy, text-based lectures (Acosta-Tello, 2015).

Research supports collaborative learning, such as collaborative note-taking, as a way to effectively engage students in classroom learning (Costley et al., 2022; Igel & Urquhart, 2012). For example, during online instruction, the use of chat, breakout rooms, and changing up classroom activities have been shown to increase students' engagement (Palmer et al., 2022; Toney et al., 2021). Yao et al. (2020) also showed that interactive teaching methods had a greater impact on student outcomes in the synchronous online teaching context during the COVID-19 pandemic, compared to students who only received online video modules. Meanwhile, utilizing Google products, especially Jamboard, was an effective method of interactive learning that boosted active student engagement in synchronous online teaching and learning during the COVID-19 pandemic (Ahshan, 2021). Additionally, a study found students were more engaged in online learning when they had their cameras on and that having cameras on did not increase fatigue (Kushlev & Epstein-Shuman, 2022).

Recent library instruction literature has focused on providing examples of online synchronous learning during the pandemic. For example, the use of Nearpod, an online application, to create an interactive lesson to increase participation with international students (Reed, 2022) and integration of the concept of "teaching presence" into instruction by using fillable PDF, chat, and keeping the instructor camera on (Budhai & Williams, 2021). However, Budhai & Williams (2021) measured student learning via a faculty survey, not directly from students. Using a flipped-classroom approach for evidence synthesis searching, during the synchronous online sessions, Fuller et al., (2021) used the chat feature to facilitate discussion, annotating slides, breakout rooms, and collaborating on a Google Document (Google Doc). While assessment using pre/post self-assessments and reflections showed students met the learning objectives and were satisfied with the online instruction, Fuller et al., (2021) did not report using statistical analysis to determine the effectiveness of the online instructional strategies.

As academic librarians and course instructors continue to teach online and utilize interactive teaching methods, choosing the most effective online teaching methods is essential. In particular, the effect of different synchronous online instructional strategies for learning RDM has not been fully explored. This present study contributes to this research gap by examining the effect of teacher-centered versus student-centered instructional methods on social science graduate students' understanding of RDM concepts in an online synchronous workshop.

3 Research question

For this study, we used different teaching methods during a synchronous online research data management workshop for graduate students in social sciences at an R1 public university. One experimental group received RDM instruction with a teacher-centered approach, using lectures; the second experimental group was taught with a student-centered, more interactive approach; and the control group received no RDM instruction. We aimed to examine the effectiveness of the different teaching methods on graduate students' acquisition of research data management skills. This study addressed the following research questions:

1. Is online RDM instruction effective in improving participants' RDM skills compared with the control group not receiving RDM instruction?
2. Is there a difference in RDM skills between the two different instructional approaches (teacher-centered vs. student-centered) in online instruction?

4 Methods

4.1 Curriculum design

This present study is a part of the Presidential Transformational Teaching grant project at Texas A&M University. Due to an abundant focus on RDM skills in STEM disciplines, this study centered on students in social science (Akers & Doty, 2013). We provided the social science graduate students basic RDM instruction through a 4-hour intensive training about RDM. The intervention was designed and attempted to cover the essential elements of the research data life cycle–from creating a data management plan to data sharing (Corti et al., 2019; Federer, 2016; Whyte & Tedds, 2011).

The intervention included four one-hour sessions covering different RDM topics, including an overview and best practices of RDM, data management plans, navigation of the Texas Data Repository and specific disciplinary Dataverse, metadata and FAIR principles, and data documentation. The learning objectives of the RDM training session aimed to recognize appropriate data management practices through the research data lifecycle (Xu, Zhou, Kogut & Clough, 2022,).

4.2 Research design

After receiving institutional review board approval, we used the institution's bulk email to recruit graduate students from the College of Education at Texas A&M University. All of the participants signed the consent form, completed a demographic pre-survey, and answered a pre-assessment through Qualtrics in order to measure the participants' RDM skills. In the pre-test phase, we received 98 valid responses.

Next, we randomly assigned the participants to the two experimental groups and the control group. The participants in both of the experimental groups received a four-hour workshop about RDM through Zoom. However, we employed different teaching methods when offering the instruction based on social constructivism (Greeno et al., 1996; Vygotsky, 1978). Experimental group 1 (teacher-centered group) received lecture-based instruction about RDM, while experimental group 2 (student-centered group) received RDM instruction with more engagement activities, in a more interactive format. We offered compensation at the rate of $20 per hour to the participants according to their involvement time in the project.

Control group. About half of the recruited participants were randomly assigned into the control group ($n = 44$) and received all the RDM training materials after the intervention.

Teacher-centered group. Experimental group 1 consisted of 22 graduate students, for which the four sessions were provided with a lecture focused instructional design. Participants met in the Zoom meeting room without encouragement for turning on the camera. A combination of native Zoom tools was used to engage students in this group, including the chat box and the polling feature. Students were periodically invited to vote in the polls and use the chat to respond to questions from instructors.

Student-centered group. Eighteen graduate students were in experimental group 2 which was designed as a more student-engaged group. The first engagement strategy

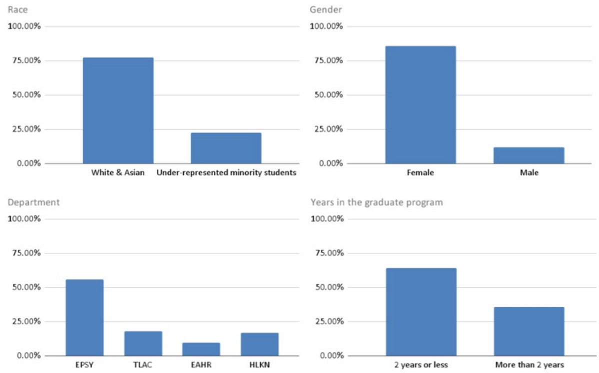

Fig. 1 Demographic information of Participants (N=84)

employed with this group was collective note-taking. To engage in collective note-taking in the Zoom environment, we leveraged the Google Docs software platform, designed to allow multiple individuals to edit a single document at the same time. After creating a general outline for the workshop in Google Docs, we shared the document with students at the beginning of the workshop and encouraged them to add notes about key concepts to the document individually throughout. The instructor also provided a Google Jamboard to facilitate active learning throughout the workshop. Additionally, learners in this group were encouraged to turn on their cameras with an additional $10 incentive if more than 90% participants did throughout the entire Zoom session.

A prior power analysis demonstrated that a sample size of 54 was enough for detecting the treatment effect when using ANCOVA analysis. In this power analysis, we estimated the model to include 4 covariates with the number of groups at 3 ($df=2$); the power was set as 0.80, the probability of error α equal to 0.05, and the effect size was set as Cohen's $d=0.44$ according to previous literature (Agogo & Anderson, 2019). Literature indicates that most commonly used strategies for the size of experimental and control groups are evenly distributed. However, the ratio of 2:1 between control group and experimental group is also evident (Dumville et al., 2006). In this study, we adopted the ratio of control versus two experimental groups in 2:1:1 ($n=44$ vs. $n=22$ vs. $n=18$). Generally, it follows that the rules of the control group and overall experimental group are even in size ($n=44$ vs. $n=40$). Figure 1 shows the descriptive statistics of the participants' gender, race, department affiliation, and their years in the program.

4.3 Measures

In order to measure participants' RDM skills, the participants completed the same set of knowledge assessments for the pre-and post-assessment. This knowledge assessment about RDM contained 12 items, which was designed based on the MANTRA Research Data Management Training course and Research Data Management Librarian Academy course's test (Xu, Zhou, Kogut & Clough, 2022). The question items attempted to cover our own curriculum and reflect our learning objectives. Previous literature has shown that self-designed assessments have their advantages and disadvantages as well (Johnson & Christensen, 2019; Xu et al., 2022).

4.4 Data analysis

4.4.1 Analytical plan

We used STATA 17 to analyze our data. The research questions were examined by a one-way ANCOVA. Eta-square was used for reporting the effect size. Prior to conducting the ANCOVA, assumptions checking was performed. Descriptive statistics such as number of participants (N), adjusted mean scores (M_{adj}), and standard deviations (SD) were used for presenting the participants' RDM skills in each group (pre/post scores). For research question one, we attempted to examine whether there was statistical significance between our two experimental groups and control group. We controlled the variables such as participants' pre-scores, race/ethnicity, department of study, and years of study in their current program in our analysis model. According to previous literature, under-represented minority students usually have more challenges in academic performance (Tinto, 1993). Furthermore, students' disciplines and their experience about doing research will have an impact on their understanding about RDM (Doucette & Fyfe, 2013, April; Frugoli et al., 2010). For research question two, we aimed to investigate whether there was statistical significance between the two experimental groups, the teacher-centered group and the student-centered group. Follow-up assessments were performed by a series of t-tests to compare the differences by the formats of online instruction. Cohen's d was used for reporting the effect size.

4.4.2 Preliminary data analysis

Prior to the data analysis for the research questions/hypotheses, assumptions checking was performed. First, no missing data and outliers were identified in this study ($n=84$), based on leverage, studentized deleted residuals (SDR), and Cook's *d* values. All the data were reasonably entered, performed by a two-way scatter plot. The results showed that the normality assumption was not violated with the skewness close to 1 at 0.15 and kurtosis close to 3 at 2.50. A density plot, a Q_Q plot, and Shapiro-Wilk test ($p=.742$) were further performed indicating that the data is normally distributed. Moreover, the homogeneity assumption was tested and found to be tenable ($Chi^2=2.92$, $p=.712$). Additionally, linearity assumption was tested by a scatterplot of the residuals versus predicted values with a Lowess line. The results showed that this assumption was tenable due to little departure from the zero on the tails of the Lowess line.

5 Results

5.1 Participants' initial research data management skills

The present study aimed to investigate whether there are significant different effects of the distinct formats of RDM instruction on graduate students' RDM skills at a large public research university in the southern US. The participants were assessed pre/post on their knowledge of RDM skills with the intervention groups compared to a control group. A total of 84 graduate students were included in the present study. Descriptive statistics of their pre/post test scores as a function of the group can be viewed in Table 1. The prior ANOVA test on participants' pre-test scores demonstrated that there was no significant difference between the experimental and control groups ($F=0.01$, $p=.902$).

5.2 Effects of the online RDM instruction

Generally, the students in both experimental groups had higher RDM post-test scores than the students in the control group. The students' post-test scores were reported in Table 1. Figure 2 also describes the post-test comparison between the two experimental groups and the control group, showing that the student-centered group had the highest scores, followed by the teacher-centered group and control group. The results of ANCOVA (Table 2) showed that the intervention had statistically signifi-

Table 1 Descriptive statistics of the participants' pre/post scores

N=84	Pre-Score			Post-Score		
	N	M_{adj}	SD	N	M_{adj}	SD
Control Group	44	12.25	6.42	44	13.09	5.81
Teacher-centered Group	22	12.73	5.24	22	21.67	9.34
Student-centered Group	18	12.94	5.74	18	28.64	5.41
Marginal Means	12.52			21.13		

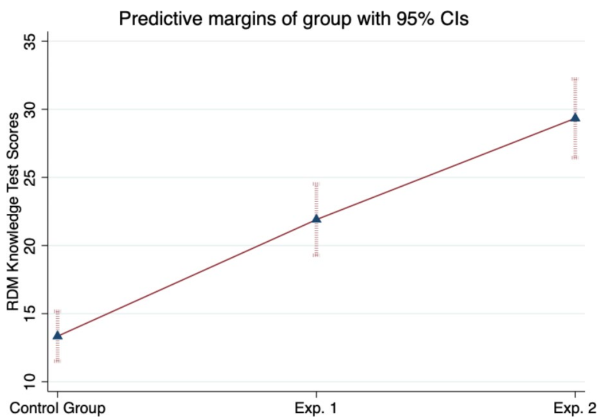

Fig. 2 Post-test comparison between the two experimental groups and control group. (**Note*: Exp. 1 = teacher-centered group and Exp. 2 = student-centered group)

Table 2 The results of ANCOVA

Variables	*SS*	*df*	*MS*	*F*	η^2
Group	2870.04	2	1435.02	39.02***	0.51
Ethnicity	0.07	1	0.07	0.00	
Department	646.98	3	215.66	5.86**	0.19
Year of study	6.81	1	6.81	0.19	
Pre-score	79.39	1	79.39	2.16	
Residual	2758.19	75	36.78		

Note: *p<.05, **p<.01, ***p<.001

Table 3 Follow-up Pairwise Comparison by Group

Contrasts	Differences	*t*	*p*	Cohen's *d*
Exp. 2 vs. Control	16.02	8.38	0.000***	2.56
Exp. 1 vs. Control	9.50	5.33	0.000***	1.41
Exp. 2 vs. Exp. 1	6.52	3.00	0.004**	1.14

Note: *p<.05, **p<.01, ***p<.001; Exp. 1=teacher-centered group and Exp. 2=student-centered group

cant effects on students' overall RDM skills ($F=39.02$, $p<.0001$) with a large effect size ($\eta^2=0.51$). In addition to the main effects of group difference, students from different departments of College of Education also demonstrated varied RDM skills in the post-test. That is, participants' department affiliation had significant impacts on their post-score in RDM skills ($F=5.86$, $p<.01$) with a medium effect size ($\eta^2=0.19$).

Additionally, the post hoc analysis by pairwise comparisons indicated that students in the student-centered group scored 16.02 points higher on the average RDM skills test scores after receiving more interactive online instruction ($t=8.38$, $p<.001$) than the control group students, which shows an extremely large intervention effect with Cohen's $d=2.56$. Moreover, the teacher-centered group scored 9.5 points higher on the average RDM skills test score ($t=5.33$, $p<.001$) than the control group students after receiving the lecture-based online instruction, which indicates a large intervention effect with Cohen's $d=1.41$.

5.3 Different approaches to online instruction matter

Furthermore, our study demonstrated that there was a significant statistical difference between two experimental groups. The student-centered group scored 6.52 points higher on the average RDM skills test scores than the teacher-centered group ($t=3.00$, $p<.01$), which indicates a large intervention effect with Cohen's $d=1.14$. Overall, the student-centered group had the strongest effect on students' RDM skills, and the teacher-centered group had a less but significant impact on student RDM skills, compared with the control group who had no instruction on RDM (See Table 3).

6 Discussion

The application of student engagement strategies in both in-person and online learning experiences has been lauded as an instructional best practice since the development of Social Constructivism, which posits that learning is an experiential and social process (Greeno et al., 1996; Vygotsky, 1978). The results of this study further endorse this theory within the unique context of RDM instruction and online learning environments. Learners in the student-centered group scored significantly higher than their counterparts who received the RDM instruction in a teacher-centered approach. While the instructional strategies are correlative to the different scores rather than causative, the engagement strategies were the primary difference between the treatment of the two experimental groups, indicating that these strategies may have had an impact on the learning in the synchronous online learning environment (Martin & Bolliger, 2018).

To differentiate the learning experiences between the two experimental groups, students in the student-centered group participated in three engagement activities throughout the workshop. The first strategy employed with the student-centered group was collective note-taking, in accordance with Greeno et al.'s (1996) assertion of the benefits of collaborative elaboration. Individual note-taking is a proven strategy for maintaining student focus and easing the cognitive load on working memory (Hartley, 1983). However, students often find it difficult to know what to record and how to organize important information (Kiewra, 1987). Collective note-taking, or group note-taking, can ease anxiety for individuals and highlight various perspectives from multiple learners. However, collective note-taking can be challenging in an online learning environment where students are unable to divide into groups without joining individual breakout sessions. We created a Google Doc to facilitate students in collective note-taking to cover the key concepts and a general outline for the workshop.

In addition to including a general outline for the workshop, the Google Doc included written prompts embedded throughout to serve as knowledge checks for content deemed critical to the learning outcomes of the workshop by the instructors. For example, learners were prompted to consider why data management is important to their research and record their responses collectively in the Google Doc by first writing their names and a brief description of their reflections.

These written prompts were inspired by Classroom Assessment Techniques (CATS), developed by Angelo & Cross (2012) to assess declarative learning. Learners were asked to categorize information from workshop content or to identify the principle(s) that would solve a particular RDM problem based on their working knowledge of the content recently covered in the workshop. CATS are touted as a means of formative assessment used by the instructor to capture immediate feedback on student comprehension of learning outcomes. However, these techniques are also a keen strategy for engaging students as they require informal application of the content (Angelo & Cross, 2012). The intermittent application of content throughout the learning experience requires student participation and promotes engagement in the learning experience. Furthermore, the immediate application of the content simulated the recall of information necessary to perform the summative assessment for the workshop, the post-test, which can improve test performance (Angelo & Cross, 1993). Therefore, this strategy may have contributed to the post-test performance of the student-centered group.

In addition to using Google Docs, we implemented a Google Jamboard to facilitate active learning and engagement throughout the workshop. Previous studies have proved that Google Jamboard benefits active student engagement in online teaching and learning during the COVID-19 Pandemic (Ahshan, 2021; Sweeney et al., 2021). The Google Jamboard is a digital platform that simulates an analog whiteboard. Individuals are able to simultaneously draw, write, and annotate the Jamboard in real time using a web browser or free mobile app (Google, 2022).

The Jamboard was used with learners in the student-centered group, to provide practice with a key learning outcome of the workshop on the topic of metadata. To integrate the Jamboard strategy, we first introduced the concepts of three metadata categories (descriptive, administrative, and structural) and the different metadata fields that fall under each category (e.g. title, funder, codebook). We then pre-populated the Jamboard with the three categories and several example metadata fields and asked students to drag the metadata field under the corresponding category. Participation in this activity was voluntary, but it allowed several students to test their knowledge collectively, while other learners observed the categorization in real-time. Again, this strategy was employed for content deemed necessary to meet the learning outcomes for the workshop and served two purposes. First, learners could apply the concepts of metadata categorization immediately allowing them to secure the concepts in their working memory. Second, the instructors could observe the learners during activity to discern their understanding of the content and determine if further instruction was needed.

In addition to these engagement strategies, learners in the student-centered group were encouraged to leave their cameras on in order to mimic a more authentic in-person learning experience. At the beginning of the workshop, we asked that learners keep their cameras on throughout the workshop and incentivized the use of cameras by adding an additional $10 to their stipend if 90% of learners kept their cameras on for the duration of the workshop. Most students did volunteer to turn their cameras on and maintain their virtual appearance in the virtual classroom throughout the workshop whereas no more than 5 students in the teacher-centered group turned on their cameras.

Experts, educators, and students agree that online learning experiences are less engaging than in-person experiences (Kushlev & Epstein-Shuman, 2022). Face-to-face communication is the strongest medium for group learning, which is a powerful advantage of in-person learning experiences, which may explain why learning via video conference is less engaging for students (Peper et al., 2021). However, when cameras are on, students are more likely to remain in place and are less likely to engage in unrelated tasks during the instruction (Kushlev, & Epstein-Suman, 2022). Therefore, students in the student-centered group were encouraged to leave their cameras on during the entirety of the workshop in order to increase their likelihood of engagement.

The engagement strategies used in the workshop were designed and deployed to counteract the contributing factors of Zoom fatigue identified in our review of the literature. Specifically, the collective note-taking and Jamboard activities were implemented to reduce the potential for distraction and multitasking by requiring participants to engage with workshop content intermittently throughout the workshop rather than passively absorbing instructor lectures (de Sobral et al., 2022). Incentivizing the use of cameras during the workshop was employed to promote accountability among learners to engage with one instructor and one another.

The results of this study support our hypothesis that the instructional strategies leveraged in the student-centered group support student engagement in synchronous online RDM instruction. The student-centered group received the RDM instruction with the interactive instructional strategies and had the most improved score of RDM knowledge in the post-test. The difference in scores between the control group and the experimental groups was significant but expected due to the nature of the content as new information. However, the effect size of the teacher-centered group to student-centered group was also large indicating that students in the student-centered group performed significantly better than those in the teacher-centered group. The only difference in the instruction provided to the two experimental groups was the three engagement strategies designed and delivered by the instructors. Therefore, we posit that these strategies correlated with higher test scores.

When providing online instruction, instructors should intentionally choose the appropriate strategy to increase students' engagement to improve learning. If collaboration between students can improve the learning outcomes, instructors can include more collaborative activities in the online learning environment, such as collective note-taking in a Google Doc and Google Jamboard use (Angelo & Cross, 1993; Sweeney et al., 2021). For another instance, if Zoom fatigue is noticed in the teaching process, instructors can encourage the students to turn on their video to keep the students engaged with the learning activities (Kushlev, & Epstein-Suman, 2022).

7 Conclusions and future study

The findings reported in this study have provided empirical evidence for the effect of different online RDM instruction approaches on graduate students' RDM skills. A proper understanding of this relationship is crucial in identifying effective instructional strategies and the sustainability of effective RDM teaching. The two different online instructional formats are both found to significantly affect graduate students' RDM skills. However, the gaps between the magnitudes of effects provided by two different approaches indicate the importance of students' engagement strategies in instruction delivery. We assumed that the strong effect was attributed to the first access to the RDM knowledge and the immediate effect was therefore obvious.

Another significant contribution of this study to the literature is that the interactive instructional modality that actively engages the audience, which is rarely reported in the literature, is essential for increased student learning during RDM instruction. Additionally, the interactive online instructional strategies used in this study could be applied to online instruction in any discipline to ease the online learning fatigue that is commonly witnessed during the post-pandemic era.

Although this study has unique contributions and impact, we acknowledge that it also has some limitations. The first limitation concerns the application of the knowledge gained from the RDM instruction. The significant impact of the instruction on student RDM skills was captured right after the one-time workshop. Therefore, there is no measurement of students' actual application of the RDM skills learned from the training. Future research can investigate whether the students applied what they learned from the RDM instruction to real-life research and examine the long-term effect of the instruction.

Even though we employed some strategies to increase the interaction and engage students in our online instruction, all of the strategies were extrinsic incentives. To increase students' motivation to learn something, intrinsic motivation might be more effective. Intrinsic motivation is defined as individuals doing an activity for their inherent satisfaction rather than for some separable consequences (Ryan & Deci, 2000). Especially for the RDM implication, we will hypothesize that students will be more likely to apply what they learned in the instruction to their research if they have more intrinsic motivations. Future studies could design more interventions that could trigger students' intrinsic motivation to learn.

Furthermore, the current study targeted social science graduate students but was providing general RDM instruction to them. We anticipate that more discipline-based RDM instruction would benefit the students and make a greater impact on them. Future researchers can work on disciplined-based RDM instruction in order to provide more tailored and discipline-needed RDM instruction to the students.

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Data availability The datasets generated during the current study are available in the Texas Data repository, [Xu, Zhihong, 2023, "RDM Intervention 2", https://doi.org/10.18738/T8/TNMPHE, Texas Data Repository, V1].

Declarations We declare that we have no conflicts of interest.

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