

Discovering the Art of Mathematics

Survey Data for Fall 2013 through Spring 2015

Overview

This report provides the results from the pre- and post-surveys administered in IBL classes, predominantly at Westfield State University, between Fall 2013 and Spring 2015. The surveys were developed to measure if the course was successful in meeting the key student learning goals, as outlined below. In addition, the post-survey collected information about the students' opinions of the course itself.

The survey was developed and has been administered in order that pre- and post-survey responses could be paired. Yet the number of responses that could not be paired (for a number of reasons, including students names left off and students not completing both pre- and post-surveys) was higher than expected. As we work to address this issue, we have decided to analyze all collected data so we have a larger sample size. We plan to compare the data from both this analysis and an analysis of only the paired data to see if the results are comparable (similar analyses have proven comparable when done on for individual semesters). We have also taken steps to help increase the proportion of data that can be paired on future surveys.

Organization

The tables that follow organize the student responses by the key goals they are addressing, as follows:

Understanding of the field of mathematics

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.

Student thinking about mathematics

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.

Student feelings about mathematics

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.

Interest in bring mathematics into their lives

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.

Prepared by

Kenneth Rath



SAGEFOX CONSULTING GROUP
AMHERST, MA • ATLANTA, GA

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Emily Deharo-Otero

The goals are referred to by number in the body of the report. No questions pertaining to Goal 10 were included on the survey. Demographic information about the students is included at the beginning.

Interpreting the Tables

The following is a key to understanding the various fields in the tables on the following pages:

Pre/Post This indicates whether the results are for the survey given at the beginning of class (Pre) or at the end (Post).

n The number of respondents to that particular item.

Mean The average value for all respondents; means for Likert scale questions were typically calculated in such a way that the most desirable response was given the highest possible value and all scales started at 1. Thus for a scale from *strongly agree* to *strongly disagree*, *strongly agree* responses were typically coded as “5” and *strongly disagree* as “1” unless disagreeing with the statement was more desirable, in which case they were coded in the reverse direction. This is noted on the tables.

σ The standard deviation of the responses.

Various letters These refer to the specific possible responses, with the numbers under each one showing the number of respondents who provided that response. In the typical agreement scale, SA refers to “strongly agree”, A to “agree”, N to “neutral”, D to “disagree” and SD to “strongly disagree”. The meaning of each label is shown beneath the table.

p The level of statistical significance of the independent-samples t-test comparing responses on the pre-survey to those on the post-survey. Color coding is used to indicate the degree to which the difference is significant, as follows:

Meaning	Not significant	Significant in desired direction	Very significant in desired direction	Extremely significant in desired direction	Significant in other location	Very significant in other direction	Extremely significant in other direction
<i>p</i> value range	$p > 0.05$	$0.05 \geq p \geq 0.01$	$0.01 > p \geq 0.001$	$p < 0.001$	$0.05 \geq p \geq 0.01$	$0.01 > p \geq 0.001$	$p < 0.001$

ES The effect size of the difference, calculated by dividing the difference between the means by the pooled standard deviation. Color coding is used to indicate the level of the effect size as follows:

Meaning	Minimal effect	Small effect in desired direction	Medium effect in desired direction	Large effect in desired direction	Small effect in other direction	Medium effect in other direction	Large effect in other direction
Effect size range	$ES < 0.2$	$0.2 \leq ES < 0.4$	$0.4 \leq ES < 0.8$	$ES \geq 0.8$	$0.2 \leq ES < 0.4$	$0.4 \leq ES < 0.8$	$ES \geq 0.8$

Survey Data***Student Demographics***

	Pre	Post
Fall 2013	100	80
Spring 2014	101	77
Fall 2014	114	87
Spring 2015	157	118
Female	231	192
Male	214	155
Other	1	2
No response	26	13
African American or Black	29	17
Asian	9	8
Hispanic, Latino, or Chicano	44	31
Native American or Alaska Native	4	3
White	389	310
Other	1	-
No response	24	12
Freshman/First Year	208	171
Sophomore/Second Year	148	113
Junior/Third Year	60	40
Senior	30	28
No response	26	10

Understanding the Field of Mathematics (Goals 1-4)

Student agreement with statements about the field of mathematics.*

Question	Pre/ Post	n	Mean	σ	SA	A	N	D	SD	p	ES
A major reason why mathematicians engage in mathematics is because they find it beautiful.	Pre	404	3.58	0.81	37	202	128	33	4	<0.001	0.702
	Post	344	4.13	0.75	112	175	48	8	1		
Mathematics requires curiosity.	Pre	442	3.81	0.72	54	275	90	21	2	<0.001	0.503
	Post	349	4.17	0.71	110	197	33	8	1		
Mathematics requires creativity.	Pre	445	3.28	0.86	13	198	143	84	7	<0.001	0.602
	Post	352	3.79	0.83	54	203	67	23	5		
Doing mathematics for its own sake is as valuable as composing music, creating art, or other intellectual endeavors.	Pre	441	3.32	0.85	21	176	180	50	14	<0.001	0.468
	Post	352	3.72	0.86	56	178	88	25	5		
Mathematicians are excited and passionate about their work.	Pre	431	4.01	0.69	94	255	76	4	2	<0.001	0.432
	Post	344	4.31	0.70	149	159	30	6	-		
There are debates within mathematics.	Pre	438	3.94	0.67	66	297	59	14	2	<0.001	0.567
	Post	351	4.31	0.63	140	183	26	2	-		
**Computers can do all the mathematics that is really needed, so mathematics is not that important anymore.	Pre	447	3.54	0.92	11	52	117	218	49	<0.001	0.287
	Post	352	3.81	0.97	9	28	66	168	81		
There are still unsolved problems in mathematics.	Pre	435	4.25	0.68	162	223	47	2	1	<0.001	0.287
	Post	352	4.44	0.64	180	151	19	1	1		
There is still a lot of mathematics for me to discover.	Pre	446	4.01	0.76	115	237	82	9	3	0.003	0.227
	Post	349	4.19	0.83	138	154	45	8	4		
Mathematics is more than the arithmetical skills needed in everyday life (e.g., balancing a checkbook, baking, etc.).	Pre	445	3.86	0.73	68	267	91	17	2	<0.001	0.363
	Post	354	4.13	0.76	114	184	46	8	2		
Mathematics has had and still has an impact on shaping history, culture, logic, philosophy, and knowledge.	Pre	445	4.00	0.76	108	243	83	7	4	0.007	0.185
	Post	352	4.14	0.75	113	186	46	4	3		
**Mathematics is mostly a tool for the sciences.	Pre	446	2.84	0.94	26	151	147	113	9	<0.001	0.338
	Post	349	3.17	1.02	18	80	99	129	23		
**Mathematics is something that only really smart people can do.	Pre	447	3.57	0.91	9	55	104	230	49	0.008	0.195
	Post	354	3.75	0.94	6	37	67	175	69		
**Someday, all of mathematics will be figured out.	Pre	409	3.64	0.94	11	36	108	188	66	<0.001	0.325
	Post	327	3.95	0.97	6	20	67	125	109		

**table doesn't include data for students who responded Don't know or No response*

***The mean for negatively worded questions was calculated so that strongly agree=1 and strongly disagree=5.*

SA = Strongly agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly disagree

Student responses about the number of mathematicians there are in the world.

	<i>n</i>	Mean	σ	Almost none	Less than 1,000	1,000-10,000	10,000-1,000,000	1,000,000-10,000,000	More than 10,000,000	p	ES
Pre	457	4.21	1.13	5	21	95	152	120	64	0.021	0.160
Post	356	4.39	1.12	1	16	53	130	84	72		

Students self reported knowledge of mathematics in society.

Question	Pre/Post	<i>n</i>	Mean	σ	p	ES
Can you name one mathematician, who is still alive and describe what you think he/she does?	Pre	455	0.07	0.25	<0.001	0.973
	Post	354	0.44	0.50		
Can you name or describe a famous unsolved or recently solved problem in mathematics?	Pre	451	0.04	0.20	<0.001	1.035
	Post	353	0.41	0.49		
Can you name or describe a historically important, generally accepted belief or theory that was changed through mathematical thinking?	Pre	454	0.18	0.39	0.020	0.195
	Post	280	0.26	0.44		
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?	Pre	454	0.09	0.28	<0.001	0.613
	Post	355	0.32	0.47		

Where Students See Mathematics Playing a Significant Role

Area	Pre/Post	<i>n</i>	Mean	σ	p	ES
Visual arts	Pre	447	0.27	0.44	<0.001	0.830
	Post	353	0.65	0.48		
Music	Pre	447	0.35	0.48	<0.001	0.792
	Post	353	0.72	0.45		
Understanding of Nature	Pre	447	0.25	0.43	<0.001	0.584
	Post	353	0.52	0.50		
Theater	Pre	447	0.14	0.35	<0.001	0.647
	Post	353	0.41	0.49		
Dance	Pre	447	0.22	0.41	<0.001	0.664
	Post	353	0.52	0.50		
History	Pre	447	0.22	0.41	<0.001	0.487
	Post	353	0.44	0.50		
Architecture	Pre	447	0.82	0.38	<0.001	0.372
	Post	353	0.94	0.23		
Arithmetic	Pre	447	0.80	0.40	<0.001	0.341
	Post	353	0.92	0.28		
Literature	Pre	447	0.05	0.21	<0.001	0.614
	Post	353	0.25	0.43		
Philosophy	Pre	447	0.21	0.40	<0.001	0.604
	Post	353	0.48	0.50		
Economics	Pre	447	0.84	0.36	0.001	0.247
	Post	353	0.92	0.27		
Language	Pre	447	0.09	0.29	<0.001	0.534
	Post	353	0.29	0.46		
Reasoning/Logic	Pre	447	0.69	0.46	<0.001	0.328
	Post	353	0.83	0.38		
Formal Decision Making	Pre	447	0.40	0.49	<0.001	0.449
	Post	353	0.62	0.49		
Criminal Justice	Pre	447	0.40	0.49	<0.001	0.324
	Post	353	0.56	0.50		
Engineering	Pre	447	0.91	0.28	0.001	0.249
	Post	353	0.97	0.18		
Games/Puzzles	Pre	447	0.79	0.41	<0.001	0.301
	Post	353	0.90	0.30		
Science	Pre	447	0.92	0.28	0.003	0.207
	Post	353	0.97	0.18		
Technology	Pre	447	0.87	0.34	0.040	0.159
	Post	353	0.92	0.28		

Student Thinking about Mathematics (Goals 5 & 7)

*Student relationships with mathematics**

Question	Pre/ Post	n	Mean	σ	SA	A	N	D	SD	p	ES
My thoughts and ideas matter when solving a mathematical problem.	Pre	457	3.57	0.82	39	232	142	37	7	<0.001	0.514
	Post	360	3.98	0.77	80	209	56	12	3		
Thoughts and ideas that come to me while working on mathematical problems will often get me closer to a solution.	Pre	450	3.42	0.85	26	209	150	57	8	<0.001	0.527
	Post	359	3.85	0.77	57	212	73	13	4		
Making mathematical mistakes is okay because it is a natural part of making sense of mathematics.	Pre	454	3.89	0.72	68	292	74	16	4	<0.001	0.339
	Post	356	4.13	0.69	101	211	35	8	1		
**I don't think mathematics can be beautiful.	Pre	446	2.80	1.03	48	125	161	91	21	<0.001	0.630
	Post	350	3.46	1.07	17	43	116	111	63		
I learn mathematics best when I work on problems in small groups.	Pre	451	3.60	1.00	12	114	168	126	29	<0.001	0.388
	Post	357	3.97	0.89	103	168	65	15	6		
I am able to understand and critique written or spoken mathematical arguments.	Pre	455	2.85	0.96	3	22	40	27	8	<0.001	0.490
	Post	358	3.32	0.96	8	39	35	14	4		
I learn mathematics best when I explain ideas to other students.	Pre	449	2.90	0.94	12	114	168	126	29	<0.001	0.453
	Post	352	3.34	1.01	37	134	106	62	13		
When I get stuck on a problem, I believe that I will eventually be able to figure it out with the help of my peers.	Pre	460	3.85	0.65	49	311	86	11	3	0.017	0.177
	Post	358	3.97	0.71	70	218	61	6	3		
When I get stuck on a problem, I believe that I will eventually be able to figure it out by myself.	Pre	460	3.03	0.91	11	149	156	130	14	0.008	0.184
	Post	356	3.20	0.94	20	129	120	77	10		
I like to ask "why" and understand how things work.	Pre	466	3.81	0.83	18	52	24	5	1	0.174	0.104
	Post	362	3.90	0.90	25	48	19	7	1		
I'm often aware of situations where my initial understanding is incomplete.	Pre	449	3.52	0.76	27	221	160	39	2	0.167	0.100
	Post	359	3.60	0.85	37	188	88	44	2		
**I can't clearly explain my mathematical thinking.	Pre	453	2.67	0.90	34	170	167	74	8	0.030	0.158
	Post	357	2.82	1.01	32	117	96	107	5		
If I hear a valid argument that is not in line with my reasoning, I am willing to change my thinking.	Pre	456	3.79	0.66	43	294	101	17	1	0.040	0.143
	Post	358	3.89	0.75	63	212	68	12	3		
I often think I understand something and later realize that I don't.	Pre	464	3.41	0.95	47	192	137	80	8	0.709	0.021
	Post	361	3.43	1.00	49	138	102	65	7		
In order to make sense of mathematics, I need to understand the precise meaning of terms.	Pre	454	3.74	0.77	64	234	130	26	-	0.016	-0.170
	Post	355	3.60	0.89	52	152	108	42	1		

*table doesn't include data for students who responded Don't know or No response

**The mean for negatively worded questions was calculated so that strongly agree=1 and strongly disagree=5.

SA = Strongly agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly disagree

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

Area	<i>n</i>	% Increased	Increased a lot	Increased a little	No change (stayed high)	No change (stayed low)	Decreased a little	Decreased a lot
My confidence in my ability to take responsibility for my own learning has	351	66%	95	138	88	14	7	9
My awareness of how I approach and solve problems has	350	77%	105	166	53	18	2	6
My curiosity about the world around me has	348	70%	100	144	81	16	2	5
My sense of empowerment as a learner has	351	68%	88	149	82	18	5	9

Students Feelings about Mathematics (Goals 8 & 9)

Student relationship to mathematics.*

Question	Pre/ Post	n	Mean	σ	SA	A	N	D	SD	p	ES
**I don't think doing mathematics is interesting.	Pre	466	2.86	1.10	63	98	172	105	28	<0.001	0.474
	Post	361	3.39	1.14	25	56	95	125	60		
**I feel anxious about mathematics.	Pre	456	2.46	1.09	104	136	131	72	13	0.001	0.228
	Post	354	2.71	1.11	57	97	103	84	13		
I have a positive attitude about mathematics.	Pre	462	3.02	1.04	43	89	175	126	29	<0.001	0.304
	Post	361	3.33	0.99	36	129	134	42	20		
**Mathematics doesn't make sense to me.	Pre	465	3.10	1.14	48	95	126	156	40	0.001	0.230
	Post	359	3.35	1.01	19	51	110	144	35		
**I believe that I can't learn to make sense of mathematics.	Pre	463	3.50	1.05	16	78	97	201	71	0.342	0.074
	Post	358	3.58	1.11	15	59	62	149	73		

*table doesn't include data for students who responded Don't know or No response

**The mean for negatively worded questions was calculated so that strongly agree=1 and strongly disagree=5.

SA = Strongly agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly disagree

Self-reported enjoyment

Question	Pre/ Post	n	Mean	σ	SE	-	N	-	NE	p	ES
Using rigorous reasoning in a math problem.	Pre	452	2.26	1.12	13	45	145	94	155	<0.001	0.484
	Post	354	2.84	1.29	34	86	103	50	81		
Working on a challenging mathematical problem.	Pre	460	2.30	1.20	12	78	114	87	169	<0.001	0.432
	Post	359	2.82	1.21	22	95	113	54	75		
Discovering a new mathematical idea.	Pre	456	2.63	1.21	28	78	163	70	117	<0.001	0.478
	Post	356	3.20	1.17	46	107	117	44	42		

NE = No Enjoyment, N = Neutral, SE = Strong Enjoyment

Student prediction/reporting of enjoyment

Question	Pre/ Post	n	Mean	σ	VM	SW	N	NM	NAA	p	ES
Do you think you will enjoy this class?	Pre	449	3.60	0.87	52	223	123	44	7	<0.001	0.268
Did you enjoy taking this class?	Post	351	3.87	1.16	124	124	59	21	23		

VM = Yes, very much, SW = Yes, somewhat, N = Neutral, NM = No, not much, NAA = No, not at all

I think I will remember this class 10 years down the road.

	n	Mean	σ	SA	A	N	D	SD
I think I will remember this class 10 years down the road.	351	3.87	1.00	96	161	59	23	12

SA = Strongly agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly disagree

Hesitancy about taking other math classes

	n	Mean	σ	Not at all hesitant	Somewhat hesitant	Very hesitant
Having taken this class, how hesitant would you be to sign up for another math class?	350	1.71	0.68	147	158	45

Interest in Bringing Mathematics into Their Lives (Goal 11)

Student relationship to mathematics.*

Question	Pre/ Post	n	Mean	σ	SA	A	N	D	SD	p	ES
**Outside of its everyday uses, nothing I learn about mathematics will impact my daily life.	Pre	452	3.18	1.00	21	105	124	176	26	<0.001	0.327
	Post	354	3.51	1.02	10	55	85	151	53		
Thinking in a mathematical way will be helpful to me in my life.	Pre	458	3.31	0.95	32	185	152	72	17	<0.001	0.254
	Post	357	3.55	0.94	46	163	102	35	11		

**Table doesn't include data for students who responded Don't know*

***The mean for negatively worded questions was calculated so that strongly agree=1 and strongly disagree=5.*

SA = Strongly agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly disagree

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

Area	n	% Increased	Increased a lot	Increased a little	No change (stayed high)	No change (stayed low)	Decreased a little	Decreased a lot
Likelihood that I will talk about mathematics with others outside of a math class has	351	41%	42	103	46	126	12	22
Likelihood that I will go to a talk or watch a video about mathematics not associated with a math class has	351	38%	35	100	51	132	8	25
Likelihood that I will read mathematics papers or books has	351	27%	23	72	57	158	18	23
My ability to think and reason more effectively has	350	82%	119	168	45	15	1	2
My ability to read and understand mathematical problems (i.e., what the problem is asking, not just how to solve it) has	349	76%	83	181	42	33	7	3
My ability to express myself clearly in writing has	350	66%	71	161	78	38	-	2
My ability to express myself clearly when talking has	351	69%	69	173	76	31	1	1