Westfield Discovering the Art of Mathematics
Survey Report, 2013-2016

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DESCRIPTION OF THE STUDY

From the fall of 2013 through the spring of 2016, students at Westfield State University taking MLA courses using IBL have been asked to take a pair of surveys, one at the beginning and one at the end of the semester, designed to examine the changes in students' attitudes to mathematics. In a couple of cases, we were also able to collect surveys from classes outside of WSU, particularly from Drs. Xiao and Schumacher in the fall of 2015 and Dr. Rossa in the fall of 2013.

The surveys were developed collaboratively by the evaluators and the project team. The two surveys were mostly the same, though a set of additional items about the impact of the course were included on the post-survey. The items fell into the following areas:

- General background information
- Students' relationship to mathematics
- Knowledge of mathematicians, famous mathematics problems, and ideas that have been changed through mathematical thinking
- Role of mathematics in society
- Personal opinions about mathematics
- Predicted (or actual) enjoyment of the class
- Likelihood that they would remember this class or sign up for another math class (post-survey only)
- Changes as a function of participating (post-survey only)

The questions on the survey, which is included at the end of this report, were designed to address the following goals of the project:

1. Students will appreciate mathematics as a human endeavor which is one of our most fundamental intellectual pursuits.
2. Students will understand that mathematics is a vital, rapidly growing field of inquiry with a dedicated cohort of practitioners.
3. Students will understand the continued impact of mathematics in shaping history, culture, logic, philosophy, and knowledge, as well as its role as a humanistic and aesthetic discipline.
4. Students will understand the ubiquitous role of mathematics in the world around them.
5. Students will strengthen their reasoning skills and become better problem solvers.
6. Students will strengthen their skills in reading, writing, argumentation and speaking.
7. Students will become more self-monitoring, reflective learners and take greater personal responsibility for their learning.
8. Students will approach mathematics more positively and gain a balanced perspective of mathematics.
9. Students will improve their mathematical confidence.
10. Students will develop awareness of the negative impact of broadly-held societal views.
11. Students will be capable of and interested in considering mathematics outside of the confines of the classroom, understanding the value of life-long learning in mathematics.

These goals were grouped into four larger categories, which is how they are reported on in the report. These are:

1. Understanding the Field of Mathematics (Goals 1-4)
2. Student Thinking about Mathematics (Goals 5 & 7)
3. Students Feelings about Mathematics (Goals 8 & 9)
4. Changes associated with participation (Goals 6, 10, & 11)

This report details the important gains associated with the first three areas, as well as providing data on the combined responses from both surveys. An example of the post-survey, the version used in the spring of 2016, is also provided for reference purposes.

NUMBER OF PARTICIPATING STUDENTS

The study includes about 630 students overall, with about 440 matched responses. Analyses were run for both MATCHED and UNMATCHED data sets. The results for significance levels and effect sizes turned out to be very similar.

KEY FINDINGS

This section of the report summarizes the most important differences in survey responses between the pre- and post-surveys given to all students from 2013 to 2016. The differences included in these tables were those that met the criteria of being both highly statistically significant ($p < 0.001$) and had an effect size that was at least moderate, defined by Cohen (1992)[1] as being 0.4 or greater. Questions are grouped in the goal categories described above.

Columns are shown for both matched and unmatched data. The matched columns only include responses from students who submitted both the pre- and post-survey and whom we were able to successfully identify on both surveys. The tests run were paired-samples t-tests, comparing the pre- and post-survey responses on an individual basis. The unmatched columns contain responses from all students who responded to the surveys, regardless of whether they took both surveys or not. For these data, we used independent-samples t-tests, comparing the surveys as separate groups.

Shading is done based on the effect size of the difference between the pre- and post-test responses. Light green is used when the effect sizes are medium (0.4 to 0.8) and darker green when they are large (0.8 and above). Differences with small effect sizes are not shaded. All ranges are based on the work of Cohen (1992).

Different scales were used for the different questions shown. These scales were as follows:

Scale	Questions
Agreement scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree	Q1-Q22, Q50-Q63
Yes/No scale: 0 = no, 1 = yes	Q26-Q30, Q31-Q49
Enjoyment scale: 1 = no enjoyment, 3 = neutral, 5 = strong enjoyment	Q23-Q25

EFFECT SIZE
The formula used to calculate the effect size is
(MEAN 1 - MEAN 2) / SQRT ((((N1 - 1)*STANDDEV1^2) + ((N2 - 1)*STANDDEV2^2))/(N1+N2-2))

Demographics for Matched Data

Student demographics – Pre/Post	Total
Female	250
Male	198
Other	0
African American or Black	37
Asian	8
Hispanic, Latino, or Chicano	29
Native American or Alaska Native	8
White	387
Other	4
Freshman/First Year	199
Sophomore/Second Year	150

[1] Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*, 155-159.

Junior/Third Year	60
Senior	37

Understanding the Field of Mathematics (Goals 1-4)

Question	Matched				Unmatched			
	Pre Mean	Post Mean	p	ES	Pre Mean	Post Mean	p	ES
Q51. Mathematics requires creativity	3.34	3.84	.000	.579	3.31	3.81	.000	.584
Q52. Doing mathematics for its own sake is as valuable as composing music, creating art, or other intellectual endeavors.	3.40	3.81	.000	.500	3.35	3.76	.000	.481
Q54. A major reason why mathematicians engage in mathematicians is because they find it beautiful.	3.62	4.13	.000	.678	3.62	4.08	.000	.602
Q55. Mathematics requires curiosity.	3.86	4.19	.000	.473	3.84	4.16	.000	.457
Q56. There are debates within mathematics	4.03	4.35	.000	.466	4.00	4.31	.000	.465
Q58. Mathematics is mostly a tool for the sciences.	3.22	2.82	.000	-.414	3.16	2.85	.000	-.327
Q59. Mathematics are excited and passionate about their work.	4.07	4.35	.000	.412	4.02	4.31	.000	.422
Q26. Can you name one mathematician, who is still alive and describe what you think he/she does?	0.10	0.56	.000	1.114	0.09	0.51	.000	1.062
Q27. Can you name or describe a famous unsolved or recently solved problem in mathematics?	0.05	0.52	.000	1.227	0.05	0.47	.000	1.133
Q30. Can you name or describe a surprising mathematical aspect of or idea in, your personal environment that you have noticed outside of your mathematics class?	0.11	0.38	.000	.663	0.11	0.35	.000	.609
Q31. Visual arts (Mathematics plays a significant role)	0.27	0.63	.000	.760	0.28	0.61	.000	.706
Q32. Theater	0.15	0.41	.000	.610	0.14	0.40	.000	.623
Q33. Music	0.38	0.73	.000	.759	0.39	0.72	.000	.701
Q34. Philosophy	0.24	0.47	.000	.479	0.23	0.46	.000	.504
Q36. History	0.24	0.48	.000	.510	0.23	0.45	.000	.481
Q38. Language	0.10	0.28	.000	.486	0.10	0.28	.000	.478
Q44. Literature	0.06	0.25	.000	.557	0.05	0.24	.000	.576
Q45. Formal decision making	0.43	0.66	.000	.469	0.42	0.61	.000	.387
Q46. Understanding of nature	0.27	0.52	.000	.540	0.26	0.49	.000	.493
Q48. Dance	0.26	0.56	.000	.648	0.25	0.53	.000	.604

Students Thinking about Mathematics (Goals 5 & 7)

Question	Matched				Unmatched			
	Pre Mean	Post Mean	p	ES	Pre Mean	Post Mean	p	ES
Q03. I am able to understand and critique written or spoken mathematical arguments.	2.80	3.34	.000	.581	2.81	3.31	.000	.535
Q08. Thoughts and ideas that come to me while working on mathematical problems will often get me closer to a solution.	3.51	3.89	.000	.479	3.47	3.83	.000	.440
Q10. My thoughts and ideas matter when solving a mathematical problem.	3.62	4.02	.000	.520	3.60	3.97	.000	.461
Q15. I don't think mathematics can be beautiful.	3.12	2.44	.000	-.650	3.17	2.54	.000	-.596
Q21. I learn mathematics best when I explain ideas to other students.	2.95	3.35	.000	.426	2.91	3.30	.000	.411

Student Feelings about Mathematics (Goals 8 & 9)

Question	Matched				Unmatched			
	Pre Mean	Post Mean	p	ES	Pre Mean	Post Mean	p	ES
Q01. I don't think doing mathematics is interesting.	3.08	2.51	.000	-.538	3.09	2.58	.000	-.470
Q23. Working on a challenging mathematical problem (How much do you enjoy…)	2.31	2.86	.000	.460	2.30	2.78	.000	.405
Q24. Discovering a new mathematical idea	2.63	3.34	.000	.591	2.63	3.22	.000	.489
Q25. Using rigorous reasoning in a math problem	2.32	2.91	.000	.511	2.29	2.83	.000	.465

Changes associated with participation

How have you change in the following areas due to your participation in this course?

Question	Post							
	N	Increased a lot	Increased a little	No change (stayed high)	No change (stayed low)	Decreased a little	Decreased a lot	Percent Increase
Q64. My ability to think and reason more effectively	440	162	221	40	14	2	1	87%
Q65. My ability to express myself clearly when talking	439	93	231	78	35	1	1	74%
Q66. My ability to express myself in writing	440	113	194	92	39	1	1	70%
Q67. My ability to read and understand mathematical problems	440	120	228	49	36	5	2	79%
Q68. Likelihood that I will read mathematics papers or books	441	29	103	77	196	19	17	30%

Q69. Likelihood that I will talk about mathematics with others outside of a math class	441	54	137	64	161	10	15	43%
Q70. Likelihood that I will go to a talk or watch a video about mathematics not associated with a math class	441	45	122	73	177	8	16	38%
Q71. My curiosity about the world around me has…	439	138	177	97	23	1	3	72%
Q72. My awareness of how I approach and solve problems has…	441	147	207	56	26	3	2	80%
Q73. My sense of empowerment as a learner has…	441	119	191	86	34	7	4	70%
Q74. My confidence in my ability to take responsibility for my own learning has…	441	140	176	91	21	9	4	72%