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RESEARCH ARTICLE

A THEORETICAL APPROACH TO ENSURING INSTRUCTIONAL AND CURRICULUM COHERENCE OF STEM WRITING INTENSIVE (STEM-WIN) COURSES: A CASE ANALYSIS OF ONE UNIVERSITY

***Weam M. Al-Tameemi, Tonya Huber, Ana Cruz and Vanessa M. Palumbo**

Texas State University, US

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ABSTRACT

Background: Colleges and universities offer various forms of Writing Intensive (WIN) courses across the curriculum to better prepare learners for their future careers. The effectiveness of WIN courses in STEM fields is important to enhance the learners' skills and representations of diversity in professions. Therefore, it is important to monitor the challenges and successes of such courses. This research paper is intended to enhance refining WIN programs in STEM fields, making more informed evidence-based decisions in creating and implementing such programs, and informing program development that can leverage the quality of STEM education. The paper will examine multiple experiences in STEM-WIN courses. The lead author closely monitored the STEM-WIN courses and taught the Math WIN courses for many years where most of the students were of Hispanic heritage. Also, student and faculty surveys were issued at the beginning and at the end of two academic semesters, and course completion or withdrawal rates were obtained from the Office of Registration Records. The theoretical framework for this study is grounded on the findings of 25 years of a systemic meta-analysis of professional literature on STEM summer bridge programs (Ashley, Cooper, Cale, and Brownell, 2017). **Results:** The work presented here informs STEM educators and program designers, as well as policymakers and educational researchers, about WIN program challenges in STEM fields. There are many different aspects that need improvement to meet the university's and students' expectations. The data collected have revealed the need to ensure instructional and curriculum coherence, including program structure and implementation. A theoretical approach presented serves to strengthen the role of Research-based Learning via Writing (RbLvW) in STEM education and many varying initiatives and practices are suggested for coherent implementation. These potential initiatives and practices, developed from the data collected and from the instructor's experiences teaching these courses, are to ensure the coherence structure of the proposed STEM-WIN Focused Model that aims to help learners have all necessary skills needed within their discipline. **Conclusion:** Although this work is specific to one Texas University, the findings may apply at other universities implementing intensive writing courses in STEM fields. Many of the same challenges are faced by educators in similar programs across the curriculum. This paper emphasizes that ideal practices serve to encourage a diversity of approaches in writing intensive courses in STEM fields, while still expecting the teaching to follow basic principles such as incorporating revisions.

Keywords: STEM education, writing intensive (WIN), undergraduate, Hispanic students, Research-based Learning via Writing (RbLvW), survey methodology, WIN STEM Focused Model.

INTRODUCTION

STEM-WIN Courses: Initially conceptualized as an acronym for the four separate disciplines of science, technology, engineering, and mathematics, *STEM* (Sanders, 2009) has become less of a replacement word for these separate disciplines and more about ways in which these disciplines are integrated with one another (Breiner *et al*., 2012; Brown *et al*., 2011; Bybee, 2013; Johnson, 2012) interpreted by (Ring, 2017) as shifting from more traditional lecture-based strategies "to the implementation of pedagogy that involves more inquiry and problem-based learning approaches" (p. 6). In this study, no investment has been made in determining the effectiveness, nor appropriateness of the different models. Rather, a brief description of the STEM courses in which the students were enrolled will be the contextualization for the focus on the writing-intensive components of the courses in STEM fields. However, it should be noted that it is important for program developers and educators to consider their own conception of STEM as they work to integrate STEM courses with writing intensive programs, since incorporating writing may align with some pedagogies better than with others. Since Ring highlighted that the challenge to implementing integrated STEM curricula lies in teacher content knowledge—integrating science, technology, engineering, and mathematics presents challenges to teachers whose background knowledge in the subject areas may be limited (Ejiwale, 2013, and Sanders, 2009, in Ring, 2017, p. 8)—it is no less true that implementing writing curricula presents parallel and additional challenges.

Corresponding author: **We'am M. Al-Tameemi**
Texas State University, US.

Delimitation: Though not a focus of this case analysis, the expansion of STEM to both (a) STEAM, where the "A" represents both the arts and humanities (Herro, Quigley, Andrews, and Delacruz, 2017) and (b) STREAM where the "R" represents reading (Portz, 2015), afford opportunities to consider how to strengthen STEM courses at the university level and address the shortage of skilled workers choosing STEM careers. While we have primarily reviewed professional literature on WIN courses in STEM, our findings will be potentially beneficial to WIN courses that are not STEM programs of study.

The Structure of Writing Intensive (WIN) Courses at Many Universities: Guidelines for WIN courses at different universities are mostly similar. Most universities restrict the class size in order to ensure a high interaction between students and instructor. They may also state a specific amount of writing, measured by pages or words, which may be distributed through formal papers and informal drafts

throughout the semester. They may also emphasize the provision of feedback for student papers. Most of the universities require that a high portion of the grade be determined by the writing component (Farris and Smith, 2010). Although most universities include these general elements in their implementation of writing intensive courses, there remain certain things that are similar and/or different from one university to another. For example, Lehman College in Bronx, New York, has offered writing intensive courses with the goal of increasing student learning through varying forms of writing. Similar to Texas A&M International University (TAMIU) in Laredo, Texas and others; Lehman College required that writing intensive courses focused on the evaluation of written work as a high portion of the student's final average grade. The College states that the intensity of their writing courses vary because they must be adjusted according to major types and levels of the course. The intensive writing component can be accomplished through a series of formal papers and informal drafts, as well as smaller assignments which should add up to a total of 15-20 pages for the entire course. Writing intensive courses in Lehman College followed the guidelines of the College Curriculum Committee and Academic Senate (Lehman College, 2011, n.d.). Harvard University's Writing Project (HWP, n.d.) also had similar guidelines at the time of this review. The guidelines focused on the student-instructor interaction and feedback on every writing assignment. They encouraged the assignment of successive drafts throughout the semester. They required that their writing intensive courses remain small, and they emphasized that a significant amount of the student's grade should be determined from their writing ability.

The University of North Carolina at Wilmington (n.d.) required nine credit hours of writing intensive courses for every degree program, similar to TAMIU's requirements. The curriculum overview identified that out of the nine credit hours required, at least three must be in the 3000-4000 level and at least three credit hours must be in a course for the student's major. The University also presented the students' learning outcomes to include the ability to write arguments, analyze content, understand ethics, and use other forms of writing. At the University of Missouri, the writing intensive requirements were also similar. Their university was using a *3-part Writing Requirement* where students were to first take English 1000, a first-year composition course, and then take two writing intensive courses in the 3000-4000 level, one of which must be in their major (MU, 2015). On the other hand, although Lehman College had a writing program similar to TAMIU's, it had different administration requirements. Entering freshmen students were to take four writing intensive courses, three before the end of their sophomore year and one after, as opposed to TAMIU's requirement that students take most of the WIN courses at the sophomore level or higher. In other words, Lehman College preferred that their students complete most of their writing intensive courses earlier (Lehman, 2011).

Texas Tech University (TTU) also included writing intensive courses across their curriculum. The only difference was that they required 6 credit hours in writing intensive coursework in each undergraduate degree to be in the student's field of study. Texas Tech considered the student's exam scores before allowing them to enroll in the Biology I WIN course; they recommended that only students with a minimum 1100 reading plus math SAT score, or ACT score of 24, or AP Biology score of 3 should enroll in such courses (TTU, 2014). Since the original review of these programs, TTU has moved from *writing intensive* courses to *communication literacy* (see TTU, 2017). At the University of Minnesota, the writing assignments were to contribute at least 33% of the student's overall grade, as opposed to TAMIU's minimum of 60% (UM Regents). At Texas A&M University, College Station, the Writing Center interacted with the faculty to help strengthen the success of WIN courses. They offered (a) help designing a writing intensive course, (b) resources for the development of writing assignments, and (c) information that helps faculty teach the writing process. In addition, TAMIU faculty could request the Writing Center to host a classroom workshop where they visit the class and present on topics such as abstracts, oral presentations, scientific writing, and dissertation proposals (TAMIU, 2015b). The efficiency of the above WIN programs and many others may be assured through different measures; the measures necessary will depend on the requirements of the program or type of learners. Though proper regulation, a clear vision of what a good model for WIN Programs in STEM fields will be solidified regardless of individual needs, one that is based on departments' needs and not university requirements for academic success.

Theoretical framework: The theoretical framework for this analysis is grounded on the findings of a meta-analysis of 25 years of professional literature on STEM summer bridge programs reviewed by Ashley, Cooper, Cala, and Brownell (2017). In summarizing their—exhaustive review of the literature, they make a recommendation that may be applied to this research since it mirrors the goals of research, intended to enhance the quality of education by making more informed evidence-based decisions in creating, implementing, and refining STEM programs:

- ✓ Document and publish program descriptions, goals, and outcomes.
- ✓ Report lessons learned from prior (unsuccessful) iterations to guide the development of more successful future programs.
- ✓ Report more information about the details of implementing programs.
- ✓ Work to align goals and measured outcomes since published reports often revealed misalignment between stated goals and outcomes that are measured, (adapted from pp. 13-15)

Additionally, the research examining the importance of writing in student learning and engagement, particularly concerning concepts and practices of science, has been reviewed to provide the pedagogical lens through which this analysis is framed. The significance of writing-intensive (WIN) courses has been highlighted by the Association of American Colleges and Universities in identifying WIN courses as one of the ten high-impact educational practices (Kuh, 2008). The guidelines identified both revision of various forms of writing and writing for different audiences in different disciplines as important aspects of writing-intensive courses. Waratuke and Kling (2016) reviewed writing across the curriculum (WAC) and STEM literature in their study of writing intensive chemistry courses and concluded that connecting scientific and reflective writing to research experiences enhances the experience and learning of the students, creates opportunities for critical thinking, and sets expectations for college-level scientific inquiry (p. 1391; see also, Bean, 2011; Gupta, *et al*., 2015). Students enrolled in the writing intensive chemistry seminar

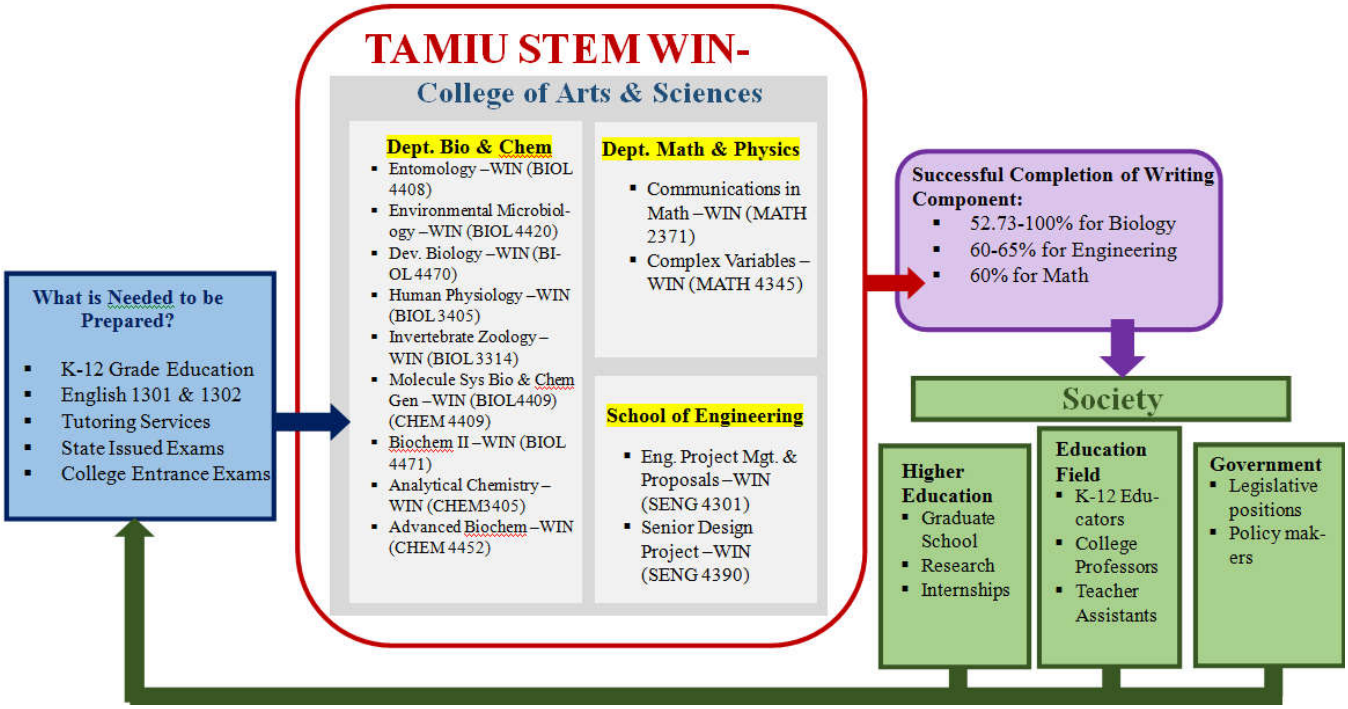

Figure 1. STEM-WIN Courses at Texas A&M International University

exceeded the university average in retention in science and math fields for all five years of the study. Waratuke and Kling also highlighted the importance of reflective writing in helping the student participants understand how much they had learned and what they had accomplished (p. 1395). In their recent study of students' writing apprehension, Fischer and Meyers (2017) stressed the importance of writing skills needed by college graduates based upon employers' perceptions of proficient written communication from e-mails to reports. Workforce research has continued to report employers are more likely to hire, retain, and promote candidates with higher writing skills (p. 69).

A case analysis of one university: win courses in the stem fields at TAMIU: In this study, no investment has been made in determining the effectiveness or appropriateness of the different models. Rather, a brief description of the STEM courses in which the students were enrolled will be the contextualization for the focus on the writing-intensive components of the courses. At Texas A&M International University (TAMIU), some of the classes required in the STEM degree programs have been offered as WIN courses. (For an overview of these courses, see Figure 1.) These STEM-WIN courses were designed so that the writing component was significantly more intense compared to other courses of the same level. WIN course enrollment remained small to ensure high interaction and feedback on writing assignments between the students and their instructors.

The general criteria included

- ✓ At least 60% of the student's grade must be obtained from written work.
- ✓ Students must receive feedback that enhanced their writing and follows specific criteria.
- ✓ Students must revise their work following the feedback, in the form of drafts.
- ✓ Writing assignments must be adjusted according to the discipline.
- ✓ WIN courses could be taken as honors courses for those students in the Honors Program.
- ✓ All undergraduate students at TAMIU were to complete 3 WIN courses as a graduation requirement.

Students were enrolled in WIN courses only after they had completed 12 semester credit hours. The first course could be a 2000 or sophomore level, but the remaining two were to be higher level courses in the 3000-4000 or junior-senior level. At least one of the three WIN courses must have been in the student's major. More details about the examined STEM courses in this study, which are in the following fields chemistry and biology, engineering, and mathematics, are listed in the Appendix. See Figure 1.

MATERIALS AND METHODS

At the time of the study, TAMIU had fixed WIN courses, meaning the university selected which classes would be writing intensive. There were WIN courses for every discipline, but we focused only on the STEM fields. Also, it is different from one discipline to another in the STEM fields; for example, *Current Topics in Biology* was the only course that offered some sections that were not writing-intensive, so the student could select whether they wanted to take the WIN section or non-WIN section. The rest of the STEM-WIN courses were offered with no selection and the students had to take them in order to fulfill graduation requirements. To examine the effectiveness of STEM-WIN courses at TAMIU, we collected data from the students in mathematics, engineering, biology, and chemistry majors, and from the faculty who teach or have taught WIN courses in these fields. We conducted a series of student surveys over the course of two semesters, Fall 2014, and Spring 2015, with one survey at the beginning of each semester and one at the end, as well as one faculty survey in the fall of 2014. We only collected data from students and faculty in the following WIN courses: Communication in Mathematics, Complex Variables, Molecular Systems Biology and Genetic Chemistry, Current

Topics in Biology, Advanced Biochemistry, Invertebrate Zoology, Systems Engineering Senior Design Project, and Engineering Project Management and Proposals, because these were the courses offered during the duration of our data collection. At the time of this study at TAMIU, a website called *Angel* was used by the students to regularly access their courses for grades, lessons, and homework submissions. The student survey was posted on the *Angel* website, and only the registered students in STEM-WIN courses were invited to participate electronically. Also, an exemption of The Institutional Review Board (IRB) was obtained from TAMIU for the data collected. The pattern of volunteer participation varied through each survey, with more students participating at the beginning of each semester, as is documented in Figure 2. The four surveys were open for a period of two weeks and consisted of multiple choice, multiple select, and essay questions. The participants' responses were recorded through *Angel* as well. In contrast, the faculty survey was available through SurveyMonkey®, a website focused on creating surveys and collecting their results. The faculty survey consisted of only four questions to support instructor's comments and suggestions towards these WIN classes. In the following subsections, we will describe the pre- and post-semester surveys, as well as the faculty survey with sample details.

Pre-Semester Survey: The pre-semester survey was conducted during the first two weeks of each semester, once in the fall of 2014, and once in the spring of 2015. The survey encompassed fourteen questions (see Table 1. for a sample question). The survey asked for demographic information, such as gender, age, GPA, academic grade level, and primary language spoken. In addition to the demographic information, the survey inquired about the students' expectations of the WIN course, and the reason they decided to enroll.

Post-Semester Survey: At the end of the semester, the students had already experienced the WIN course, so we wanted them to share their opinion based on their experience. The post-semester survey was conducted during the last two weeks before the end of classes of each semester, in the fall of 2014 and then again in the spring of 2015. This survey encompassed 25 questions. Similar to the pre-semester survey, the post-semester survey asked for demographic information but some of the other questions were different (see Table 2 for a sample question). Therefore, in the post-semester survey, the questions were about how the course met or did not meet the students' expectations, whether or not the students felt they benefited from the course, what new information they learned, and whether or not the students' writing and research skills had increased.

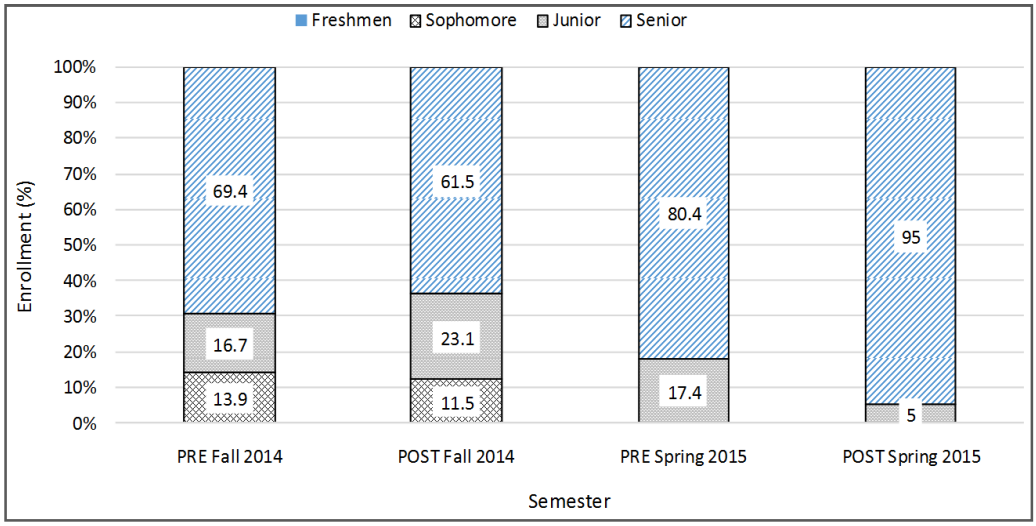

Figure 2. Type of Enrollment per Academic Grade Level

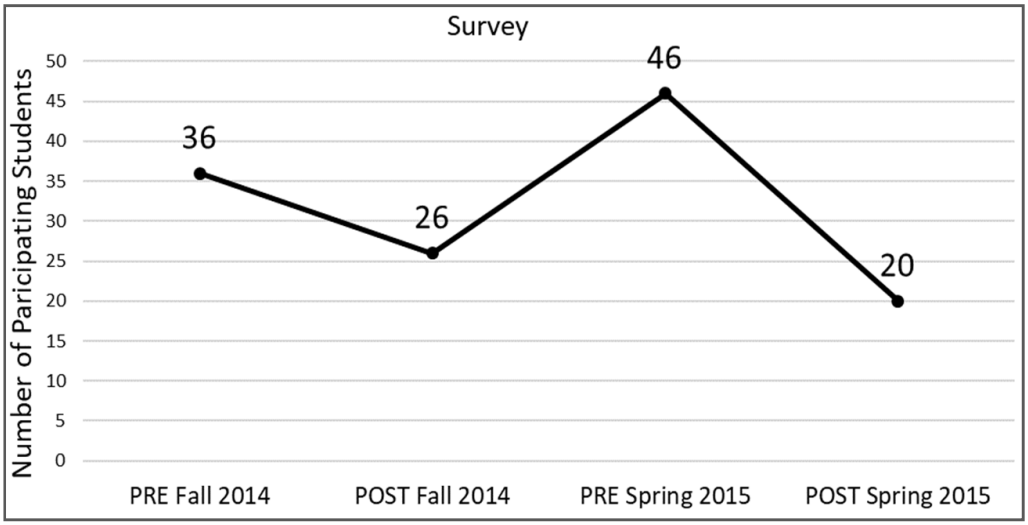

Figure 3. Student Participating per Survey

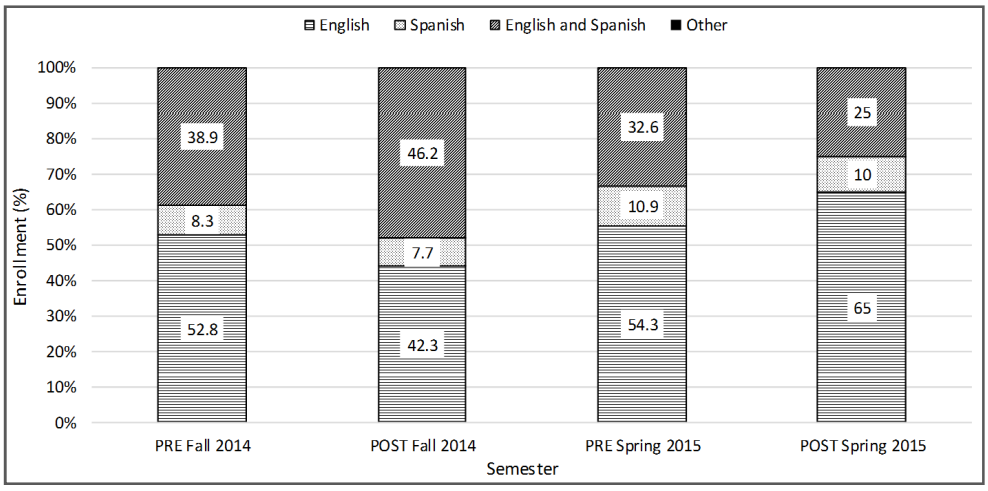

Figure 4. Enrollment vs. Primary Language

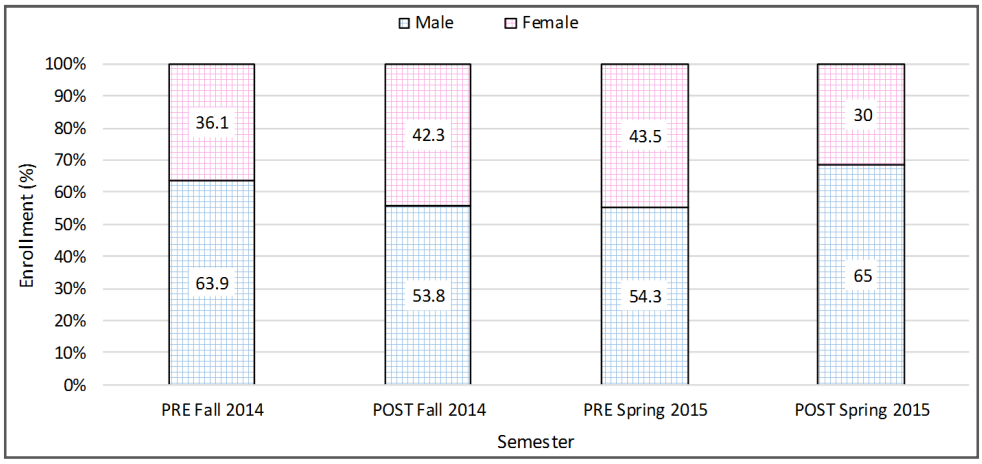

Figure 5. Gender Enrollment

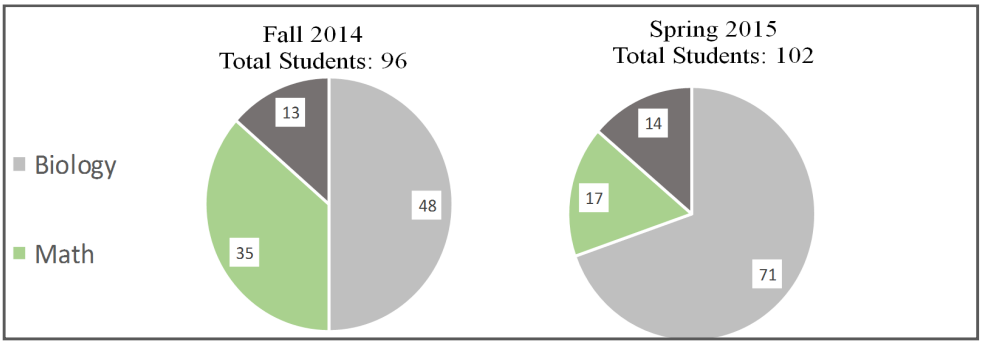

Figure 6. STEM WIN-Course Enrollment per Semester and Major

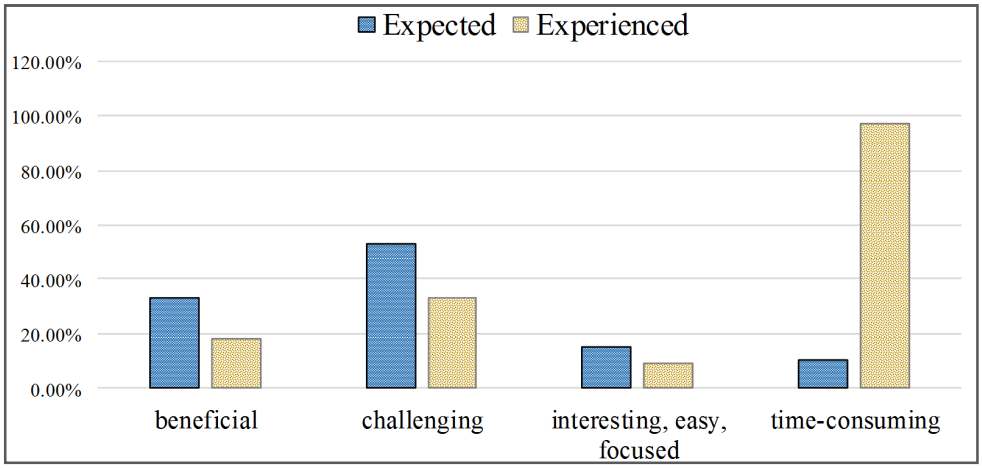

Figure 7. Student Expectations and Experiences

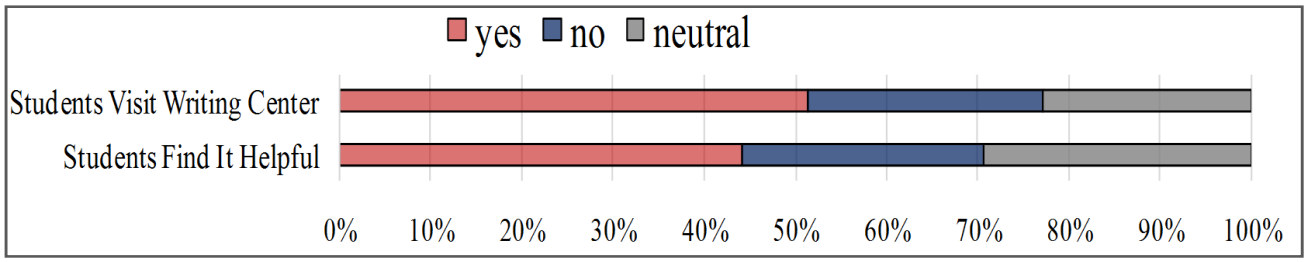

Figure 8. Student's experience at writing center

Table 1. Sample Questions for Pre-Semester Survey

Sample Questions for Pre-Semester Survey	
Question	Response Options
What are the most frequent reasons for enrolling in WIN-courses? (select all that apply)	a. A part of major / minor requirement b. A part of major / minor requirement without knowing what a WIN-course means c. To improve research experience d. To improve writing skills e. To improve knowledge about a certain topic
Do you prefer WIN-courses to be conducted under the honors program at TAMIU?	a. yes b. no
If you selected either yes or no, tell us why?	[essay response]

Table 2. Sample Questions for Post-Semester Survey

Sample Questions for Post-Semester Survey	
Question	Response Options
For a major requirement, do you want your WIN-course to be fixed by the university or do you want to select it?	a. Fixed by University b. Selected by student
By the end of the semester, your experience toward a WIN-course is … (select all that apply)	a. easy b. hard c. neutral d. joyful e. challenging f. same g. motivated h. beneficial
Writing in LaTeX or Microsoft Office is a tool that enhances my learning	Strongly agree Agree Neutral Disagree Strongly disagree

Table 3. Complete Faculty Survey Questions

Complete Faculty Survey Questions	
Question	Response Options
Are you teaching or have you ever taught a WIN-course?	a. yes b. no
For a major requirement, do you think the WIN-courses should be fixed by the university or selected by the students?	a. Fixed by University b. Selected by students
To satisfy the WIN-course requirement in the major and to give faculty and students more options, would you be in favor of a limited number of slots (about 5) being reserved for WIN registrants in every course in the major?	a. yes b. no
Other thoughts about WIN-courses?	[essay response]

Table 4. Undergraduate Ethnicity for Duration of Study

Undergraduate Ethnicity for Duration of study		
	Semester	
Ethnicity	**Fall 2014**	**Spring 2015**
American Indian	4	3
Asian / Pacific	40	35
Black	38	30
Hawaiian	3	3
Hispanic	6371	5801
International	127	112
White	144	132
Unknown	14	11
Total	6741	6127

The survey also asked the students if they had any ideas or comments about how the WIN course could be improved.

Faculty Survey: In addition to the four student surveys, we conducted a survey for the faculty (see Table 3). The faculty survey was designed to collect information on the faculty's support of the current administration of WIN courses at the university. It consisted of four questions, three multiple choice and one essay. The survey provided the faculty an opportunity to share any other thoughts about the WIN courses through the essay question.

Pattern of Enrollment in WIN Courses: Our data analysis showed that the pattern of enrollment in WIN courses varied due to gender, major, academic grade level, and primary language spoken, among other aspects (see Figures 2, 3, 4 and 5). In both the fall and spring, most STEM students enrolling in WIN courses were in the biology majors, and the fewest were in systems engineering (see Figure 6). The data also represents that there are more biology courses being offered as writing intensive at TAMIU than math or engineering. In addition, the total number of STEM students enrolled in WIN courses is higher in the spring because there are more STEM-WIN courses offered than in the fall semester, and Spring semester is closer to the end of the year graduation. In Table 4, we summarize the ethnicity of the undergraduates at TAMIU. This reflects the predominantly Hispanic community on campus and in the city. Most of the participants were seniors and juniors, with a few sophomores in the fall (see Figure 2). This told us that most of the students enrolled were from higher classifications. Most of the participants responded that their primary language was either English or both English and Spanish, so we could confirm that most of the students enrolled in STEM-WIN courses were familiar with writing in the English language. Also, the participants reported to have a GPA of 2.0 and higher, meaning they were mostly prepared for the intensity of these courses. These demographics helped us examine some of the factors involved in the students' success in STEM-WIN courses.

DISCUSSION

In this section, we analyze the students' survey responses regarding the students' experiences in these STEM-WIN courses. This will start from reasons for enrollment to helpful tools used through the course to determine what aspects need improvement. We also considered their level of satisfaction with WIN courses curriculum and instructional coherence.

Reasons for Enrolling in STEM-WIN Courses: All 76 students that completed the surveys reported that they enrolled in the WIN course to fulfill graduation requirements, about 17% of them did not know what a WIN course was when they enrolled. Also, 25% of students that enrolled in these courses had other goals; for example, they enrolled for self-improvement purposes such as enhancing their writing skills, increasing their knowledge on a topic of their choice, or gaining the research experience necessary for their future graduate studies. In Figure 7, we represent the students' reports about WIN courses. Although most of the students believed they would benefit from WIN courses, they would probably not enroll in them if it was not required by the university. In addition, when students were informed about what a WIN course was, they felt unprepared. They did not know what to expect from the course and they felt that they might be overwhelmed with the amount of writing needed.

Student expectations, experience, and satisfaction with STEM-WIN Courses: In the pre-semester surveys, we asked the students what they expected from a WIN course. In the responses, about 32% of students thought it would be beneficial to them, and about 52% thought it would be challenging, while 15% of students thought it would be interesting, easy, and focused on their major. In contrast, about 10% expected it to be time-consuming and unrewarding. As demonstrated in the Expected vs. Actual Final Average per Semester, most students expected to obtain grades higher than 70, and no students expected to drop or fail the course. This indicates that although the students expected the courses to be mostly challenging, they expected that they could succeed in them and may depend on help from the Writing Center or the course instructors. In other words, whether the students expected the class to be challenging or not, the fact that the writing component was 60% of the grade enticed the students to put in the writing effort necessary to avoid failing the class. Students also suggested extending due dates. They commented that they felt overwhelmed with the writing assignments and did not have time to put as much effort into their other classes.

They stated that in order to make the course less time-consuming, the professors should only assign 5 written assignments that focus on their major and about 23% said they prefer to work in groups on their projects since these courses require plenty of time and effort. Additionally, about 26% of students suggested that there should not be more material added as lectures for at least the last two weeks of the semester so they can focus on completing their final research project. The students also reported that some courses require less writing than others, and this can discourage students from taking the WIN courses seriously. In the survey responses, 20% of students stated that they were not required to write 1-5 pages weekly. This implies that students focused more on the amount of writing rather than the topic of the course when deciding what WIN course to take. For example, in the biology courses, which have more diversity and course choices, students may enroll in a class based on how much writing is required and not the content, the topic of interest, or self-improvement reasons stated in a previous section. Also, some of the students believed that writing is unnecessary in their future careers. At the end of the course, we examined the students' experiences through their ability to meet due dates, their writing skills, the knowledge they gained, and their overall opinion of the course.

Thirty-two percent of the students reported their overall experience in the courses was challenging, while 18% reported it as beneficial. In addition, about 9% of students reported that their experience was easy and joyful, and about 10% responded that they felt motivated. The motivated percentage was significantly low. To understand why the students' experiences were mostly challenging, we asked them whether they were expected to write 1-5 pages weekly and only about 25% responded yes. The inconsistent writing component may explain why the students' grades varied throughout the disciplines. The data also indicated that not all WIN courses were instructed uniformly in regards to university policy of the writing program, even within the same discipline; some courses required more writing than others, so many students were trying to take the one that seemed the easiest towards their degree, meaning fewer writing assignments and easier prompts. Additionally, about 97% of the students thought the course was time consuming because of the intensive writing

component. Although the students felt that the course was challenging and time consuming, about 65% of them were meeting the due dates of assignments. In fact, 80% of participating students felt that the course met their expectations toward improving their writing and research skills, and about 42% of students felt that they improved their language skills. The effort the students put into these courses does prove to benefit them. Also, in math WIN courses, the students were required to write in LaTeX language. The instructor taught them the basics of LaTeX in the first two weeks of the semester, and they had to submit their assignments in LaTeX for the rest of the semester. Based on the math students' experiences in their WIN courses, about 40% of the students reported they preferred Microsoft Office and about 11% were eager to write in LaTeX; more than half believed writing in either of these two modes enhanced their learning. Upon taking the course, the students expressed that the requirement to write, whether it was in Microsoft Office or LaTeX, helped them write more efficiently for research papers, literature reviews, essays, lab reports, and homework assignments. Despite this fact, about 14% of students felt that the WIN course did not meet their expectations and about 5% felt that sometimes it did and sometimes it did not. This may have been because they believe writing is unnecessary in their field or that the writing was not focused on their interest.

Also, while about 77% of faculty said they were satisfied with the WIN courses being fixed, about 21% of participating students said the same. In contrast, about 22% of faculty and about 75% of students said they wanted classes to be selected by students. This means that students would like to choose from all WIN courses offered within their major, the one that would most interest them. The difference in support for fixed courses between faculty and students may be attributed to the students' desire for more diverse subjects to choose from and the faculty's concern about increased implementation challenges and workload. At the time of this study, students could take the STEM-WIN courses at TAMIU in any order. We asked the students if they were satisfied with this availability of WIN courses or if they would have preferred for them to have prerequisites. The responses showed that about 56% of the survey participants wanted the STEM-WIN courses to have prerequisites, while about 30% did not. Also, about 9% first said they should not have prerequisites, but after the course, they said they should. This may be because they initially did not know what to expect in the WIN course, and after the semester, they realized a prerequisite course might have helped them succeed. In contrast, 3.9% of students first said the course should have prerequisites and later changed their mind. In this case, the students may have expected the course to be challenging, but then they realized they were prepared and did not need a prerequisite course.

University Honors Program and STEM-WIN Courses: At the time of this study, the University Honors Program offered undergraduates the opportunity to challenge themselves with an enhanced curriculum of rigorous honors core courses in the students' major. The STEM-WIN courses were available to all the students at the university, whether the students were part of the Honors Program or not. In the survey, we asked the students if the courses should continue to be offered for everyone, or if the courses should be exclusive to the honors students. About 35% of participants said they preferred for the WIN courses to be conducted under the honors program because they felt that the honors students should be challenged more, or they felt that the courses had a level of intensity that was only found in honors curriculum. On the other hand, about 46% said the WIN courses should be offered to everybody since not every student is enrolled in the honors program and they all deserved the opportunity to improve their knowledge and writing skills, which would benefit their future careers. Additionally, about 18% of students changed their minds between yes and no; maybe because they were unfamiliar with the honors program or they were unsure which mode of offering the courses would be more beneficial.

Writing Center and STEM-WIN Courses: The TAMIU Writing Center employees, or writing tutors, usually assist undergraduate and graduate students with their written assignments from various disciplines. They provide help with brainstorming, organization, sentence structure, research, and provide feedback for revisions. Students enrolled in WIN courses are required to make regular writing center visits as part of university policy. Regarding the Writing Center, about 51% of the student survey participants said they visited the writing tutors for help; about 25% said they did not, and about 22% may or may not have used the tutoring services. We also asked the students if they felt that the writing center helped them improve their writing skills. About 44% of the students agreed that visiting the writing center helped them, but about 26% said it did not, and about 29% remained neutral. Also, about 22% suggested that the number of visits to the Writing Center should be reduced since it is difficult to schedule an appointment, especially during midterm exams and/or finals.

Completion Rate: In order to be classified as successfully completing a WIN course, the student must obtain a C (70-79%) or better in the course. After examining students in STEM writing intensive courses for one school year, Fall 2014, to Spring 2015, we found several patterns in the completion rate. In other words, the successful completion rate varied among fields or courses = casing. For example, systems of engineering had a 100% successful completion rate, Biology had 91.6%, and mathematics had the lowest successful completion rate of only 75%. The results showed that although most students expected to obtain an "A" in the course, most of them obtained 89 or lower. The highest averages were found in the engineering and biology courses. As for the mathematics courses, Communication in Math had the highest number of withdrawals, and Complex Variables had the highest number of failing grades. Furthermore, about 6% of the students dropped the course within a month. This finding may correlate with the data about the students' primary language. A small percentage stated Spanish was their primary language, so the small percentage of drops could also be attributed to this. Another main reason a student would drop the course is the lack of understanding of what a WIN course is in the first place. The percentage of students who dropped is significantly lower than those who completed the course successfully. In addition, many of the students believed that WIN courses were time-consuming. It is also possible that some of the students were overwhelmed by the amount of writing, especially if they were taking more than 15 semester credit hours.

What data suggest about the coherence of win programs in STEM fields: The presented study intends to find evidence of learning from multiple experiences in STEM-WIN courses to guide local program development. The study formulated a student and faculty survey to answer specific research questions based on student, instructor, and university concerns.

Typically, writing classes are a priority at all levels across the curriculum. From the data collected, we can observe that the WIN courses completion rates in STEM fields at TAMIU are below expectations, especially in mathematics. Many students are afraid of enrolling in these courses because they think WIN courses are more difficult than regular courses. They also do not value the writing process as facilitation of their understanding. The study also addresses numerous concerns that are fundamental to STEM education and for TAMIU students. For example:

- ✓ What do experienced STEM students consider to be beneficial when enrolling in WIN courses?
- ✓ How do these students see the relationship between WIN instructions and course work?
- ✓ How does WIN class size affect student's success?
- ✓ Are writing assignments contributing to the student's course grade as a passing grade despite their understanding of content?
- ✓ Are critical components of WIN courses standardized or different from one discipline to another?
- ✓ Do students need to use different types of writing to reflect their learning experience?
- ✓ Do instructors provide sufficient feedback about WIN course requirements?

Similar problems or concerns might be a challenge not just at TAMIU but also at many other institutions that might prevent them from adequately transforming their students into effective communicators, active learners, and professional writers within and/or outside of their discipline. Also, not enough attention has been focused on the variation in design and how these design decisions impact student outcomes. According to Julie Reynolds, Christopher Thaiss, Wendy Katkin, and Robert Thompson, Jr. (2012), a significant challenge in science education is how to move students from thinking about science as a collection of facts to be memorized toward a deeper understanding of concepts and scientific ways of thinking. Within undergraduate science, technology, engineering, and mathematics (STEM) education, one approach that has garnered considerable attention is learning-to-write strategies designed to improve student scientific writing (Moskovitz and Kellogg, 2011). In contrast, there has been a relative neglect of writing-to-learn (WTL) using writing to improve student understanding of content, concepts, and the scientific method (p. 17). This brings us again to WIN programs as one of the most useful tools that can be designed to improve not only STEM students' writing skills, but also to increase their knowledge on a topic of their choice and enhance their research experience. A question arises here: in order to help build professional STEM students, do we need to design WIN programs where the writing to learn (WTL) process strengthens gradually from the first day until graduation, or do we just want them to experience it at a certain level (freshman, sophomore, junior, or senior) of their degree? Having reported the findings of the case analysis and other models used, our focus now will be on developing a new theoretical approach with more coherent structure as a STEM-WIN program. The new model will help overcome challenges where students need to be more confident about the benefit of this WIN experience and how it can develop their thinking about writing as an integral part of the learning process. We will also describe some important initiatives and practices for a coherent STEM-WIN program. We also believe that the conditions that foster these writing patterns through increasing quantitative course requirements (i.e., page counts) on a condensed one-level experience may hamper students' ability to adopt qualitatively better writing strategies.

Developing a STEM-WIN Focused Model: After closely monitoring the STEM-WIN courses for more than 3 years and analyzing the TAMIU experience and literature, the lead authors propose a new model called the *STEM-WIN Focused Model* as a more active learning approach that can ensure the importance of developing a sound core of career-relevant writing skills, and learning how to keep developing these skills to meet changing professional demands. The proposed model will set down a very specific Research project-based Learning methodology via Writing (RbLvW) that can engage more students, increase their level of academic preparation, and simultaneously use WIN courses as a gate to integrate that learning process in STEM Education. The *STEM-WIN Focused Model* is an original and emphasizes on two approaches: first Learn to Write (LTW), and second Write to Learn (WTL). It also emphasizes the concept of mentoring networks rather than the traditional notion of the dyadic mentor-mentee relationship. The mentors in the network will be from both the academic and the non-academic areas, and they are to connect, collaborate, and concert their efforts towards their student's success on every level. Moreover, the mutual open communication among mentors will provide the opportunity for the mentee to clarify, refine, and hone their steadily acquired knowledge and skills. The mentor-mentee interaction will consist of four series of activities in a spherical level (two from LTW level and two from WTL level), which will train and build gradually new knowledge via research and project-based-learning. The new model focuses on how to transform students from thinking about science as a collection of facts to be memorized towards a deeper understanding of concepts and scientific ways of thinking. These levels will help students apply their acquired knowledge with the highest sense of ethical and social responsibility. It will also measure the students' interest in the STEM discipline as well as their success along the path to graduation.

The innovative thinking in this model was manifested through combining and hybridizing a network morphology with the layering of context which will develop a new pedagogy for STEM education in general. The *STEM-WIN Focused Model* offers a unique opportunity that helps integrate many rich and diverse STEM experiences and practices among U.S. institutions into one model. It will empower and build authentic science skills and practices via writing that help students build confidence and take the lead in learning how to explore, communicate, and reach other people. Also, this architecture network is designed to cultivate the seamless mix of context that will support the transmission of knowledge between mentors and mentee. It will also create a *STEM-WIN Focused Platform* that will consist of an appropriate mix of methods in running a successful series of RbLvW. The STEM packet will enhance STEM education curriculum by cultivating a sense of importance of writing via thinking, speaking, and communicating logically in the discipline, improving faculty teaching approaches, and increasing partnerships between academia, industry, and others to translate their needs through (both the short and the long term) RbLvW. This will cultivate 21st-century skills so desperately needed in the workplace and help ensure that the diverse minority students will earn the highest preparation for their future careers. On the other side, other universities can benefit

from this experience and overcome similar organizational crises in various contexts. Choosing this exciting and engaging STEM learning environment will develop new curricular materials and new methods of instruction. It will also adequately transform people's mindset towards the big impact of writing in STEM education, which shifts students from trying to improve their writing skills for academic requirements to focusing more on students' success. Such model does not exist in the literature yet.

Mechanism of the Model: The new layering context technique of RbLvW will be introduced in a series of four with two different levels: grammatical and stylistic, then writing in the discipline and outreach writing. This new pedagogy will encounter virtually all types of writing an academic student might need before graduating and will help students cultivate a sense of importance of writing in transforming them to critical thinkers and professional communicators. During this series, instructors will enforce the use of varying writing styles, teaching the difference between narrative writing and scientific writing, which includes quantitative and qualitative reasoning. Furthermore, clear instructor's guidelines and feedback on students' drafts and revisions will promote their learning of the course material. It will also refine important habits and skills such as ability to read strategically, communicate clearly in writing or during presentations, and it will lead to increased confidence and competence. We will need to start with some initiatives.

First Initiative: The university needs to offer, with the help of the Writing Center and the Office of Information Technology, a STEM-WIN Course Orientation to first- and second-year STEM students.

All freshman and sophomore students, before enrolling in any WIN course, need to attend a *STEM-WIN Program Orientation*. The purpose of this orientation is to educate students about university expectations in STEM fields and provide them with the necessary information needed to know what a STEM-WIN course means. It should explain the connection between such courses and their careers, and how these courses are structurally different than their regular classes (depending on the discipline). The orientation should notify students about the intense writing component in these STEM-WIN courses so students do not get overwhelmed by the high amount of time and attention these courses require after already enrolling in the courses.

The university academic advisors also need to ensure that students are not overwhelmed when registering for STEM-WIN courses, since they will need to plan enough time to focus on written assignments, drafts, visits to the writing center, and visits with their faculty. In addition, students need to know during the orientation that these STEM-WIN classes will provide students the opportunity to get ready to engage within and outside of their discipline. It will challenge their learning experience and enhance them to reach other programs such as Women in Science, Statistical Data Mining programs, NSA for undergraduate research …etc. It will inform them about the Learning Management System (LMS), used like Blackboard, and other online systems and how to use the droboxes to submit their writing work. Also, in the orientation, the university will explain the role of the writing center in supporting writing assignments and how it is important that students schedule themselves during the course period if needed. By engaging in these practices from the beginning, the university will ensure an improvement in the image of such courses and help students have better expectations of what a STEM-WIN course is all about. Furthermore, this initiative would also require the university to support the continuous network effort between departments, faculty, writing center, and office of information and technology to fulfill students' needs for success. They should be more explicit in their explanation of STEM-WIN course requirements, and students should have enough choices of these classes to select from within their major. We suggest these courses should be considered to be RbLvW courses, focused on STEM fields.

Second Initiative: A team of faculty need to work together to develop RbLvW pedagogical techniques and improve *STEM-WIN* courses structure to benefit its students.

New pedagogical techniques that have better layering context need to be created to motivate students to be more engaged and prepared for their future careers. This, in turn, will help them value the benefit of registering in such courses. For example, these courses should be RbLvW, focusing on grammatical, stylistic, writing in the discipline, and outreach writing. These courses can be designed as a series that could be run over four semesters through the curriculum. Such pedagogical techniques would include virtually all types of writing an academic student might need before graduating. It will also help students cultivate a sense of the importance of writing in transforming them to critical thinkers and professional communicators. Many faculties see teaching WIN courses as teaching with added labor. The faculty may be reluctant in taking the initiative because of the intense time commitment needed. They may not be motivated to put forth more effort to explain and determine all instructions needed on the writing assignments. The university, with the help of the Writing Center, can strengthen the faculty productivity by implementing the following actions.

Train and give privileges to interested faculty and let them understand their own responsibility when teaching STEM-WIN courses: These trainings should prepare faculty to organize their schedules and have the appropriate time needed to: (a) explain and determine instructions about the length and timeline for students' assignments and type of research work, (b) provide students with instructions on what topic choices are the best related to STEM fields and their interest that will improve the students' critical thinking and innovation, and (c) help students with their writing assignments when enrolling in such courses.

Provide writing assistance employees: These writing assistance employees can collaborate with the faculty to help accomplish their goals in the appropriate time and better serve the students and follow their revised assignments.

Support faculty to create a STEM-WIN Platform: The STEM-WIN platform consists of an appropriate mix of methods needed in running a successful and engaging series of RbLvW. The platform would also help faculty develop their expertise based on knowledge and help them connect their research work with engaged students to support STEM academia needs. We all know that WIN courses aim to develop students' critical thinking and understanding of the content through essential writing practice (like written assignments and research projects). It may seem odd to assert that the

opportunity to reflect on one's *pedagogy* is a benefit when teaching WIN courses. In other words, to meet STEM students' expectations, university WIN program pedagogy and guidelines should apply to all WIN courses similarly. This means that to accomplish both the *cognitive* (writing to learn) and *rhetorical* (learning to write) goals of a WIN program, these courses need to focus on improving knowledge through a sequence of research projects and not individual homework written assignments. For example, guidelines for assignments might be designed to focus on:

- ✓ Writing used to help students learn course contents,
- ✓ Writing used to help students learn ways of writing in the discipline, and
- ✓ The number of writing assignments communicated in writing in the WIN course.

These assignments may also share the same descriptions of practices for individual conferencing, revision policies, and syllabi statements, but they might have different instructor guidelines. Instructor guidelines may require or recommend different types of assignments throughout the WIN course; for example, individual instructors may ask to generate assignments that discuss ethical issues of the discipline or expose students to a disciplinary problem to be solved, or to a question on which experts disagree. On the other hand, instructors teaching these courses need to share and follow the same university pedagogy and guidelines (rubric descriptions) about the purpose and the amount of writing needed in these WIN courses. As we can see, the relation between the university and faculty is a crucial element needed for the success of STEM-WIN courses, and support of the above practices will prevent the major loss of students from STEM fields.

Third Initiative: **We need to bring students' voices to that dialogue:** Serving the needs of students within a STEM-WIN Focused Program has also become a matter of programmatic concern. There are many ways of monitoring the success of students and the program. One of the best sources to find new programmatic developments is to coordinate with campus services (e.g., the registration office, writing center(s), peer tutors, and other people involved). For example, the *Student Expectations and Experiences* diagram (see Figure 7) shows that a high number of students find WIN courses time consuming and challenging, and some students reported that WIN courses played an important role in their learning and helped them become better thinkers. Also, 23% liked working in groups and having small size WIN classes, about 22% suggest reducing the number of visits to the Writing Center since it is difficult to schedule an appointment especially during midterm exams and finals, and about 26 % suggested that there should not be more material to be added while lecturing for at least the last two weeks before the last class day so they can focus on finalizing their research projects. So, to ensure that students have enough time to focus on assignments, drafts, visits to the Writing Center, and visits with the faculty, the university needs to provide professional individuals who can develop new strategies and new responses to the complex contingencies of the unfolding situation with appropriate tactical decisions and practices. Such practices are essential for students' success in STEM-WIN courses and need to be taken under consideration. An example of this is how many math students found the mathematics WIN courses to be very challenging as summarized in Figure 7, the math courses had the highest number of withdrawals and failing grades). The students felt unprepared for WIN course material while also learning the required new LaTeX language. They felt overwhelmed. They reported that it would be better to have a prerequisite course introducing the LaTeX language before taking the math WIN course. This happened because writing in the LaTeX language was new to many of the students, and it takes time and effort for them to learn the basics and to apply it when doing their homework assignments. In addition, students reported that they really liked doing presentations about their topics. Also, over half of students believe that the university should let them select which courses they want to take as writing-intensive courses. Students also suggested that professors should only assign 5 written assignments that focus on their major. Such students' expectations can be achieved if the faculty and university team know how to articulate the reasoning behind curricular choices. Understanding students' needs for choice, purpose, voice, competence, encouragement, and acceptance can provide insight into some of the conditions needed to get students involved with academic tasks. Faculty need to provide more examples on how writing is used in the STEM fields and how it is useful to them in the real world. Also, increased competence inspires continued motivation to engage. This cycle supports improved student achievement. University and department chairs can also play a big role in supporting students' projects in WIN courses and provide them chances to participate in conferences.

By doing so, students can realize the importance of undergraduate research and the need of good communication skills when expressing their scientific thoughts. In addition, the university can take under consideration increasing WIN course options within related STEM disciplines. For example, at TAMIU, engineering and math majors have only two WIN courses in each major, so for students in these majors to meet graduation requirements, they must take both required WIN courses with no other options. To give these STEM majors more options, we have at least two options: one is to create new WIN courses for these two fields which will require more labor, and the other is to offer multidisciplinary WIN courses. Creating more options for students will raise student motivation, attention, effort, and success in STEM-WIN courses. We also list some of the good practices when dealing with such program.

First Practice: Strengthen the interaction between Students and Faculty: More attention from the faculty promotes more interaction with students. In addition, smaller classes can also increase an institution's attractiveness to students, boosting enrollment. Therefore, students enrolling in small-size classes are expecting that the faculty needs to work with them as a team with a final goal of students' success. In this regard, students should benefit from small class size and take advantage of scheduling themselves to meet with their faculty more often, on a weekly basis, and gradually increase the number of visits as needed. This teamwork ensures that instructors obtain accurate feedback about students' needs in their WIN courses and students are getting all the support they need to succeed. Also, it is important to clarify how writing will affect students' final grade. Many students sometimes report, "I should pass the WIN course since I submitted all of the writing assignments requested on the due date," but they need to understand that is not the case! It is true that university guidelines may recommend that grades on written work make up a certain percentage of the course grade, but this is a point

sometimes not easily negotiated in WIN courses taught by disciplinary faculty. For example, at TAMIU, a total of 60% of the grade devoted to writing would be good; 40% is probably too low. But, on the other hand, students in these WIN courses need to understand that faculty maintains final control over the shape of the course regarding student's input and knowledge gained over the semester. It might be best for students wishing to take a WIN course for WIN credit to receive an S (satisfactory) or F (fail) for the writing component of the course and have instructors separate the writing part of the grade from the rest of the course grade.

Second Practice: The Effect of the Writing Center on Student Success: The data presented in Figure 8, *Student's Experience at Writing Center,* demonstrated that only about half of students seek help from the Writing Center, but not all those students find the tutoring helpful. To improve the role of the Writing Center and boost its effectiveness, we present several initiatives. To begin, we need to support the collaboration between the faculty and the Writing Center as one of the main factors that needs improvement for the success of WIN courses. The Writing Center tutors must be trained to help faculty with their work, whether it is grading writing assignments or formulating guidelines for the course. In addition, they should provide information about thesis, research methods, and anything related to writing in the STEM fields. If the Writing Center gets involved in supporting revision of students' projects, students will feel more confident about their work and will encourage them to engage in meaningful visits for revisions. Furthermore, the Writing Center can help in facilitating the appointment process and visiting schedules. As soon as students enroll in a WIN course, they should automatically be scheduled for weekly appointments throughout the semester.

The appointments would be correlated according to due dates of assignments stated in the course syllabi. This way, students get first pick and get help when they need it. Of course, it would be the students' responsibility to attend these automatically scheduled appointments, and they must not miss more than three in the entire semester. By doing so, it will increase the students' interaction and confidence in the role of the Writing Center towards their success.

Conclusion

In addressing the challenge related to STEM pedagogy and practices in WIN courses in STEM fields and others explicated by Ashley, Cooper, Cala, and Brownell (2017), additional refinements of such programs are needed. At TAMIU, we examined the STEM-WIN courses with multiple experiences and found that in order to meet the university' and students' expectations, we need to report lessons learned from prior (unsuccessful) iterations to guide the development of more successful future programs. The work in this paper agrees with the theoretical framework introduced in section 1.2, and it mirrors the goals of research, intending to enhance the quality of education to make more informed evidence-based decisions in creating, implementing, and refining programs. A *STEM-WIN Focused Model* introduced based on RbLvW with many initiatives and practices that emphasize the importance of curriculum and instructional coherence structure of STEM-WIN programs is a priority for the success of STEM students. The new layering context of research-based learning via writing pedagogy is introduced in a series of four different levels: grammatical, stylistically, writing in the discipline, and outreach writing. The new pedagogical technique encounters virtually all types of writing an academic student might need before graduating and will help build a community of science faculty committed to undertaking and applying necessary pedagogical research. This will help resolve the absence of a conceptual framework to a systematically presence of guided studies that can integrate findings. It will also help students cultivate a sense of the importance of writing in transforming them to critical thinkers and professional communicators. Universities also need to monitor their WIN programs and improve them as needed. It is important that students realize that STEM-WIN courses strengthen their knowledge and help them build more personal relationships with professors, senior students, and other students to enhance their learning and help them succeed at large universities. The use of different types of writings and the faculty's feedback on their drafts and revisions promotes their learning of the course material. All in all, taking the one case of the STEM-WIN Course at TAMIU under consideration has helped to reveal new potential models and many initiatives and practices that will help strengthen the productivity for education in STEM fields. Finally, the goal of offering and continue improving STEM-WIN courses is to ensure that STEM undergraduates are in fact obtaining the necessary skills and experience needed to fill the STEM jobs.

Declaration

Availability of data and material: All data generated or analyzed during this study are included in this paper except the surveys. We can provide that as needed.

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Appendix

Biology and Chemistry: The Biology and Chemistry WIN courses at TAMIU at the time of the study are identified in (Figure 1). These courses had a cap of 24 students and required the use of Microsoft Office Word to complete the writing assignments. In the following section, we provide the writing components for some of the courses.

- ✓ Current Topics in Biology was a seminar course that focuses on topics of current interest in the biology field. In the laboratory section, students were required to complete reports on one of the topics of interest. This course incorporated writing in every assignment, quiz, and exam. It also required students to write several research papers. The student's final average grade consisted of a 100% written component.
- ✓ Invertebrate Zoology required the students to complete intensive field work and included a laboratory section. The required 60% of the course was based on the writing component.
- ✓ Molecular Systems Biology and Chemical Genetics focused on the discussion of current approaches to studying systems biology and included a lab section. Students were required to maintain a lab notebook to record entries for each lab exercise. They were also required to complete weekly short answer problem sets and a minimum of 13 pages distributed between 6 research papers throughout the semester. The intensive writing component made up 65% of the student's final average grade.
- ✓ Advanced Biochemistry was a course of detailed study through the use of literature sources. The written component of the course included homework assignments, quizzes, and exams, as well as the actual research papers so that the final average grade considered 100% of the student's writing. (TAMIU, 2015d)

In summary, the Biology and Chemistry WIN courses incorporated writing in the following ways

- ✓ Outside readings and assignments, such as a term paper;
- ✓ Writing homework assignments, or essay questions on exams;
- ✓ Outlines and drafts as preparation and development of writing;
- ✓ Revisions on each draft, following feedback;
- ✓ Lab and field journal entries and lab reports; and
- ✓ Oral presentations.

Engineering: The two Engineering WIN courses at TAMIU, Engineering Management and Proposals and Senior Design Project (see Figure 1), were required to be taken the year of graduation. Students were required to use Microsoft Office Word to complete their writing assignments. This section provides the writing components for both courses. The writing component of *Engineering Management and Proposals* made up 65% of the student's final average grade. It required students to complete *Technical Communication* as a prerequisite. Students were required to submit project proposals and technical reports including specifications, time lines, schedules, and budgets for every project that they planned to implement in the next course, *Systems Engineering Senior Design Project*, in which students built, tested, and documented the approved project they proposed in *Engineering Management and Proposals* within budget and schedule. The course required a written report and an oral presentation upon completion of the project. The written component corresponded to 60% of the student's final average grade (TAMIU, 2015d).

In summary, Engineering WIN courses incorporated writing in the following ways:

- ✓ presentations;
- ✓ homework related to project management;
- ✓ project proposal, including two drafts; and
- ✓ writing assignments about teamwork and ethics.

Mathematics: The two WIN courses at TAMIU in the Mathematics Department were *Communications in Mathematics* and *Complex Variables* (see Figure 1). This section provides the writing components for both courses. In the first course, the focus was on the writing of proofs within topics of set theory, logic, and properties of real numbers at an elementary level. Students were required to write their proofs using LaTeX language. This course consisted of a 60% written component. Students usually took Communications in Mathematics, in the fall, as a prerequisite for *Complex Variables* because the students were to continue to write using LaTeX language. The course also had a 60% written component (TAMIU, 2015d).

In summary, Math WIN courses incorporated writing in the following ways

- ✓ Write every week, through homework assignments, using an organized essay format;
- ✓ Write a main paper, for which they submitted two drafts before the final paper was due;
- ✓ Write a paper on ethics;
- ✓ Write a paper on their experience in the course; and
- ✓ Write for extra credit.

The STEM-WIN courses offered at TAMIU played a vital role in preparing students for their future careers, especially to communicate their scientific thoughts and findings effectively. The diagram in Figure 1 summarizes the relation between STEM-WIN courses at TAMIU and student success.

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