Flexible Learning Project Completion Report

Report Completion Date: 2015/11/19

1. PROJECT OVERVIEW

1.1. General Information

Project Name: 2014FL2_SCIE_MATH_Cytrynbaum

Principal Investigator: Dr. Eric Cytrynbaum

Team Members (Table 1.1) - *(Please fill in the following table)*

Table 1.1 - Roles and Responsibilities of the Project Team

Individual	Title/Affiliation	Responsibilities
Dr. Eric Cytrynbaum	Principal Investigator	Oversee project
Christina Koch	alumna, MSc. Mathematics	Prioritize and distribute work
Bernhard Konrad	alumna, Ph.D. Mathematics	Prioritize and distribute work
Dr. Fok-Shuen Leung	Faculty Member, Mathematics	Advisor
Dr. Warren Code	Skylight (Science Centre for Learning and Teaching)	Advisor, Administrative and Research Support

Project Initiation Date: 2014/04/01	**Project Completion Date: 2015/11/19**

1.2. Project Summary

The Math Exam Resources (MER) wiki, hosted on the UBC wiki, is a free online learning resource for UBC students taking large multi-section math courses, particularly first year calculus. The resource, located at http://wiki.ubc.ca/Science:Math_Exam_Resources, consists of over 1500 reviewed hints and solutions to more than 30 previous department exams, with all hints and solutions written and curated by math graduate students on a voluntary basis.

We proposed to develop and execute a study to measure how the MER wiki is used by students and how it impacts their learning, in particular mathematical understanding and problem-solving skills. This aim of the study was to help evaluate the benefits of sustaining the MER wiki as an online learning resource. As a second objective, we proposed an expansion to the scope and reach of the MER wiki to develop its potential and to increase its flexibility of use.

1.3. Student Impact (Table 1.2) - *Please fill in the following table for the period of time when your project was active. [Note: Adapt this section to the context of your project if this table does not capture the nature of it].*

The MER wiki went online in February 2012 and has been available ever since. In particular, the courses we service include MATH100, MATH101, MATH102, MATH103, MATH104, MATH105, MATH110, MATH180, MATH184, MATH200, MATH215, MATH220, MATH221, MATH257, MATH307, MATH312, MATH437 and therefore impacts all students enrolled in these classes.

Terms of study intervention (online surveys and in-person interviews):

Term 1 2014/2015, Term 2 2014/2015.

The developed resources remain available online at wiki.ubc.ca/Science:Math_Exam_Resources and www.math-education-resources.com

2. PRODUCTS AND ACHIEVEMENTS

2.1. Products and Achievements - *Please update the project products and achievements as necessary and indicate the corresponding implementation date [Examples: 10 online interactive lecture modules (SEPT-DEC 2013); A fully flipped course (JAN-APR 2014); Piloted two-stage midterms and final exam (SEPT-DEC 2013)]. Also please indicate the current location of such products [Examples: Department website, Connect, shared workspace, etc.].*

Table 2.1 – Products and Achievements

Product(s)/Achievement(s):	Implementation Date:	Location:
Built new web framework to address shortcomings and suggestions from students	NOV 2014 - ongoing	www.math-education-resources.com
Pilot allocation of TA hours towards curating content	JAN-APR 2015	Mathematics Department
Detailed cost-and-benefit analysis of long-term TA support from Math Department	JUNE 2015	Head Mathematics Department, Appendix B
Detailed report of study findings	NOV 2015	https://github.com/MathEducationResources/FL-TLEF_Report/blob/master/report.md, Head Mathematics Department, to appear in UBC cIRcle

2.2. Item(s) not Met - *Please list all of the intended project products and achievements that were not attained and the reason(s) for this.*

Table 2.2 – Item(s) not met

Item(s) Not Met:	Reason:

Google Analytics Analysis	Despite what was initially hoped, the project team was ultimately not granted access to any of the detailed MER analytics data (MER data was mixed in with all UBC Wiki data), only an incomplete and coarser data set was made available.

4. **PROJECT SUPPORT –** *Please provide feedback on the support you received during the life of your project, as applicable. Did the received support meet your needs and expectations? What can you recommend to improve the support process?*

At the beginning of the process we received a lot of help from Skylight/CTLT, in particular discussing the budget, timeline, finding an RA, and designing the online survey and cognitive interview questions. We further received extensive support from Warren Code with regards to data collection and storage. Warren was also very helpful in the second part of the project, when we prepared for the second-term surveys and interviews, and also helped us to keep on our timeline and budget.

However, in the second half of the project almost all of the active project members (Bernhard Konrad, Carmen Bruni, Iain Moyles, William Thompson, Michael Lindstrom) were rushing to finish their Ph.D. theses, leaving little time to properly complete this FL-TLEF project. More support in the final stages, like advice on what to include in the final report and how to best use the last remaining RA hours would have been very helpful. We believe that it would benefit future FL-TLEF recipients if there were a properly documented case study of a very successful project to provide some guidance at each phase (beginning, middle, and end) of the project.

Further, it was unfortunate that we were never able to excite the Department of Mathematics at UBC enough to support our group in the study or platform. Hence, with dwindling resources as MER members graduated, we had to "battle on several fronts" and complete the FL-TLEF project while also trying to make it as easy as possible for UBC Math to adopt our long-term sustainability model.

For future projects we encourage UBC to put a stronger emphasis on marketing the importance of sufficiently broad support from within the relevant department(s)/unit(s), so that FL-TLEF projects can meet their strategic goals. When our MER project required support from the department head or other faculty or staff member in the department, there was a clear sense of low priority, misunderstanding, and disinterest, often adding unnecessary obstacles and additional work to the project. A stronger marketing role would potentially engage the whole UBC community to helping FL-TLEF projects successfully meet their goals.

5. **PROJECT EVALUATION**

5.1. Project Outcomes (Table 5.1) - *Please list the intended outcomes or benefits of the project for students, TAs and/or instructors. Also include the indicators used to guide your evaluation, and what constitutes your project's success.*

Table 5.1 – Evaluation and Indicators

Intended Outcomes (e.g., increased active in-class participation)	**Indicator(s)** (e.g., number of students participating in class; quality of the interventions)	**What constitutes "success"?** (e.g., larger numbers of students participating in class; greater integration of content in their comments/questions; 10% attendance increase)
1. Training in project managements skills and data analysis (RA and all active team members)	-organizing meetings to set concrete objectives -delegating tasks to project coordinators -analyze student surveys and interviews	-reports and documents outlining successes and failures of objectives -properly understood and defined roles and contribution -reports highlighting patterns in student responses and impact of MER
2. Improve understanding of how students are using MER and how MER impacts their learning	-communicating to students through surveys and interviews	-finding a common response in the survey or narrative in the interview
3. Develop long-term sustainability model	-number of project contributors -priority of project within the department/university	-larger number of contributors -stronger faculty development, greater contribution of supportive and infrastructure resources
4. Develop new web platform to improve interactivity and impact	-quality of website -quantity of users -usage analytics	-website has more interactive features -number of users increases -students engaging with new features as indicated by analytics

5.2 Data Collection and Evaluation Method*s* - *Indicate your evaluation methods including who was responsible for the evaluation. Please describe the data collection strategies used, how the data was analysed, and perceived limitations.* ***Note: Please attach copies of data collection tools (e.g., surveys and interview protocols), any additional data or other relevant items.***

The student improvement project goal had data collected via an online survey and cognitive interviews with students. The survey and interview questions (see Appendix A) were designed by Carmen Bruni, Jiao Ji, Christina Koch, Bernhard Konrad, Michael Lindstrom, Iain Moyles, and Will Thompson (referred hereafter as the *project team*) with advice from Warren Code. The survey was an online survey hosted on UBC's previous online survey tool (Vovici EFM) and a link was distributed through the Mathematics department to students enrolled in undergraduate mathematics courses. The data was collected anonymously and stored by Warren Code on UBC's secure network storage solution Workspace. Students were asked to provide a contact email address (kept separately from their response data) so that they could be offered a complimentary version of a mobile app for the MER wiki as a gift for completing the survey. The survey had a

question indicating if students would be willing to be contacted for a follow-up interview and a random selection of 15 people who agreed to the interviews were chosen. The interviews were conducted with various members of the project team with one interview participant and 2 to 3 project team members per interview. Jiao Ji was present for all the interviews and was responsible for recording each of them. The interviews were transcribed by Carmen Bruni, Jiao Ji, and Bernhard Konrad.

The raw data for the online surveys was collected and analyzed by Jiao Ji for various tests of statistical significance. The analysis of these data and the full implications of these results are ongoing. The transcripts of the interviews were analyzed by Jiao Ji and summarized into broad categories of impact on learning and suggested wiki improvements. The final report which summarizes the conclusions from statistical analysis of data and inferences from interviews is available at https://github.com/MathEducationResources/FL-TLEF_Report/blob/master/report.md.

The main metric for project sustainability was a pilot project for departmental TA support on the MER wiki. The evaluation involved communicating with the TA in charge of the project and documenting their experiences and suggestions (see Appendix B).

A new web application has been developed by Bernhard Konrad, William Thompson as well as three volunteers Wing Wa Yu, Sida Zhou and Isabell Konrad. This new website, which is hosted at www.math-education-resources.com and mirrors the content of the wiki, has a fresh design and drastically simplifies the interface for contributors. It further lays the groundwork for more sophisticated analysis and display of MER's content, such as highlighting the most important topics per course and suggesting what question to work on next, based on course, topic, and user difficulty rating. The new web app has been active since November 2014 and the traffic has been shared with the initial MER wiki (hosted on the UBC Wiki), hence there is no independent analysis of its impact on student activity.

5.3 Evaluation Results/Findings - *Explain to what extent your intended project outcomes or benefits for students, TAs and or/instructors were achieved or not achieved. You are encouraged to include both graphical representations of data as well as scenarios or quotes to represent key themes.*

Training in project managements skills and data analysis

This goal was achieved to full extent. The roles of contributing were clearly understood by all team members throughout the project. An extensive final report has been created that summarizes the student responses to the survey and interview questions, and highlights MER's impact on students. We gathered plenty of new data and the final report gave plenty of opportunity to practice data analysis skills.

Improve understanding of how students are using MER and how MER impacts their learning

This goal was achieved to a satisfactory level, see the full report at https://github.com/MathEducationResources/FL-TLEF_Report/blob/master/report.md.

Develop long-term sustainability model

This goal could not be fully achieved. The number of volunteer contributors could not be increased significantly and faculty involvement was extremely limited. In fact, since the current contributors all graduated, there is no ongoing wiki development. However, we were able to pilot a sustainability model with graduate and undergraduate teaching assistants producing and editing solution content (see Appendix B) as well as a model where students contribute content as a review activity in their course (see Section 6.1 for details). This sustainability plan was discussed with the head of the Department of Mathematics as well as the faculty responsible for TA assignments. The implementation of this sustainability plan is a choice entirely up to the Department of Mathematics. We hope that the final report underscores the positive impact of the MER wiki on student learning and helps the Department of Mathematics sees the value in continuing the work on MER.

Develop new web platform to improve interactivity and impact

This goal was achieved to a major extent. We were able to automatically mirror the content of MER to the new platform (located at www.math-education-resources.com), increase the number of interactive features, and drastically simplify the process for contributors. Some of the new interactive features include multiple choice questions, an easier voting system, and a more streamlined topic search functionality mainly provide aesthetic improvements. However, the improvements of the content creation system can not be overstated in terms of how much they simplify the overall content contribution process. Using the old wiki, contributors needed to have a fairly sophisticated knowledge of the raw code involved, even for simple tasks like adding or reviewing solutions. This has all been automated through the use of custom graphical user interfaces. The overall goal of long term sustainability previously mentioned may not have been accomplished to a standard we would have liked in the lifetime of the FL funding, but the implementation of our new platform has made long term sustainability a much more attainable goal. As with the content of MER, all work on the new platform is open source under an open licence. Some features that could improve the interactive features of the website even further have been suggested but have not yet been implemented due to time constraints.

5.4 Expected Long-Term Impact – *If applicable, indicate the impact your project is expected to have in this and/or other courses beyond completion.*

The resources and web application developed with this grant will be online and useful to learners at UBC and elsewhere for years to come. As such, it will continue to impact thousands of math-taking undergraduate students. This remains true even in the absence of new contributors, since the current version has over 1500 solutions which will continue to be accessible to future cohorts of students regardless of system updates. However, should the developed sustainability model become implemented by the UBC Mathematics Department, this would ensure that the online material gets updated and

extended regularly, improving the service to current and future students. Our report outlining the positive impact of the MER on student learning could inspire similar online learning platforms at UBC or other institutions of higher education. Further, MER has also proven the potential of the UBC Wiki and could be a role model for future innovation on this UBC platform.

5.5 Dissemination – *Please provide a list of scholarly activities (e.g., publications, presentations, invited talks, etc.) in which you or anyone from your team have referred this Flexible Learning project. Include any disseminations activities you intend to accomplish in the future.*

We have submitted a variety of papers, presentations, and posters related to the TLEF funding

Papers:

C. Bruni, C. Koch, B. Konrad, M. Lindstrom, I. Moyles, and W. Thompson. *From exam to education: the math exam/educational resources wiki*. Problems, Resources, and Issues in Mathematics Undergraduate Studies, 2015. Accepted.

Posters:

The Math Educational Resources Wiki. Carl Wieman Science Education Initiative End-of-Year Event 2014. Vancouver, British Columbia, April 2014.
http://cwsei.ubc.ca/Files/EOY/EOY2014/Posters/Math_Resources-Wiki_CWSEI-EOY2014.pdf

The Math Exam/Educational Resources Wiki I. Flexible Learning Project Showcase. Vancouver, British Columbia, June 2014.

The Math Exam/Educational Resources Wiki II. CMS Winter Meeting. Hamilton, Ontario, December 2014.

Presentations:

The Math Exam/Educational Resources Wiki. Presented in the session *Undergraduate Mathematics Education in 21st Century: Rethinking Curriculum*. The Canadian Mathematical Society Winter Meeting. Hamilton, Ontario, December 2014

After thoroughly completing the analysis of the online survey data and interview responses we plan on producing a manuscript or series of manuscripts about the results and implications.

6. DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS - R*eflect on the broader implications of the project. Indicate instances where your project has impacted courses or individuals not identified in your proposal. Include any recommendations you have for future Flexible Learning project leads.*

6.1. Teaching Practices – *Please indicate if your teaching practices have changed as a result of your Flexible Learning project. If so, in what ways? Do you see these changes as sustainable over time? If not, why do you think that is the case?*

One initiative that came out of the flexible learning project was for the course Math 307 taught at UBC by Iain Moyles. The class size was 114 students. In considering various sustainability models for MER, he implemented a pilot project in the course whereby students would submit solutions for previous Math 307 exam problems. Aside from the benefits of helping students to study for the course, they were rewarded with a 10% communication grade. The end result was that more than 6 exams worth of questions were added into the database for future Math 307 students to study from. The instructor and the project team learned a lot from this pilot study: The immediate advantage from an MER perspective was the mass content generation which is the largest hurdle in project sustainability. However, since the solutions were being solved by students enrolled in the course the quality varied substantially. Because of this, a lot of post processing was required by the project team to ensure that the solutions presented by students met the high quality standard of other solutions on the MER. From communicating with students in the course, there seemed to be a pedagogical advantage to them completing solutions as well. Students were getting course grades to effectively study for the final exam and many students commented that they felt well prepared for the exam as a result of the assignment. It would be worth a follow-up study to analyze if there is a positive correlation between submitting MER content and increase exam performance. Overall, the instructor would consider implementing such a project again, but there would need to be a wider departmental support. This ties into the overall sustainability model of the MER because the small volunteer based MER committee isn't sufficient to handle large quantities of content generation if they require significant quality improvements. With departmental resources including teaching assistants or otherwise, this project would be a very sustainable way to generate new content for any course the department desired.

6.2. Student Involvement in FL team – *Were there any undergraduate or graduate students involved in the development and/or evaluation of your FL project? Please describe their contributions and overall experiences as part of your Flexible Learning team.*

This project was entirely run by graduate students, with minimal advice from faculty. We also hired a graduate RA to help with the design, execution, and analysis of the online surveys and cognitive interviews. It was a good experience supervising another student and collaborating with the FL-TLEF team. The major downside of relying entirely on graduate students for a long project like this is that they graduate. Due to the lack of a running sustainability model, our project suffered as graduating contributors were not replaced with new volunteers. Unfortunately, this resulted in some goals not being met and funds not being spent in the final phase of the FL-TLEF grant.

7. PROJECT SUSTAINMENT - *Please describe the sustainment strategy for the project components. How will this be sustained and potentially expanded (e.g., over the next five years). What challenges do you foresee for achieving the expected long-term impacts listed above?*

The content of this online resource will be available and relevant for many years to come. It only makes sense to sustain, update, and expand MER if the UBC Department of Mathematics has interest in this project. We have

therefore developed, tested, and proposed a detailed sustainability model laying out the tasks and required minimum number of regular TA hours. Together with the final report on our findings regarding the effectiveness of MER, as well as the newly developed web application, we have provided the rationale, platform, and required resources to sustain the MER project. The final decision on the future of this project lies at the discretion of administrators within the Department of Mathematics.

Appendix A

Online Survey Questions

MER Wiki Fall 2014 and January 2015 online survey

I) How did you first hear about the Math Exam/Educational Resources (MER) wiki?

1. Instructor
2. Course Webpage
3. Flyer in Math Learning Centre
4. Tutor in Math Learning centre
5. Friends
6. From this research flyer
7. Internet search
8. Don't remember
9. Other (Text field)

II) Have you ever used the MER wiki?

1. Yes
2. No

III) Why did you use the MER wiki?

1. To prepare for a mid-term exam
2. To prepare for a final exam
3. To improve on concepts that I did not understand after a mid-term or a final exam
4. To make up for a lecture I missed
5. To refresh my memory about materials that I have learnt in previous courses

6. To better understand a topic that I did not fully understand during the lecture or tutorial
7. Please list any other reasons you used the wiki that are not listed above.

IV) How satisfied are you with the following MER wiki features? (Likert scale)

1. Studying questions by browsing my course's previous exams
2. Studying questions via the topic pages
3. Watching the videos on the topic pages
4. Sending a comment via the feedback form or wiki discussion page
5. Rating a question using the rating bar
6. Using the rating to select which question to work on next
7. Using the dynamic course syllabus
8. Checking hours of the Math Learning Centre
9. Finding a private tutor using the webform
10. Browse and track progress with the Android app
11. Please let us know your satisfaction with any other features not listed above.

V) When do you typically reveal the hint on a question page?

1. Immediately, before starting my solution
2. The first time I get stuck during my solution
3. As checkpoints for my work during my solution
4. At the end, to compare with my solution
5. I usually don't use the hint

VI) When do you typically reveal the solution on a question page?

1. Immediately, before starting my solution
2. The first time I get stuck during my solution
3. As checkpoints for my work during my solution
4. At the end, to compare with my solution
5. I usually don't use the hint

VII) How much do you agree with the following statements about the hints on the MER wiki?

1. Hints motivate me to solve the question on my own.
2. Hints remind me of the material I should know to solve the question.
3. Hints help me when I'm stuck on a difficult step.
4. Hints should be more detailed.
5. Hints should reveal less.
6. Overall the hints are effective.
7. Solutions should be more detailed.
8. Solutions are poorly worded and difficult to follow.
9. Solutions often use techniques I am unfamiliar with.
10. Solutions show me new ways of solving a problem.
11. Overall solutions are effective.

VIII) What feature of the MER wiki do you like best? Please briefly explain the reason.

IX) How can we improve the MER wiki? Is there a feature you would like to see?

X) What impact do you perceive the MER wiki has on your math learning or math exam performance?

XI) Please choose the number that most represents your opinion towards your personal math learning experience. (Likert scale)

1. I can usually figure out a way to solve math problems.
2. I often have difficulty organizing my thoughts during a math test.
3. To learn math, the best approach for me is to memorize solutions to sample problems.
4. I enjoy solving math problems.
5. I like to find the latest math related information online.
6. If I am stuck on a math problem for more than ten minutes, I give up or get help from someone else.
7. The general mathematical ability of a person is something that cannot be changed very much.
8. For me, my current math class is easy.
9. No matter how much I prepare, I am still not confident when taking math tests.
10. Showing intermediate steps for a math problem is not important as long as I can find the correct answer.
11. Learning new things in math is fun for me.
12. I like to complete math problems I find online to practise my skills.
13. If the mathematical content is difficult, I will choose to give up.
14. Nearly everyone is capable of understanding math if they work at it.
15. I can understand the most difficult part of math materials on my own.
16. During math exams, I think about the consequences of failing the exam.
17. In studying math, I can combine my previous knowledge with the learning materials.
18. Please choose Disagree for this statement to let us know you are reading and responding carefully.
19. I would be interested in taking more math classes than required by my program.
20. I will ask someone for help immediately when I encounter a confusing part of a math question.
21. How well I learn maths depends mainly on my instructors.
22. In studying math, I like to repeatedly practice similar question types.
23. I ask myself questions to make sure I know the material I have been studying.
24. If I make a mistake in my solution, I will go over the instructor's or textbook solution to find out where I went wrong.
25. I work on practice exercises and answer end-of-chapter-questions even when they are not for credit.
26. Even when math study materials are dull and uninteresting, I keep working until I finish.
27. In studying math, I will set up my own target and follow through on my agenda.
28. After a midterm or final exam, I will review what I did right and wrong.

XII) What is your gender?

XIII) How would you describe your own identity, in ethnic or cultural terms, for example, Canadian,

American, Mexican, Chinese, Korean, Indian and etc? (Your ethnic or cultural identity is the ethnic or cultural group or groups to which you feel you belong). Please leave blank if you prefer not to say.

XIV) Your most recent math high school grade (If applicable. Please report on a scale from 1-100, where 1 is the worst and 100 is the best score):

XV) What kind of online learning experiences, mathematical or otherwise, have you had before (Choose all that apply)? :

1. Taking online course(s) (eg. Coursera, Udacity)
2. Attending online conference(s)
3. Attending online learning discussion group(s)
4. Using online learning resource(s) for class work
5. Ask math questions online (eg. Yahoo Answers, StackOverflow)
6. Edit a Wiki Page (on wikipedia or elsewhere)
7. Ask questions via email (eg. friends, classmates or teachers).
8. No previous experience with online learning
9. Other (Text field)

XVI) Which year of study are you in? (If you transferred from other universities/colleges to UBC, please choose the official UBC program year listed on your SSC Account)

XVII) Which faculty are you studying in?

XIII) If you have one, please write down your intended major/specialization:

XIX) Which math course are you taking currently? (Choose all that apply) :

1. Math 100/180: Differential Calculus with Applications to Physical Sciences and Engineering
2. Math 101: Integral Calculus with Applications to Physical Sciences and Engineering
3. Math 102: Differential Calculus with Applications to Life Sciences
4. Math 103: Integral Calculus with Applications to Life Sciences
5. Math 104/184: Differential Calculus with Applications to Commerce and Social Sciences
6. Math 105: Integral Calculus with Applications to Commerce and Social Sciences
7. Math 110: Differential Calculus
8. Math 152: Linear Systems
9. Math 200: Multivariable Calculus
10. Math 215: Elementary Differential Equations I
11. Math 220: Mathematical Proof
12. Math 221: Matrix Algebra
13. Math 253: Multivariable Calculus
14. Math 257: Partial Differential Equations
15. Math 307: Applied Linear Algebra
16. Math 312: Introduction to Number Theory
17. Math 437/537: Elementary Number Theory

18. Other (Text field)

XX) Your student ID (The purpose of collecting student ID is only to match participants with their grades - it will be kept confidential by the research team and your instructor will not be aware of your individual participation in this survey):

XXI) Your email address (Optional. Leaving your email address for a free MER wiki android app and a chance for $20 cash; the collected email addresses will only be used to contact people about these items):

XXII) Would you like to participate in a 30-60 minute face-to-face interview about the MER wiki? You would receive $15 cash in compensation.: Yes, please use the email address above to contact me about an interview.

Response Counts with average grades of respondents versus their whole class:

	MATH	Respondent Count	Respondent Mean Grade*	Course Total Count	Course Mean Grade**
1	100	170	72	1382	68
2	101	183	70	1719	66
3	102	119	74	754	70
4	103	128	70	766	68
5	104	48	76	968	68
6	105	74	72	1205	62
7	110	19	69	388	63
8	152	81	68	803	64
9	180	80	57	517	57
10	184	46	70	748	64
11	200	59	73	1026	68
12	210	6	74	55	64
13	215	28	73	335	68
14	217	15	74	105	74
15	220	33	66	436	66
16	221	72	73	909	68
17	223	4	75	52	75
18	226	7	75	49	79
19	227	7	77	33	77
20	253	14	71	672	70
21	255	25	76	422	71
22	256	9	55	431	64
23	257	14	73	287	71
24	264	2	70	198	65
25	300	10	74	222	69
26	301	3	82	37	77
27	302	6	72	201	71

28	305	2	61	82	68
29	307	15	81	238	68
30	308	6	77	81	71
31	312	2	81	56	70
32	316	15	83	196	74
33	317	11	82	262	69
34	318	7	56	100	67
35	320	3	54	75	70
36	321	1	70	35	68
37	340	7	82	199	71
38	342	4	72	45	62
39	345	6	65	47	74
40	361	2	92	44	79
41	400	3	78	111	68
42	414	2	78	27	86
43	442	4	62	26	67

* For courses with at least 15 respondents, standard deviations are in the range of 13-20 and standard errors are smaller than 1%.

** Standard deviations in the range 14-20, standard errors less than 1%.

Comments on the response rates: Generally, grades of students who responded are somewhat above the average for their course, but do represent a range of opinions and not just those of the most successful students. This is similar to the response on other kinds of surveys in courses: the least engaged students, who are also achieving the lowest grades, are less likely to respond to surveys.

MER Wiki January 2015 follow-up survey

A) Did you use the MER wiki to help you prepare for your most recent final math exam?

If no: A1) Why did you not continue to use the MER wiki for math exam preparation? We would appreciate any suggestions that could help us make it a more useful resource for you and for others.

If yes: continue.

B) How do you usually find the MER wiki webpage? [Choose all that apply]

1. Google search
2. Through my Math course's common page
3. Through the UBC wiki page
4. MER wiki page bookmark
5. Facebook
6. Other (Text field)

C) When preparing for the final exam, what features of the MER wiki website have you used? And how satisfied are you with each feature? [score from 0-5, 0 represents "not used for the final exam", 1 represents "very dissatisfied" and 5 represents "very satisfied"]

1. Download pdf version of previous final exam questions
2. Download pdf version of final answers to previous final exam questions
3. Download pdf version of full solutions to previous final exam questions
4. Studying questions by browsing my course's previous exams
5. Studying questions via the topic pages (For example: http://wiki.ubc.ca/Category:MER_Tag_Chain_rule)
6. Searching for terminology definition through searching bar
7. Watching the videos on the topic pages (For example: http://wiki.ubc.ca/Category:MER_Tag_Chain_rule)
8. Sending a comment via the feedback form or wiki discussion page
9. Rating a question using the rating bar
10. Using the rating to select which question to work on next
11. Checking hours of the Math Learning Centre
12. Checking schedules for math exams
13. Finding a private tutor using the webform
14. Browse and track progress with the Android app

D) Do you think the MER wiki helped you to prepare for the final exam? How or why not?

E) Have you recommended the MER wiki website to your friends for math final exam preparation? Why or why not?

F) Do you have any additional suggestions that you would like to share with the MER developers on how they could improve the MER to be even more useful for your Math class?

Interview Protocol

1. How did you learn about the MER wiki?

2. Could you please share with us your latest MER wiki user experience? For example:

- What motivates you to use the MER wiki?

- What did you do in the wiki? How long was that experience?

- Which features of the MER have you used?

- When do you usually access the Wiki?

3. What feature of the MER wiki do you like best? And why?

4. What annoys you in the wiki? Can you give an example for something that you want to do but can't?

5. How can we improve the MER wiki?

6. What impact do you perceive the MER wiki has on your math learning or math examination? Would you please share your learning experience with the MER wiki?

7. How effective of a study tool was the wiki compared to other methods you used in the past or simultaneously?

8. Did your course instructor recommend the MER wiki? If not, would you use it more often if she/he did? If yes, would you use it less often if she/he did not? And why?

Appendix B

In the term Jan 2015 - April 2015 the Math Department allocated 106 GTA hours and 40 UTA hours towards MER in the following manner:

7 GTAs at 10 hours each

- Solve and type up hints and solutions for one 1st year exam each
- Make mathematical corrections and clarifications as advised by TOM (**T**A **O**perator of **M**ER)
- The following exams were solved
    - 100, 101, 102, 103, 104, 105, 152 (turned out to take more than 10h, see discussion below)

1 GTA TOM (**T**A **O**perator of **M**ER) at 36 hours total

- Proof-reads original content from GTAs for mathematical correctness and clarity
- Chooses which UTAs to hire
- Handles file transfer GTA -> compile script -> UTA
- Advises UTAs on typographical changes and minor clarifications of content
- Oversee all other TAs
- Speical case: Typed up hints and solutions for most recent MATH110 exam since TOM had LaTeX solutions as previous instructor

4 UTAs at 10 hours each

- Make typographical corrections and minor clarifications of content after it passed the first round of review with GTAs and TOM.
- Paste content from provided text files to online wiki

- 5h per exam for corrections and upload for 101, 102, 103, 104, 105, 110 (Math 100 was done by MER volunteers to test LaTeX->mediawiki compile script) left 10 hours. UTAs used the remaining time to add topic tags to the questions.

Takeaways and suggestions for the future (no particular order)

1. The hours allocated were generally sufficient to complete the tasks (except 152, see below)
2. The biggest challenge is to ensure high quality and educational value of content. This varies a lot by GTA and a low original quality is not easy to compensate for later. We suggest to address this with the following points:
    a. We emphasize the importance of choosing GTAs with interest and great interest in education and student learning.
    b. Ideally the GTAs have taught the course before to be familiar with the concepts that students struggle with, and with the mathematical level and tools used in the course. A minimum requirement should be that the GTAs have passed MATH 599 or otherwise demonstrated interest in mathematical education.
    c. MER will provide a more detailed guide for “How to write hints and solution for maximal clarity and educational value.” This will also serve as a reference of the expectations towards the GTAs.
    d. TOM is a key role, the GTA for this role should be familiar with all first year courses and ideally have a passion for teaching.
    e. UTA input is very valuable and should be encouraged more. After all, MER is a resource for undergraduate students. Ideal UTAs have just passed their first-year course and is **not** necessarily top-of-the-class (so that the difference between a clear and an unclear solution is apparent to them). Some exposure to LaTeX is beneficial but not required.
    f. UTAs should be involved in the quality control, not just make typographic corrections. We propose the following workflow:
        i. GTA hands first draft of hints and solutions to TOM
        ii. TOM reviews for mathematical correctness and obviously lacking explanations. Corrections are made by GTA if required.
        iii. UTA receives content for clarity and educational value. UTA must suggest “At least 2 things that can be improved in this hint/solution.”
        iv. TOM reviews UTAs suggestions, which are fixed by GTA (if hours remain) or UTA, if required (go back to step iii).
        v. Finally, UTA fixes typographical errors.
3. Traditionally the Math 152 exam has many more questions than other first year exams. Hence we suggest to split the work into two terms: Short-answer questions in term 1, long-answer questions in term 2. Ideally one the UTAs has an engineering background to serve as a reviewer for Math 152 content.
4. Hence we suggest the following scheme for the MER TAs:
    a. 5 GTAs at 10 hours each, 1 TOM at 36 hours total, 4 UTAs at 10 hours each.
    b. Sep-Dec term: One GTA for each of MATH 100, 102, 104, 110, 152 (short-answer questions).
    c. Jan-Apr term: One GTA for each of MATH 101, 103, 105, 110, 152 (long-answer questions)

   d. This means a slightly reduced workload for GTAs (only half of 152), TOM (fewer exams to review) and UTAs (fewer exams to correct) compared to this term, which frees up time to perform the additional tasks described in 2.f. above.
   e. Additional GTA time may be spent on adding content for 2nd year exams. Addional UTA time may be spent on adding topic tags to 1st year questions.
5. Transitioning from the wiki to the new website www.math-education-resouces.com makes contributing to MER easier and will free up more time for UTAs (e.g. solutions can be inserted in the database directly, so no more hours need to be spent pasting content on the UBC wiki).
6. Each additional exam to be solved, eg MATH 200, requires 10h GTA (content), 5h TOM (review), 8h UTA (review, make corrections and add topic tags).