Using a discussion forum to encourage writing in a differential equations class

Van Lierde, V.

School of Science and Engineering, Al Akhawayn University, Ifrane, Morocco

v.lierde@aui.ma

Abstract: *In 2009, Al Akhawayn University, a liberal arts college in Morocco, started a Writing Across the Curriculum (WAC) program. The question that drove my action research project was how to make writing more continuous in a WAC class. In addition to the writing assignments, weekly prompts on the discussion forum of the Learning Management System were used in a Differential Equations class. The discussion forum was chosen for several reasons. First, it helps students to have a clear audience: who are they writing for? In this case, they were writing for their classmates. Secondly, the goal was also to encourage students to interact with each other. Students were invited to answer each other's questions or to comment on previous posts. When analysing the posts on the forum, it was found that students' participation in the forum (the number of posts) was strongly correlated to their course grade. Students indicated that they had learned both math and writing skills. However, interaction between the students was limited.*

INTRODUCTION

The past decades, different innovative ideas have been introduced in the teaching of mathematics. One of them is Writing Across the Curriculum (WAC). Students express thoughts and ideas in writing. This helps them clarify their understanding of and reasoning with concepts. They also learn how to write in the discipline: the writing done in the assignments, tasks, projects etc. is like the writing that people in the professions do. This has two benefits: students expand their writing skills, and their understanding of the specific subject matter improves as well.

In this paper, I describe my experience with this program, more specifically with one of the writing activities in a Differential Equations class at a small liberal arts college in Morocco. The university follows the North American system of education. Faculty can add the label "WAC-class" to a class if it is writing-intensive, which means that at least 10% of the course grade is devoted to assignments or other activities where writing is important. This is typically done through writing assignments: students get several short writing assignments over the semester. The grading is based on writing and on content. As graded writing seemed to be more discrete and was limited to

these writing assignments, it was natural to ask how to turn writing into a more continuous activity throughout the semester. This was the origin of the research question in an action research project: "how can I make writing more continuous throughout the semester?"

This study focuses on the prompts on the discussion forum for several reasons. First, students write better if they have a clear audience. In a forum, the audience consists of their classmates. Secondly, a student would be more motivated to write higher quality answers if they know that their classmates can learn from reading their answers online. And finally, I was hoping that this would also improve interaction between students, and hence, contribute to their learning. For years, students in my classes had been encouraged to post questions and answers on the course forum on the Learning Management System that is used on campus, but very few students did so. Our students often have a teacher-centered view on learning. They typically do not feel comfortable answering other students' questions, both in class and online. So, this was also a way to encourage students to use the forum and to form a community of learners.

Writing in mathematics has gained considerable attention since the introduction of the Writing Across the Curriculum concept. There has recently been a tendency to abandon an over-emphasis on calculations and computations, which have become almost obsolete because of computer technology. Writing is one way to return to conceptualization in mathematics, according to Gopen and Smith (1990). They stress the importance of a WAC program to help instructors teach and analyse writing. The key idea is to move from a "writer strategy" to "reader expectation." In the former, the writer asks himself what he can write, whereas in the latter, the writer asks whether the reader is 'likely to come away from this prose with the precise thought(s) I intended to communicate?' Thus, the emphasis moves from the writer to the reader. Thinking about how to answer this question makes the student more effective, and hence, better, writers. This 'reader expectation' approach was used when giving feedback to students in weekly lab reports in an introductory calculus course. It can be used in other subjects as well. Gopen and Smith (1990) also point out some issues that typically arise when using writing in a mathematics class. The first issue, which makes it confusing for students as to why and how they must write in a mathematics assignment, is the contrast between words and numbers. Numbers seem to refer to (the) truth, whereas words are associated with interpretation, hence with multiple truths. A second issue is that students narrate (or list things) than conceptualize (or explain), while the latter is precisely what we want them to do.

Similarly, Habre (2002) uses writing in a reformed differential equations class. In a reformed differential equations class, the emphasis is on qualitative analysis of solutions to differential equations (by looking at the geometry of the solutions), rather than on finding analytical solutions. The rationale behind this approach is that a lot of differential equations that occur in real-life problems can simply not be solved analytically, and for those differential equations that can be solved analytically, technology can be used to find the solution. Like Gopen and Smith, Habre

argues that the advance of technology has led to less emphasis on pencil-and-paper calculations, and more stress on concepts. Habre describes how changes in how calculus is typically taught, also reverberate in the teaching of differential equations (which is a course that heavily uses calculus). In calculus, the so-called "Rule of Three," which refers to an algebraic, visual, and numerical approach to concepts, is now often complemented by writing. By working with and writing about concepts, students can improve their understanding of the subject at hand.

Habre (2002) assesses writing as a mechanism to interpret results that were obtained geometrically, rather than as a tool to understand and learn concepts. Habre mentions that students have a challenging time accepting the idea of writing in math: "the idea of writing in mathematics is alien to them." However, by the end of the course, the students found that the writing they had carried out helped them learn. In the action research project described in the current paper, a discussion forum is used. Studies with this medium have been conducted, also in mathematics classes. Theoret and Luna (2009) claim that writing can help students to develop and extend their statistical reasoning abilities. The authors refer to Fulwiler (1987), who recommended "writing as a way to develop and extend thinking." Theoret and Luna assigned ten writing prompts in two different sections of a statistics course. One section responded through an online discussion board, whereas the other section answered through journal entries. So, the prompts were the same, but the students answered them in diverse ways. Theoret and Luna investigated the writing of the students and identified distinct categories. They argue that it is difficult to compare the writing of the students in the two sections: since the students are writing for a different audience (the classmates in the discussion board, and the instructor for the journal entries), their writing differs. Some themes that were identified by Theoret and Luna are: the use of concrete examples to make a point, and of personal connections to the topic at hand. Though Theoret and Luna had expected more questions on the discussion board than were posted, the students still asked more questions in the discussion board than through the journal entries. On the discussion board, students validated each other's answers, and there was dialogue and debate between students. This led to a "social construction of knowledge," which could not occur in the journal entries. Overall, students preferred the discussion board over the journal entries, and most of the students who had used the discussion board believed that they had benefitted from reading the responses of the other students. Baser, Ozden and Karaarslan (2017) found that virtual learning spaces, including forums, were beneficial for collaborative problem-based learning. Whichadee (2014) concluded that the discussion forum on a learning management system has the potential to improve students' writing skills, when used as a platform for EFL writing.

A more nuanced view is given by Schuck (2003), who concludes that the medium of the discussion board, although it does generate reflection and social learning, does not suit all types of learners. Schuck investigated a Question-and-Answer forum in a math teacher education program in Australia. According to Schuck, it is important to provide future primary school teachers of mathematics with examples of how they can encourage social learning among their future pupils.

Participation on the forum was part of the participation score in the course if the student chose so. Rather than having to answer prompts, students in this study could post and answer questions themselves. Usually, a core of students participated in the online discussion. There were also silent observers. 66% of the students who used the forum, found it interesting, because it helped them reflect and develop understanding in a way that might not have happened without the forum. Schuck believes that the justification and reflection on the forum led to a better understanding than by a classical lecture by the instructor.

Kay (2006) offers us another example of how a discussion forum can be used to impact learning performance. Kay used a forum with secondary school students learning introductory Computer Science topics (HTML and programming). Kay found a positive correlation between participation in the forum and learning performance. Like Schuck (2003), Kay found that the forum can be a strong tool in supplementing the regular classroom, as the online discussion went beyond what was covered in class. Participation in the forum counted for 10% towards the students' final grade. However, Kay noted that this policy must be reviewed carefully if the number of 'convinced' participants is limited. Kay also pointed out various difficulties in navigating a discussion forum, such as length of the messages, subject lines, and the number of entries. In our action research project, we tried to avoid these issues by using prompts and by setting time limits on the answers. According to Moller (1998), it is not best to let students decide on the direction of the discussion on the forum if one wants to achieve a higher-level discussion. For this action research project, it was decided to work with prompts instead of (or in addition to) an open discussion, to investigate the question as to how the writing can become more continuous in a Differential Equations WAC-class.

METHODOLOGY

Weekly prompts on the course forum were used in a Differential Equations course. This class is the fifth class in a math sequence. The students taking Differential Equations mostly major in General Engineering or in Engineering and Management Science. The group of students was small (12 students), and I am giving my own reflection on the process. According to the principles of qualitative research, there is no *a priori* theory or hypothesis that is being tested (Cresswell, 2003: 195). Rather, the goal is to see whether any themes can be distilled from the findings.

A total of 11 prompts were assigned on the course forum, about 1 per week. Some examples of prompts include:

(1) Concluding Chapter 2. Write advice for classmates reviewing chapter 2: address one or more of the following questions (answer with one or two paragraphs):

- What are the most important ideas?
- Is there anything that deserves special attention and why?
- Which common mistakes should they try to avoid?

- What did you find particularly difficult/confusing, and what did you do about it?
- Do you have any good strategies for reviewing this chapter?

(2) Comparing undetermined coefficients and variation of parameters. Some professors prefer to teach only variation of parameters, because it works in all cases (provided that certain integrals exist). Others teach only the method of undetermined coefficients because it works for many applications.

- What do you think is the best course of action, and why?
- There are no right or wrong answers to this question. Just make sure you justify your answer.

(3) Applications of unit step functions, convolutions, or the Dirac Delta function. Write one paragraph about an (=ONE) application of one of the following:

- Unit step functions
- Convolutions
- The Dirac Delta function

Try to find applications related to your major. If you are using online sources or books, then do not copy/paste but write in your own words what you learned, in a language that your classmates can follow. Include a reference to your source, for example a link to the web page you used.

The sole criterion for designing the prompts was that they had to be "writable," and there should not be one correct answer. The forum activity was included in the course syllabus, under the WAC component of the class. Students' answers to the prompts were graded and counted for 3% towards their course grade. For each prompt, students had a week time to respond. The appendix includes a few samples of students' answers. As I wanted to encourage interaction between students, I intervened as little as possible. Information was gathered through two questionnaires (one halfway through the semester, and one at the end of the term). These included the following questions:

(1) Have you responded to at least one prompt on the forum? Circle Yes or No.
(2) Do you feel you have had enough opportunities to express your opinions fully? Circle Yes or No.
(3) Explain your decisions to write or not to write on the forum.
(4) What have you learned by writing on the forum?
(5) What have you learned by reading on the forum?
(6) Do you have any suggestions: how can we make the forum experience more educationally useful?

The questionnaires were analyzed for common themes. The answers to the prompts were also examined. I investigated whether there was a correlation between the activity on the forum (number of posts) and the rest of the course grade.

RESULTS

It was found that 67% of the students wrote on the forum at least once. For comparison: Schuck (2003) found that 60% of the students never visited the forum. So, this was quite good. Activity on the forum was strongly correlated with the rest of the course grade: the students who had written more posts had overall course grades that were higher than students who wrote fewer posts. When analysing the answers to the question, three categories of answers were identified: math-related skills, writing skills, or other. By writing skills, I mean transferable skills related to writing. In both questionnaires, about half of the students who had written on the forum listed writing skills. Math-specific skills were also mentioned by about half of the students (some students listed several skills). Here are some examples of students' answers:

- "I learned many things from the material and how to express my opinion."
- "Several key points about the applications and uses of mathematics."
- "By writing on the forum, I learned how to express my opinion. It allowed me also to learn how to do research."
- "Applications of Euler; how do we analyze (sic) qualitatively/quantitatively functions' behavior?"

When asked what they had learned from reading on the forum, most of the answers were math related. When it came to motivation to write, only a minority of the students said they wrote to get the 3% of the course grade. Two students said that initially, they wrote for the grade, but then they started liking it and they realized it helped them learn, so they continued for that reason. The students who did not write indicated they felt that they had nothing to add, or they did not like sharing their opinions or thoughts with the whole class. There seemed to be a core of students (about half of the class) who responded most of the time. Also, the students' posts got longer as the semester progressed. So, some students really enjoyed the assignment. There was, however, little interaction between the students.

DISCUSSION

Writing was more continuous for at least half of the class. A considerable number of students participated in this activity. It is important to note that only 17% of the students had ever used a course forum before, and that most students use English (the language of instruction at the university, and the language used on the forum) as their second, third or even fourth language.

There was a positive correlation between forum activity and course grades. Students who took part in the forum did better in the course. However, correlation does not mean causality: students who wrote more and better posts, got higher course grades. However, this does not necessarily mean that their writing helped them do better in the class. It may be that the students who took this activity seriously do this because they are more conscientious in their studies. For this reason, it

was important to pair this correlation with the answers in the questionnaires, more precisely the answers to the question: "what have you learned by writing on the forum?" The students who took the forum activity more seriously articulated more skills and a higher learning output. This shows that the forum writing helped them learn. This was evident from their answers to the writing prompts on the forum, and from their responses to the questionnaires. The fact that the other students read their answers provided extra motivation, and helped students learn from each other. So, the forum is a useful tool for instructors who want to increase student learning and encourage students to write more, even in a non-native setting.

Some limitations of this action research project are the small class size and the limited interaction between students. The small class size may not have generated enough momentum to engage more students in writing. This activity did not lead to more spontaneous interaction between students, at least not visibly. The goal of increasing dialogue and interaction between students was not reached. Other means should be explored to encourage more student interaction.

In this context, most students have a teacher-centered view on learning. This raises the issue of whether this should be an optional or a required activity. On the one hand, students who wrote did benefit from the experience. On the other hand, students who prefer to interact through other venues should be given alternatives. Differences in learning and communication styles should be respected. Should online writing be optional or graded? Students need to learn to communicate with their peers, as they will need this skill in their future workplace. The fact that some students learned the value of writing because they were compelled first to do it (at least if they wanted to get the marks), which means that they may not have done any writing if there had not been any grade attached to it. In that case, they would never have learned that this was a useful activity.

CONCLUSIONS

The aim of this paper is to share my experiences in using the discussion forum in a mathematics class. The central idea in WAC is that writing should happen across different disciplines, not just in the standard composition courses. The emphasis is on writing to learn. The students who took part in the forums and interacted with other students through writing are getting value in terms of improved academic performance and comprehension of the subject matter. WAC is clearly a useful, albeit an incomplete, tool of Mathematics education. Future research needs to address whether WAC can induce cooperation among students in the form of written responses to their fellow students as well as study group formation. In addition, larger samples are needed to generate the statistics that can test its utility quantitatively. The questions that need to be explored include:

- What are the predictors of participation and buy-in among the students for WAC?
- What interventions can teachers use to encourage forum participation?

- To what extent do personal and demographic factors correlate with WAC participation?

With the rise of advanced, AI-equipped Learning Management systems, it is now possible to create team-written assignments with clearly delegated individual responsibility for text. The new LMS (Learning Management System) systems also allow the student immense flexibility in terms of viewing and interacting with other students' text. Consequently, there is an urgent need to study WAC further in these contexts.

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APPENDIX

We include some examples of students' writing, with no corrections made to the spelling and grammar used.

(1) Writing prompt: Concluding Chapter 2. Write advice for classmates reviewing chapter 2: address one or more of the following questions (answer with one or two paragraphs):

- What are the most important ideas?
- Is there anything that deserves special attention and why?
- Which common mistakes should they try to avoid?
- What did you find particularly difficult/confusing, and what did you do about it?
- Do you have any good strategies for reviewing this chapter?

Sample student answers:

Student A: "Chapter2 difficulty is mainly about detecting the type of DE and the method to use to solve it. This is why my advice is about doing as much exercises as possible to avoid losing time during the exam. The book companion Site:

http://www.wadsworth.com/cgi-wadsworth/course_products_wp.pl?fid=M20b&product_isbn_issn=9780495556237&discipline_number=1&token=5C64243E8BB6BE473E38D34A925BAC5F759A8772F28987177BCF3CD1C268CBFA5B87431A40DE1DA4CE299E423C789C21

the chapter2 review at the end of the book is a good practice. Also, there is a book in the reserve that offers a range of exercises."

Student B: "To review effectively for the 1st exam which is next Friday, you should manage your time and not cram until Thursday. Then, concerning chapter 2, I think as Student A mentioned, the main difficulty is to identify which method to use in order to solve the DE. And to reach that stage, you need to do 2 or 3 exercises solving each type so you can detect the method you're going to use before starting the exercise. This will help you not to waste your time during the exam that will be 90min long."

Student C: "In order to prepare for the first midterm this Friday, I advise my classmates to work on the problems in the Textbook and review the both assignments, and focus more on chapter 2 (which is more challenging) so as to be able to determine the method with which we would use to solve D.E problems."

Student D: "Chapter 2 deals essentially with special kinds of DE. It gives guidelines to follow in order to solve first-order DE, such as the DE's with separable variables, linear DE's using IF, exact and non-exact DE's, homogeneous DE's, Bernoulli's DE's and DE's of the form f(Ax+By+C) using substitutions. To pass the midterm, it's crucial to be able to identify each type of the DE's we have discussed in this chapter. Writing down the guidelines on the cheat-sheet would be a good idea since many of us get lost due to the stress of the exam. I think the most important and difficult part in the process of solving a DE is to find the integrals. Therefore, we must know how to use all the

integration techniques (integration by part, change of variable, partial fractions,..) by heart. Without those techniques, we won't be able to solve any DE. And be careful with the calculations !!"

Student F: "Regarding chapter 2, you should make sure you are able to make the distinction between the different types of differential equations. I believe solving the DE goes faster if you proceed in this order: start by checking if you can use separable variables. If not, check for linearity. Check if it is a Bernoulli's equation since these equations are easier to spot. Then check if it is exact or homogeneous. If nothing works out, try using a substitution u = Ax + By + C to reduce it to separable variables.

When solving a first order DE, one common mistake I try to avoid is to check for linearity in y and in case the equation is not linear in y, I check if it is in x before I conclude the equation is not linear and think about another method to use.

Also, before you start solving separable variables problems, you should review basic integration formulas and integration techniques."

Student G: "For chapter 2, the trick is to recognize the function and its type. If you know the steps for each type, it will be easy afterwards. That's why, practice is the key to succeed this course. Doing as much problems as possible will allow us to get familiar with each type."

(2) **Writing prompt Applications of unit step functions, convolutions, or the Dirac Delta function.** Write one paragraph about an (=ONE) application of one of the following:

- Unit step functions
- Convolutions
- The Dirac Delta function

Try to find applications related to your major. If you are using online sources or books, then do not copy/paste but write in your own words what you learned, in a language that your classmates can follow. Include a reference to your source, for example a link to the web page you used.

Student A: "In electrical circuits, we often deal with functions that change abruptly at a certain time t. One of the applications of the Unit step functions in EC is the switch on, switch off. Indeed, if we give the switch off a value of 0 and switch on a value of 1, while switching on/ switching off the, we will have functions that are portions of 0s and 1s. In this case, to find the function, we apply the unit step then Laplace transform and the inverse Laplace to find the expression of the function."

Student C: "Unit Step function: In many applications that are related to engineering, we find the functions whose values change at specific time t. For instance, in electrical circuit there is the voltage that can be switched on or off at specified value of time t. Such as functions are described by using the process of the Unit Step Function (and it's known also as the process of switching on or off)."

Student G: “Convolution: I choose convolution and physics field as its application. Convolution is present we have a linear system and we deal with superposition principle. For example, the potential of a charge is the convolution between an electric charge distribution function and electric potential function of a point charge. Another example would be in electric circuits: convolution makes an appearance between the input signal and the impulse response.”

Student F: “In probability theory and statistics, a probability mass function (pmf) is a function that gives the probability that a discrete random variable is exactly equal to some value. The Dirac delta function is used to obtain the probability mass function. If X is a discrete random variable that assumes the values a1, …, an with probabilities p1, …, pn respectively such that $\sum pi = 1$ for i E [1,n] then the probability mass function of X can be represented as $p(x) = \sum pi\ \delta(x - ai)$. The delta function can also be used to obtain discrete probability distributions as well as to compute the probability density function of a continuous random variable which is the function that describes the relative likelihood for this random variable to take on a given value. Reference: http://www.pvamu.edu/Include/Math/AAM/Vol3_No1/Chakraborty%20MAA-R14-071406%20Final%20_4_%206-12-08.pdf”

Student D: “The Dirac Delta function is used in image processing. An image can be represented using a Dirac Delta function. A picture can be considered as a sum of point sources. Each of these point sources can be regarded as the limit of a sequence pictures whose nonzero values become more and more concentrated spatially, and can be represented as a function which takes two values, 0 and 1, over certain intervals. For instance, it can be a rectangle function whose limit is the Dirac Delta function.

Source: http://r2labs.org/pct/Kak_Slaney_book/CTI_Ch02.pdf , 29.”