Assessment Committee Report, 2018-2019
Department of Mathematics, University of Oregon

Following the Math Major Assessment Plan of December 3, 2018, this committee is charged with assessing Learning Outcomes 3, 4 and 5 which are defined as follows:

LO3: Read and write mathematical proofs, producing arguments that are logically and syntactically correct.

LO4: Demonstrate an in-depth understanding of some area of mathematics.

LO5: (For students on the secondary education track only) Pass the licensure examination in mathematics.

In previous years, this committee has selected a small number of problems from final exams in relevant courses such as Math 316-317, Math 347-348 or Math 391-392, and audited student solutions to those problems in order to assess whether students are engaging in mathematical reasoning and/or proof (LO3), and whether the answers indicate in-depth understanding of the subject matter (LO4). Typically the data thus obtained has been presented graphically, although it is very hard to interpret. For LO5, there has been discussion of developing a system for tracking majors after graduation to obtain data on their success in the licensure examination.

The committee this year elected to evaluate LO3 and LO4 by focussing on the winter term of the three most advanced year-long classes taught to math majors, namely, Math 414 (Analysis), Math 432 (Topology) and Math 444 (Abstract Algebra). We assembled copies of the examinations and students' solutions from these classes (with names redacted).

In Math 414 and Math 432 there were in fact only two students enrolled in the class by this time. These classes are taught simultaneously with Math 514 and Math 532, which are taken by incoming graduate students in our program. This aspect actually makes these classes particularly demanding for our undergraduate majors, and we recognize that only our strongest undergraduates are taking these classes. In Math 444 there were nine undergraduate students enrolled. The committee was curious as to whether these low undergraduate student numbers in these classes was part of a long term decline or if it was just an anomaly in this particular year, consequently we made a systematic review of enrollment numbers in these classes. The data we collected is attached at the end of this report. There is a lot of noise in this data, but we did not notice any evidence of a long term decline in student numbers in these classes based on this data. Certainly, a 50% drop in student numbers from Fall to Winter term seems to have been the norm in all of these classes (but after that there is usually not a decline from Winter to Spring). It seems possible that Topology in recent years has seen a larger drop in student numbers from Fall to Winter compared to previous versions of this course.

Turning to the evaluation of the materials collected, the committee decided that with such small numbers it did not make sense to make a numerical evaluation of the students' performances, so instead we elected to make a subjective judgement as to whether the exam solutions provide evidence that we are successfully giving the students skills mentioned in LO3 and LO4. Summaries of our evaluations are attached at the end of this report.

Overall, from looking at student solutions to these three examinations, the committee felt that the exams were successful, and they all offered students the opportunity to apply theoretical materials of the courses to answer specific questions, and to demonstrate proof reading skills. The problems tested logical reasoning and the ability to write clean and coherent mathematics. The students for the most part were able to demonstrate these cognitive skills, and showed some in-depth understanding of these broad areas of mathematics.

The assessment committee makes the following recommendations for the future.

1. This committee should be directed more closely by the Chair of the Undergraduate Affairs Commitee. The committee should meet physically with that person during the Fall term to receive a specific charge. This will enable appropriate continuity and direction for the committee between years. (It may in fact be appropriate to make the Chair of the Undergraduate Affairs Committee also the Chair of the Assessment Committee.)
2. In past years this committee has attempted to make an objective assessment of students' performance on particular problems. While this is appropriate for lower level computational-based classes, evaluating items LO3 and LO4 above in smaller classes is largely subjective, and this approach may not be the most useful way to draw useful conclusions going forward.
3. It may be worth revisiting the accessibility of the year-long sequences which were evaluated this year by the committee for undergraduate students. The challenge of teaching classes taken by both undergraduate and graduate students in a way that is successful and relevant for both categories of students is significant. We would like to see a better retention rate for undergraduates in these classes between Fall and Winter term.
4. We are not aware if any progress towards developing an tracking system for LO5 has been made, and would encourage some discussion of that in the near future.

The Assessment Committee,
Department of Mathematics,
6/6/2019.

Undergraduate Enrollment in Math 413/4, Math 431/2 and Math 443/4.

Year	Algebra F/W	Analysis F/W	Topology F/W
1998	15/6	15/7	8/2
1999	6/4	4/2	11/3
2000	9/6	11/6	9/3
2001	6/2	1/1	16/5
2002	18/11	4/4	10/9
2003	17/10	13/10	14/10
2004	16/9	9/7	6/3
2005	9/6	3/2	6/3
2006	9/5	14/5	11/7
2007	14/9	9/7	13/5
2008	10/5	9/3	4/4
2009	14/4	13/5	8/3
2010	21/9	11/6	11/7
2011	18/12	13/6	9/3
2012	12/7	10/4	10/5
2013	12/5	13/8	7/4
2014	10/5	6/2	5/1
2015	9/5	12/5	9/2
2016	8/5	12/5	14/3
2017	9/5	12/9	13/2
2018	23/9	6/2	13/2

Committee Evaluation of Math 414, Introduction to Analysis II

Problem 1: Let f be non-decreasing on [a,b] and non-increasing on [b,c]. Prove or disprove the assertion that f is Riemann integrable.

Evaluation: Student 1 recognized that the assertion was true but incorrectly stated there were only a finite number of discontinuities; had that been the case the desired result would have followed. Unfortunately that is not true so the student received no credit on the problem. Student 2 correctly noted that f was bounded and, being monotone, was integrable on [a,b] and [b,c] citing a theorem from Rudin.

Problem 2: Consider the algebra of polynomials p[x^2]. Is this dense in the space of continuous functions on [-1,1]?

Evaluation: Student 1 correctly noted that this was false, the counterexample being f[y]=y which is an odd function. Student 2 correctly noted the Stone-Weierstrass theorem did not apply because the algebra does not separate points, but did not provide an actual counterexample. The problem was meant to test whether or not the students understood why all the hypotheses in the Stone Weierstrauss theorem were necessary.

Problem 3: If f is continuously differentiable and periodic, does the symmetric Fourier series converge pointwise?

Student 1 noted the hypotheses implied the function was Lipschitz and then cited a theorem that the symmetric Fourier series converges in this setting. Student 2 gave essentially the same argument but actually showed the function was Lipschitz. The problem was meant to test whether or not students could verify the hypotheses of a major theorem were in fact satisfied and then apply the result.

Problem 4: Let $f(x)=\sum 4^{-n}\sin(2^n x)$. Either compute f'(0) or show f'(0) does not exist.

Evaluation: Student 1 noted that the derivatives of the partial sums converged uniformly and hence the derivative of the limit was the derivative of the limit. The argument provided by Student 2 was essentially the same, the student discussed bounding by a geometric series and use of Weierstrass M-test.

Conclusions: The four problems examined tested the extent to which the students could apply theoretical material from the course to deal with specific situations. They also examined the extent to which students could give clear and coherent reasons. The problems were well written and apart from minor fumbles, the students demonstrated both good writing and cognitive skills.

Committee Evaluation of Math 432, Introduction to Topology II

Problem 1: (1) State Sard's theorem. (2) Use Sard's theorem to show if f is a smooth bijective map from X to Y then dim(X) is at least dim(Y). (3) Show in this setting dim(X) is at most dim(Y).

Evaluation: Student 1 correctly stated Sard's theorem modulo a minor mistake and then was able to apply it. For (3), this student used the submersion theorem correctly. So with a hint, was able to use material from the course to prove a big theorem. Student 2 again proceeded correctly but provided a bit more detail. The writing of student 2 was a bit better.

Problem 2: Discuss submersion theory.

Evaluation: Student 1 was able to give the definition of a submersion, to use the chain rule to show the existence of a right inverse implied the map was a submersion, and to show that the natural map from the tangent bundle to the manifold was a submersion. Student 2 was not able to deal as well with the question of a right inverse.

Problem 3: Discuss the winding number.

Evaluation: Student 1 elected not to do this problem. (The requirement was to do 5/6 problems; student 1 did only four). Student 2 could define the winding number but could not discuss homotopy invariance nor give a formula for computing it.

Conclusions: The questions on the exam were well written to determine if the students understood the basic material of the course and could apply it. My impression is that the students did a bit less well than on the analysis exam and the quality of mathematical reasoning displayed was a bit lower.

Committee Evaluation of Math 444, Introduction to Algebra II

<u>Problem:</u> Construct a field with 27 elements.

Evaluation: Student 1 examined Z_3[x]/x^3+2x+1 and noted this set had 27 elements. showed the defining polynomial had no roots, but did not then state must be irreducible, did not actually state that meant one obtained a field and was dinged points for that. However the argument cogent and convincing and showing a clear grasp of logical reasoning if occasionally omitting points. Student 2 used the polynomial x^3+x^2+x+2, showed it had no roots, mentioned maximal ideals and mentioned division algorithm: a very complete answer. Student 3 used x^3+2x+1 and gave a complete and well written exposition. Student 4 did not show x^3+2x+1 was irreducible but apart from that the discussion was correct. Student 5 used the polynomial x^3+x^2+x+1 but apart from that the answer was correct. Apparently only six students took this exam, but one solution set was not made available to us.

<u>Conclusion:</u> The variation in student abilities was much greater than either in the analysis or in the topology exam. Nevertheless the students are writing well and demonstrate some in-depth understanding of abstract algebra.

Report from the Undergraduate Affairs Committee, 2018-2019 Department of Mathematics, University of Oregon

We detail here the activities made by the Undergraduate Affairs Committee during the year 2018-2019 related to our mathematics major.

The UAC Chair continued the practice of collecting final examinations for Math 251 at the end of Fall term. This is the first term of the calculus sequence and is taught in many small section, many of which are taught by GEs, often as their first taste of teaching second year undergraduate classes. The purpose of this process is to ensure some consistency between the levels of these examinations between different instructors.

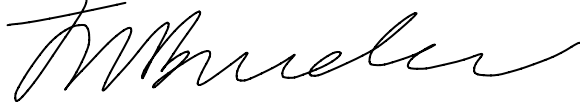The UAC met formally in Spring term to discuss two issues that had arisen during the year.

1. We discussed the possibility of adding a Writing 121 requirement to our 300-level proof based classes (Math 316, 347, 391, and 394). One reason for doing this is to address concerns that students for whom English is a second language are currently taking math major classes at this level before completing their university-wide language requirements. In fact there is a significant difference between these proof-based classes and earlier more computational classes in the mathematics major, and it is very difficult to be successful without the necessary language skills. Another point is that by listing writing as a pre-requisite it will give all students fair warning that they will be expected to be writing sentences in that class. The UAC supported this change, and it now needs to be taken up with the appropriate curriculum committee.
2. The possibility of renumbering our Math 261-263 Calculus with Theory class as a 300 level sequence was raised. This is an outstanding class for bright entering students to be taking as their first university-level math class. However we have struggled with enrollment in the class over many years, in part due to the fact that these students have usually already received credit for a full year of calculus from classes taken in high school. In the end, we decided not to take any action towards this, as it creates conflicts with classes such as Math 316-317 which covers similar material, and it may be too intimidating for incoming students to be jumping straight into a 300 level math class. Nevertheless, we need to increase our recruitment efforts for this class directed to incoming students with suitable GPA/placement exam tests.

Other issues:
1. There has apparently been some effort made towards incorporating a fifth year Masters program into our undergraduate mathematics major. We currently have

year-long sequences at the 4/500 level which have quite low undergraduate enrollments, but are outstanding classes. This seems like an excellent opportunity since these classes are already in place and would be perfect for our stronger undergraduate majors who are nevertheless not quite at the level required to take these classes in the regular four year timeframe. We would like to encourage this proposal to be pursued further!

2. Concerns have been raised over the year about the lack of consistency in the teaching of Math 307, Introduction to Proof. This is an important class aimed at preparing students for more proof-based classes where basic language of sets and functions is an absolute requirement. We recommend this is looked at more closely next year, perhaps with an eye to creating a more formal syllabus. This is relevant to the success of students in more advanced 400-level classes such as the ones considered by the Assessment Committee this year.

3. Only one student completed an honors thesis this year. We hope this number increases in subsequent years, perhaps the addition of our summer reading program will have an impact on this.

Jonathan Brundan
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6/6/2019.