Webtools as Strategy: Online Resources to Support Academic Writing in Lower-Division

STEM Courses

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Abstract

This study investigates the use of webtools to provide strategy support for student writing in lower-division STEM courses. In recent decades, writing with technology tools has become more of a part of school and life tasks. By the first years of university, students have had years of instruction and experience with writing; yet, the demands of writing also continue. For students in STEM subjects, the writing of lab reports as a new and distinct genre can pose challenges. This mixed-methods project sought to explore lower-division STEM students' perspectives about writing via an online survey and follow-up interviews as well as analyze their use of online (e.g., short videos, infographics) webtools that offered ideas and strategies to better improve their planning, drafting, and editing texts. The results indicated that students find academic writing to be a challenge. Their use of the online webtools and feedback offered through this project demonstrated improvement in their writing.

Keywords: writing; technology; strategy instruction

Writing is a core skill that students need to succeed in school (Ibrahim et al., 2017). Teachers, students, and parents can all benefit from learning about online tools and writing strategies that can help them better manage composing text for specific purposes. The academic writing tasks of universities and colleges is one example. By expressing and sharing ideas and opinions clearly and concisely, students can demonstrate their ideas and findings to their audience (Alkhamra et al., 2012; Dennis & Swinth, 2001). Students' written texts are often a teacher's primary, or sometimes only, tool for evaluating their understanding of class content and academic achievement (Alkhamra et al., 2012). Students' progress and proficiency with writing helps them succeed in their undergraduate course work and future careers (Kellogg & Raulerson III, 2007). At the same time, adapting writing process, skills, and convention practices to discipline-specific expectations can be a challenge for students given the relationship between disciplinary knowledge and writing as a way of understanding and expressing disciplinary knowledge (Carter 2007; Hayes et al., 2017; Wolfe et al., 2014;). This adaptation process can be especially challenging for students writing in STEM courses, given the often distinct genre expectations and conventions. This study offered lower-division STEM students the opportunity to 1) offer their perspectives about writing in an online survey and follow-up interviews, 2) review short videos and infographics about writing strategies, and 3) receive feedback from an adult editor on their drafts of written assignments.

Many Students Struggle with Writing

Writing persists to be an issue of inequity for many students (Amalia et al., 2021; Fischer & Meyers, 2017). Bilikozen (2019) concluded that university students' underdeveloped literacy skills are a common point of complaint by academics at higher education institutions. Academic literacy, in the university context, refers to students' reading and writing skills and their ability to communicate competently in a community that relies on academic discourse (Calvo et al., 2020). According to Kumari (2016), students enrolling for the first time in STEM courses, for example engineering, can lack the kinds

of writing skills needed to support higher learning within the respective disciplines. Beyond a lack of familiarity with STEM writing, students' writing difficulties may also result from their learning challenges with reading, writing (e.g., conventions or idea generation), or attentional issues. Alkhamra et al. (2012) suggest that learning challenges can be attributed to students' lack of practice to improve writing, reading, listening, and speaking skills. These students are likely to report challenges with perception, planning, studying, or editing. These problems intensify in secondary school where there is increased complexity in content and expectations for the successful completion of writing assignments. Support for writing instruction within disciplinary contexts, especially, can assist students as they navigate these complexities in content and tasks.

Many students struggle with writing (National Assessment of Educational Progress-Writing, 2021). The process of developing ideas, organizing them for a coherent text structure, spelling proficiency, drafting sentences and paragraphs, and making edits can be demanding for students who lack the efficient executive functioning (e.g., attention, memory) skills, in particular, to manage writing's multifaceted processes. These students can find reading, too, as a challenge, which results in fewer experiences and fewer examples of what good writing entails. About 4.2% of students may have a learning disability—difficulties with attention, perception, and working as well as long-term memory skills (Zablotsky & Alford, 2020). Providing students with a means to listen to texts (e.g., eReaders) and strategy ideas (e.g., short videos, infographics) can help offer these students options to help manage the writing process.

Second language learners can also face challenges in writing English texts (Al-Mubarak, 2017). Writing plays an indispensable function in foreign language learning within universities and colleges. These learners can face difficulties with vocabulary choice, grammar, use of irregular verb forms, and punctuation. Taken as a whole, these challenges to equity and inclusion can negatively affect the writing skills of students who have English as a second language (ESL).

Pineteh (2014) suggests that the acquisition of appropriate writing skills promotes students' learning and comprehension across subject areas. For ESL learners, improving their writing skills is crucial for student success (Karakoç et al., 2017). These skills also allow a learner to better manage in other academic fields that require effective communication and comprehension. Instructors across all disciplines have a key role in this development process. By employing pedagogical approaches that promote active teaching and learning, faculty can support writing across the curriculum and the transfer of writing skills across courses. A key component is employing research/evidence-based practices that help address students' writing challenges.

How Writing can be Challenging for Students

Writing is a multifaceted skill for students to master (Graham, 2020). A key first practice to being a successful writer is to be a competent and avid reader. Reviewing published and high-quality texts in a given genre offers readers the opportunity to see and hear what a text can include, how it is organized and structured, and the type of vocabulary that is employed by experts. Analyzing published texts can be helpful for students to practice as they create their own prose to complete their writing assignments.

Struggling writers tend to have difficulty with idea generation and planning (De Smedt et al., 2018). Due to typically being infrequent readers, they sometimes do not have a sense of where to start in the writing process. This can be even more true when writing STEM genres given their often-technical vocabulary and content. Once a student has noted some ideas, their observations need to be formatted into a genre-appropriate plan or outline. These demands on executive processing in the brain along with spelling, word choice/vocabulary, sentence formation, and text structure of the overall order of subtopics renders real challenges for struggling writers. As a result, their resulting texts are often short, underdeveloped, and may be missing key elements.

High School and Lower-Division (STEM) University Students' Perspectives about Writing

Writing is a core skill in academics, yet many students at the high school level do not write as frequently as expected, leaving them underprepared for writing tasks when they reach the university level (LeBlanc, 2021). High school students may lack sufficient time to learn how to criticize an idea, specify their stance on an argument, define a problem and propose a solution, or finesse their text into high-quality prose. They then enter an institution of higher education without the writing skills needed to help them achieve academic and career success in a chosen STEM field. Instructors in institutes of higher education can then find themselves struggling to offer strategies to help students with writing. One common strategy is the introduction of educational technology tools as supplemental resources (e.g., Grammarly.com; Purdue's OWL) to help students manage writing skills.

Writing Intervention Strategy Examples

For many people, writing is not an inherent skill. Students often benefit from being taught ways to manage writing tasks and then offered opportunities to practice and promote proficiency and adeptness. Graham et al. (2012) completed a meta-analysis about writing instruction methods. They found that those methods with the most positive impact included the following: strategy instruction such as self-regulated strategy development (SRSD; choosing a strategy that meets students' needs for improvement, discussing the strategy with students, modeling it, having students practice it with the instructor, and then students' applying the strategy themselves); use of imagery such as to illustrate ideas and content before drafting text; peer and adult feedback; and goal setting. Methods with low effect impact included the following: teaching transcription skills (e.g., create five topic sentences as a wrote/stand-alone activity apart from choosing a topic and drafting continuous text) and grammar instruction (e.g., focusing solely on wrote spelling and punctuation activities). Technology tools did not appear in Graham and colleagues' list, but their inclusion in the Common Core State Standards (2021) and Smarter Balanced Assessments (2021) make computers, mobile devices, and apps key parts of the current practice of writing.

Other research supports the concept of strategy development, daily practice with writing texts, and use of technology. Schmidt (2021) investigated the practices of first-year college students who had low perceptions of high school writing practices. The author examined students' texts from independent writing sessions to assess their strengths and weaknesses. Schmidt concluded that most students could improve if provided inclusive practices such as teacher feedback, a choice in writing topics based on the students' interests, and materials and tools to help manage their writing. This research illustrates that technologies and educational tools can help address challenges to equity (Schmidt, 2021). When teachers employ strategy instruction and guided practice with technology tools, students have an enhanced opportunity to improve their writing skills.

Al-Jarf (2009) recommends the use of mind-mapping software among freshman students as a way of improving writing skills. Mind mapping software offers a type of graphic organizer composed of a central image and branches of text bubbles to generate thoughts and ideas, taking notes, improving memory, and developing concepts. For freshman students undertaking their first writing course in English as a Foreign Language (EFL), Al-Jarf (2009) revealed that before the integration of the mind mapping software, no differences were detected between the groups. However, after the application of the software, there were substantial variations in the students' generation of ideas, paragraphing, writing of topic sentences, and supporting written information with facts. Mind-mapping software can be a useful tool for learning and enhancing students' understanding of classroom concepts.

Gruenbaum (2012) validates the effectiveness of the Reciprocal Teaching (RT) technique in improving writing skills among students. With its focus on understanding texts, RT incorporates numerous approaches, including clarifying, predicting, questioning, and summarizing, which increase an individual's comprehension of texts. The method has teachers and students take turns while leading class discussions. At the same time, teachers also encourage and motivate their students to participate in peer learning and interactions. RT can be conducted on virtual-meeting platforms from where teachers and

students can interact with one another, ask and answer questions, and discuss writing and comprehension issues. Other technological platforms, such as films, can also help instructors teach their students appropriate research skills that can enhance their writing skills through knowledge of grammar and mechanics (Baratta & Jones, 2008). Hawthorne et al. (2017) further suggest that self-regulated learning with rubrics can be a possible intervention to help address students' writing challenges. Using research that involved 596 undergraduate students enrolled in university coursework with an exam, Hawthorne et al. (2017) found that regardless of achievement levels, students benefited from the use of a detailed rubric as compared to those using a general rubric group.

Students can benefit from designated time to practice strategies. Graham and colleagues (2012), as well as Grunke and Leonard-Zabel (2015), concluded that offering students time to practice writing using research-based strategies and tools promoted the opportunity for students to improve their writing skills. The authors believe that teaching rote skills is not a best practice approach as it can lead to students' weaknesses in writing, which can continue with them into university. Rather, teachers should ensure that their practices address students' diverse needs and expectations for writing, including offering students time to engage in peer learning and participate in dialogue and feedback from the teacher to improve students' writing, academic skills, and opportunities in a future career. Multimodal resources, such as the webtools included in this study, can enhance students' writing development because they tap into multiple modes of learning (multiple literacies) for students to support comprehension and understanding. We administered an online survey and interviews to collect feedback on students' writing challenges and their use of the writing webtools provided in this study. The research team in this project sought to promote equity and inclusion by better defining what can help STEM students improve their writing skills in their first two years of coursework.

This study included the following three research questions:

1. What do lower-division STEM students at a western US university view as their strengths and weaknesses in writing?

2. What resources do the lower-division STEM students seek when they find writing to be challenging?

3. After using some researcher-created webtools for this study, how did lower-division STEM students' writing skills change during the use of the webtools paired with an adult-editor's feedback on their drafts for a course's writing assignment?

Methods

This study focused on identifying STEM undergraduate students' perspectives about writing to help identify what types of webtools could be developed to help support and improve their writing skills. The study employed a sequential explanatory mixed method design (Kroll & Neri, 2009). The authors preferred the sequential/explanatory mixed method given the survey data followed by interview and writing intervention sequence of this study. In the interpretation phase, the data obtained from the interviews, questionnaires, and the online writing intervention was used in making a deductive comparison—reviewing students' pre/post-intervention texts to assess changes in skills over time.

The method included a sequential sequence of quantitative and qualitative data collection: a quantitative survey, semi-structured qualitative interviews, and descriptive analysis of writing-intervention participants' texts per a writing rubric (Association of American Colleges & Universities, 2021). The data from the qualitative component was used to analyze and explain the findings obtained in the quantitative phases. The authors received human subjects approval to complete this study.

Participants

A total of 75 STEM undergraduate students participated in the study. The participants were

lower-division (i.e., freshman and sophomore) students in STEM classes at a large public university

located in the western region of the United States. Their age range was 17-56; mean=20.32; SD=4.86).

The gender distribution was 27% male, 73% female. The participants' race/ethnicity is described in Table

1.

Table 1

Participants' Race/Ethnicity

White/Caucasian	66.20%
Black or African American	0.00%
Native Hawaiian or Other Pacific Islander	0.00%
Hispanic or Latino	14.08%
American Indian or Alaska Native	5.63%
Asian	7.04%
Two or more races	4.23%
Other descriptor: (Western European descent)	1.41%
Prefer not to answer	1.41%

The students' type of class is defined in Table 2.

Table 2

Participants' Type of Class

Class Type	Freshman	Sophomore	Junior	Senior

Science (e.g., chemistry, biology, astronomy)	36.07%	36.07%	22.95%	4.92%
Math (includes Physics)	46.15%	26.92%	15.38%	11.54%
Engineering	55.00%	25.00%	10.00%	10.00%
Computer Science	53.85%	38.46%	0.00%	7.69%
Other:	42.86%	21.43%	28.57%	7.14%

Procedures

The research team asked the instructors of two classes (astronomy and biology; N=200) to forward the email invitation to complete the consent form and survey. The quantitative phase involved administering questionnaires to the 75 student participants (38% response rate). The qualitative semi-structured interviews (N=8) were completed 1:1 with the first author. The interviews sought students' perspectives about writing (e.g., what did they find challenging about writing? What did they do when they needed help?). In the third component of this study, the researchers reviewed students' texts from an online writing intervention (N=3): three pre-intervention texts, and three post-intervention texts.

Instruments

Survey. The research team developed a 12-question, likert-scale survey (see Table 3) about students' perspectives about writing. The questions included topics such as experiences with reading and writing skills and how well students could listen/maintain attention in class, follow explanations in class, take notes, and manage writing tasks.

Table 3

Survey Questions

Question Number	Question
1	Do you like writing?
2	Do you voluntarily seek and read academic texts similar to your writing assignments to see what published writers do?
3	What is your experience with the following aspects of writing?
	Focusing attention in class.
	Having the writing assignment explained in class.
	Attaining answers to questions about the writing assignment.
	Reading the required texts before completing a writing assignment.
	Finding source texts to reference in my own writing.
	Planning and organizing my ideas.
	Spelling words and creating sentences.
	Making a first draft.
	Reading my own writing.
	Knowing what edits to make.
	Attaining feedback (e.g., peer, campus writing center)
	Attaining a good grade on my writing assignments (e.g., B or better).
4	Was writing difficult for you in school?
5	Was reading difficult for you in school?
6	Gender?
7	What is your age as of September 1 fall semester?
8	What is your race/ethnicity?
9	You are a student in what type of class (e.g., biology, astronomy, etc.)?

The research team asked a literacy researcher to review the survey, who affirmed that the questions were clear and focused on topics that could impact students' writing skills.

Interviews. The research team developed a set of questions to explore a small sub-sample of students' perspectives about their strengths/weaknesses with writing. The questions included the following: How do you feel about your writing skills? What is easy? Difficult? When you find an aspect of writing to be hard, what do you do? What resources have you found to be helpful? Why? What resources could be enhanced or created to help you more?

The interviews were conducted via online video-conferencing software (Zoom, 2021). Each participant met with the first author 1:1. The interviews ranged in duration between 20-30 minutes (mean=25 minutes). The descriptive information about each participant is listed in Table 4.

Table 4

Interview Participants' Descriptive Information

Participant	Gender	Race/Ethnicity	Year	Program Type
Yoshe	Female	Asian	Freshman	Computer Science
Roberto	Male	Hispanic	Freshman	Computer Science
Isabella	Female	White	Sophomore	Wildlife
Hannah	Female	White	Sophomore	Electrical Engineering

Xia	Female	Asian	Freshman	Computer Science
Nisha	Female	Asian	Sophomore	Computer Science
Sophia	Female	White	Junior	Public Relations (Astronomy)
Aria	Female	White	Junior	Elementary Education (English)

Online writing intervention: students' texts. The biology and astronomy instructors each provided a rubric to students for their class writing assignment. The online intervention's webtools also included videos by each instructor discussing their rubric, a high-quality exemplar, and a low-quality exemplar. Online writing intervention students composed their lab report assignment in a password-protected OneDrive account, where a paid asynchronous editor could read the students' writing and provide weekly feedback to the students. Using the VALUE rubric for writing communication (Association of American Colleges & Universities, 2021), three members of the researcher team scored the students' writing individually and came to a consensus on the scores assigned to the writing products that were completed in different stages of the intervention.

Data Analysis Methods

Interview Data. For data analysis, the research team used a five-step framework analysis approach (Hruschka et al., 2004; Ritchie & Spencer, 1994; Rubin & Rubin, 1995; Silverman, 2000). They divided thematic analysis into five steps. They individually completed steps 1-4 and later met to compare notes and complete step five. First (familiarization with the data), they read all four teacher transcripts in analysis-ready form multiple times to become familiar with the content, made notes, and created initial

categories. Second (coding to identifying a thematic framework), they coded key themes, concepts, and ideas from each page into categories as well as overarching sub themes. Third (indexing), after they reviewed the transcripts to create the codes, they analyzed their notes while cross-referencing back to the research questions to ensure the codes captured the participants' ideas. Fourth (charting), they summarized the data into a matrix for each theme by having a row for selected data from each participant, noting key ideas and/or illustrative example quotes, and using participants' verbatim keywords to correspond to the coded themes. Fifth (mapping and interpretation), the authors reviewed their matrices within and across participants to begin their interpretation of the data to develop coherent/agreed upon themes and possible explanations of interviewees' comments and ideas.

Attaining a good grade versus understanding course content. One-way ANOVA, correlation, and logistic regression analyses were used to determine differences in students' experience in attaining a good grade on the writing assignment based on students' self-reported Likert-scale scores. The items on the Likert-scale prompted responses about their ability to understand the course content, read the text, and draft, read, and edit their own writings, as well as inquiring about how the levels of difficulty for students to attain good grades on writing assignments could be affected by students' reading the assigned texts and their focused attention in class.

Results

The authors employed quantitative and qualitative methods to analyze the data from this mixed-methods study. The researchers sought to explore lower-division STEM student's perspectives about writing, what they find challenging, what could help them improve, and if participation in an online writing intervention with asynchronous webtools and a master's student feedback could help improve their writing skills.

Quantitative Results

To address **research question 1**, we assessed the correlation of the variables using a sample of 75 college-student participants enrolled in STEM courses. Six of the variables among the ones investigated in the survey had strong correlations with students' grades in their writing assignments. The variables that showed statistically significant correlations with writing grades include students' capability of focusing attention in class to understand the content ($r = .323$), planning and organizing ideas ($r = .265$), making a first draft ($r = .404$), reading their own writing ($r = .375$), knowing what edits to make ($r = .442$), and the chances of attaining feedback from peers, instructors, or writing centers ($r = .262$).

Logistic regression analysis was then conducted to determine whether attaining a good grade in a writing assignment (having difficulty vs. never having difficulty) could be predicted from the aforementioned six predictor variables. Good model fit was evidenced by statistically significant results on an omnibus test of model coefficient, $\chi^2 (6, 75) = 26.99$, $p < 0.001$, and large effect size indices when interpreted using Cohen (1988) (Cox and Snell $R^2 = .32$, Nagelkerke $R^2 = .43$), indicating that between 32% and 43 % of the variance in the dependent variable, whether students have difficulty or not in attaining good writing grades, can be explained by our independent variables.

Furthermore, we received a nonsignificant value of the Hosmer-Lemeshow test, $\chi^2 (8, 75) = 7.3$, $p = 0.505$, which nicely supports a good fit of our model. The results suggest that the predictors, as a set, distinguished between college students who have difficulty in obtaining a good grade in writing versus never having difficulty. With the data in our analysis, we had a high percentage accuracy in classification (PAC) of 0.789, which indicates that 79% of the time when we make the predictions, we will be correct. It shows that our model has good predictive capabilities.

In terms of the relationships between the independent variables and the binary dependent variable, participants falling into the category of "sometimes having difficulty in reading my writing" provided us with conclusive information on prediction ($p = .035$, Exp(B)=7.16). The odds ratio of 7.16

indicates that the odds of having difficulty in obtaining a good grade in a writing assignment (compared to never having difficulty) are increased by a factor of 7.16 if a student has difficulty in reading their own writing from time to time.

The rest of the predictor variables along with their categories were not statistically significant, which suggests that the odds for having difficulty in obtaining high scores in writing (relative to never having difficulty) are similar regardless of students' performance in focusing attention to understand the content, planning and organizing ideas, making the first draft, knowing what edits to make, and attaining feedback. Even though the results are not significant, likely due to sample size, they can still convey meaning for us to understand the impact of the covariates on improving writing grades given the small sample size in this study (Wasserstein et al., 2019). Specifically, we can consider that the odds of gaining a good grade are increased by a factor of 2.6 by the ability to focus attention during class to understand the course content. The odds that a student who knows how to plan and organize his/her ideas will obtain a good grade in a writing assignment are 1.11. The odds that a student who can easily make the first draft will receive a good grade are 2.19. The odds that someone who can easily read his/her writing will have a high score in a writing assignment are 2.19. If a student knows what edits to make, the odds for the student to have a high grade are 1.98. However, the odds of having difficulty in achieving a high score for writing are decreased by a factor of 0.84 by being able to attain feedback from peers or instructors.

Overall, with the current sample size, the category of "sometimes having difficulty in reading my own writing" has strong predictive capabilities to estimate the levels of difficulty that students encounter in their writing assignments. Other covariates, although yielding nonsignificant results, can still provide meaningful information for us to understand how they can predict students' writing performance in a science class.

Results for the Online Writing Intervention Participants' Texts

Three students participated in the one-semester long, asynchronous, online writing intervention:

access to 1) webtools (short instructor videos about the writing assignment's rubric, discussion of a low-

quality example, high-quality example, effective habits of good writers) and 2) a master's student's

asynchronous editing feedback and comments—**research question 3**. Their writing products at the

beginning, in the middle, and at the end of the intervention were scored by the research team using the

VALUE rubric (see Figure 1).

Criterion/Learning Outcome	4 (Capstone)	3	2	1 (Benchmark)
Context of and Purpose for Writing		Student B Student C	Student A	
Content Development			Student A Student B Student C	
Sources and Evidence			Student B Student C	Student A
Control of Syntax and Mechanics			Student C	Student A Student B

Figure 1. Themes related to helping students improve their writing skills

The students' baseline scores were low and scored 1 and 2 in the four aspects of the rubric: context of and

purpose for writing, content development, sources and evidence, and control of syntax and mechanics. By

the mid-point of the semester, three students demonstrated an increased score from 2 and 3, but one

student's writing still scored 1 point at this stage. By the end of the intervention, all three participants'

writing quality improved by 2-3 points.

Qualitative Results

The themes and subthemes from the qualitative data are presented in Figure 2.

Themes	Subthemes
Students' perceptions of their writing skills	- Taking the time - Generating ideas - Proper grammar and syntax
Writing Instruction	- Students' comfort level varied by writing genre - More specific instruction would help to manage rubric's multiple criteria - Challenging to generate ideas
Resources that students find helpful	- Ask professor/instructor/TA - Library - Writing center - Purdue's OWL

Figure 2. Themes related to helping students improve their writing skills

Interview Results

The qualitative portion, which addressed **research question 2**, revealed diverse views from participants regarding various aspects of the writing process. Most of the interviewees observed that writing was difficult and that resources were not always available. There were three overarching themes related to students' writing experiences: their perceptions about writing, its inherent challenges, and the types of resources they use.

Students' Perceptions about Writing and its Inherent Challenges

One of the main themes in the findings is the participants' impressions of writing and their perceived challenges. The interviewees concurred that writing poses a significant challenge and that most

do not have the strategies needed to coherently organize their thoughts and ideas. As one participant

remarked, "I have difficulty to start writing an assignment, generating ideas, and creating a structure"

(Elementary Education student). It emerged that some students find it easy to write specific papers, more

so research papers, but other writing assignments, such as opinion essays, pose a significant challenge.

For example, one participant shared the following: "in general, I find writing pretty easy, especially like

for like research papers I can make such it, it goes a lot smoother I think I definitely find a hard time like

finding the motivation to start writing" (Astronomy student). Another participant observed "but opinion

essay more difficult" (Computer science student). The generation of ideas and structuring of these ideas

coherently emerged as one of the most critical problems:

> I think I don't find any of it easy to be honest. To me would be difficult to write an essay trying to
>
> gather all the all the ideas I have and trying to put on the paper and make sure that later on, make
>
> sense. (Computer engineering student)

At the same time, the interviews revealed that students find it challenging to initiate the writing

process. For instance, they experienced considerable challenges when deciding what they were expected

to write about. The problem was encountered the most when students were asked to give their opinions

about a particular subject area or topic. However, some participants agreed that their writing was good

and that it came naturally to them. Hence, the interview revealed the varied perceptions students have

regarding the writing process.

Writing Instruction that the Students Received/Need

The second theme focused on the type of training students received that affected their attitudes

and competencies in writing. Students commented on how they worked to address the challenges they

experienced in improving their writing. Some of the students depended on their peers and class notes to

enhance their writing skills. The students stated the information provided in rubrics was overwhelming at

times and that they found it challenging to follow everything in the instructions and requirements. As one

participant shared, "the rubric did not always clarify the instructions" (Computer engineering student).

The interviews further revealed that the teacher's notes, exemplars, and classmates' notes could be

valuable sources of information: "some helpful resources are exemplars, teachers' notes, and my

classmates' writing" (Computer science student). The students discovered over time that the teaching

assistant was a helpful resource. As one student shared, "although I did not do well on my first/rough

draft, the teaching assistant's feedback helped me to attain a B+" (Public relations student). Instruction

should meet students' needs to help them manage and have success in writing tasks.

Students agreed that the inclusion of user-friendly resources such as videos would enhance their

experience and augment their writing skills:

> I think that having videos to explain different topics would be very useful. I have video of how to
>
> do math equations. I think this would be very useful for writing to help me understand how to
>
> manage the task. (Computer engineering student)

Students could be offered videos about what good writers do. Reviewing exemplars and why they are

high or low quality would help. Students should have the choice to view discussions of exemplars at a

pace with which they are comfortable to ensure they learn the skills they need to write. This would help

them see that writing is a skill that takes time to master.

The Resources Students Use

The interviews indicated the multiple resources students use to help with their writing skills. One

participant listed the following resources as helpful:

> I use the internet for anything like structure grammar; Google is a prime example. If it is a
>
> question about the assignment's criteria, I prefer to go to teaching assistant rather than the
>
> professor, especially with bigger classes. (English student)

The library was also a valuable resource for the students because of the large number of materials. Some participants commented that writing resources such as Purdue's Writing Lab were challenging to navigate, but others said the campus writing center was the most important source of help (Computer Science student). Students commented that multiple resources can be helpful to improve their writing skills.

Quantitative and Qualitative Results: Similarities and Differences

The results of the quantitative and qualitative analyses had similarities and differences. In terms of similarity, both quantitative and qualitative findings emphasized that writing was challenging to most of the participants. The quantitative and qualitative analyses both indicated that students had difficulty understanding and editing their writing, and their ability to do these was associated with the grade they attained for their writing. The quantitative and qualitative results both illustrated how critical the first draft is and that students typically had difficulty generating ideas, which affected their writing scores.

In terms of the differences, the quantitative portion centered on the variables that affected students' grades for their writing assignments and the predictors pertaining to the quality of their writing. Although both analyses emphasized the pivotal role of editing, the quantitative analysis concluded that this variable is a significant predictor of students' writing grades; however, the qualitative results did not emphasize editing to the same extent. In addition to the predicative function of editing, the quantitative analysis also found that students' ability to focus attention on the course content and their capability to read the assigned texts were key factors associated with students' writing grades. The qualitative results indicated that there were many tools that the students found to be useful, including the teaching assistant,

the writing center, and their classmates' feedback. Receiving clear instructions for tasks and providing writing samples to students was crucial in attaining a higher grade in writing assignments.

Discussion

This study explored lower-division STEM students' perspective about writing and their change in skills during participation in an asynchronous online writing intervention with a master's-student editor's feedback. The findings indicate that students often have inadequate resources to help them learn and improve their writing skills. Students have difficulty when starting to write an assignment. They also face challenges with the complexity of information in classes, as it is difficult to understand and interpret when attempting to apply it to their writing processes and production. Resources such as the library and internet (e.g., Purdue's OWL) were helpful to students, but these kinds of online resources are not always easy to navigate (Singh, 2019). These findings suggest that universities should provide adequate and user-friendly resources to help students in learning and improving their writing skills (Changwong et al., 2018).

Similar to Alkhamra et al. (2012), the survey and interview results (**research questions 1-2**) illustrate that writing can be a challenging task for some students. They do access existing online webtools (e.g., Purdue's OWL), and they found value in the webtools developed and offered in this project for their specific STEM courses. Of note, many student participants voiced their lingering challenge of feeling a sense of learned helplessness: they do not feel empowered to invest a lot of time and energy into written assignments as they have not had good success with writing in the past. Webtools of strategy examples and the instructor's videos discussing what is required in written assignments can help these students with writing, but the bigger challenge remains of overcoming an attitude barrier of feeling powerless in starting well before an assignment's due date to plan and edit their text into higher quality prose.

The intervention participants' VALUE rubric scores (**research question 4**) indicate some improvement. Like interventions for writing offered in public schools (e.g., grade 2-12) that have indicated positive improvement in students' writing skills, tools that offer lower-division university students ideas to help improve their writing can also have a positive impact. Similar to Graham et al. (2012), Schmidt (2021), and Al-Jarf (2009), offering students strategies that help them manage a task with planning, drafting, editing, and revising to a finessed product helps them learn the process, produce better quality, and have a higher senses of self-regulation skills in doing the task more on their own in the future.

Implications

Research shows that STEM faculty find writing to be effective in supporting students in learning content (Stroumbakis et al. 2010). Writing instruction research validates that writing facilitates learning while it confirms that writing is also a skill to be learned and developed (Moon et al. 2018). In particular, research on rhetorical genre studies (Bawarshi and Reiff 2008) and writing transfer (Beaufort 2008; Adler-Kassner et al. 2017) suggests that writing and adapting to new writing tasks and less familiar genres is a complex rhetorical process that students navigate as writers from discipline to discipline and class to class as undergraduates. As such, our study suggests that webtools informed by a strategy instruction approach can support students in the process of learning and adapting to genres that they have less writing experience with, such as can often be the case in lower-division STEM courses with writing assignments. That is, webtools that include resources such as strategy examples and instructor video explanations of writing tasks with discussion of genre expectations are especially valued by students and identified by students as useful writing instruction resources**.**

Limitations and Future Research

This study was conducted at one university location in the western US during a pandemic. Students were experiencing several stressors during the timeline of the project which may have impacted their thinking about writing and the challenges that it can face. While a large percentage of students in the US public demonstrate severe challenges with writing, how that mapped to the students in this sample was left to participants' self-reporting of their writing ability as indicated in the survey and interview results.

Writing is a core academic skill in education along with reading and math. While writing has received renewed focus in public schools with the Common Core State Standards (2021) and Smarter Balanced (2021) assessments, intervention programming and strategy instruction continue to be mostly found in professional journals with a few housed in open sources across the web. Access to educators and classroom teachers for implementing best practices is therefore constrained. More accessible online intervention tools are needed to help students access when and where they choose for the types (genres) of writing they seek to complete. The development of webtools that provide multimodal writing-in-the-discipline strategy support, in particular, can assist students in negotiating audience awareness, purpose, and genre as they move through the planning, drafting, revising, and editing process of academic writing tasks.

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