AC 2010-1534: ARE WE REALLY "CROSSING THE BOUNDARY"? ASSESSING A NOVEL INTEGRATED MATH/SCIENCE COURSE

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Are We Really "Crossing the Boundary"?
Assessing a Novel Integrated Math/Science Course

In recognition of the critical need for an increased and diverse workforce in science, technology, engineering, and math (STEM), the University of Michigan (U-M) College of Engineering developed the M-STEM Academy. Based on the successful Meyerhoff Scholars Program,[1,2,3,4] we identify talented diverse incoming engineering students with interest in STEM fields who, for reasons of socioeconomic class, first generation college student status, race, gender, or lack of high school rigor might not be successful in pursuing an engineering degree. Like the Meyherhoff Scholars Program, the M-STEM Academy provides these students with a highly coordinated support system during the critical transition years between high school graduation and the declaration of an engineering major by the junior undergraduate year. Components of the M-STEM Academy include:

- Careful identification and selection of students,
- A pre-freshman, six-week, intensive, summer transition program,
- A "Living Community" program during the freshman year through which M-STEM students live in the same residence hall,
- Required advising and academic coaching that focuses on academic planning and success strategies as well as on dealing with personal challenges,
- Peer study groups, tutoring, and supplemental instruction,
- Mentoring and other professional development opportunities,
- Monthly "family meetings" where student cohorts and M-STEM staff discuss academic and personal opportunities, challenges, and strategies,
- Research opportunities during the academic year or during the summer between the first and second year, and
- A $3,000 financial incentive for full participation and for maintaining a B average.

These components were designed to incorporate a variety of research-based best practices and provide students with resources necessary to overcome challenges that can often result in student attrition.[5,6,7] In particular, the six-week intensive summer transition program provides students with the opportunity to learn resources and best practices for success in college and to be affirmed in their capabilities.[8,9,10] The transition program provides challenging learning opportunities, encourages students to work collaboratively across racial groups, and fosters an atmosphere of trust within the classroom environment. Similarly, components that build a community around the learning process by linking the living and learning aspects of the college experience have been shown to increase students' intellectual abilities, critical thinking skills and cognitive development.[11,12,13,14,15] Further, participation in undergraduate research positively influences students' academic achievement and persistence, level of engagement, and post-graduate academic pursuits.[16,17]

The day to day management of the M-STEM Program is done through a very tight and well coordinated *Leadership Team*. This team is composed of the M-STEM Faculty Director, two Co-Administrative Directors and the Chair of Diversity and Outreach Council of the College of Engineering (CoE). The team receives direction and guidance from the Associate Dean for Undergraduate Education in CoE. The team also oversees the work of the Program Evaluation

Team and meets regularly to establish policy and procedures and to evaluate M-STEM projects. Finally, the M-STEM Program is supported by four project teams (1) *Coaching/Mentoring*; (2) *Teaching/Academics*; (3) *Internship/Research Experience*; and (4) *Operations*.

The focus of this paper is on one aspect of the summer transition program. That program is designed to prepare students for the new expectations and requirements of rigorous college courses as well as to promote social and academic integrations. It is structured as a six-week "academic term" with three classes. The first is an introductory math course that covers either pre-calculus or introductory calculus basics. The second course presents technical communications and provides an introduction to engineering design and team work. The third course, "Crossing the Boundary," reintroduces students to basic math and science concepts by presenting the materials in an integrated way. "Crossing the Boundary" has the following four goals:

Goal 1 to prepare students for the math exams they will encounter during their first college term,

Goal 2 to show students the connections between math, science, and engineering in order to provide a deeper understanding of the fundamental concepts,

Goal 3 to enhance students' ability to work effectively in teams, and

Goal 4 to provide an opportunity for students to develop the skills necessary to succeed in college and to improve their self-confidence.

This course and its goals are grounded in the knowledge that integration of subjects within engineering leads to a deeper understanding of the connections between math and science, the relevance of these basic subjects to engineering applications and thus improved knowledge retention.[1818,19,20] In this paper, we describe our assessment of "Crossing the Boundary" and its progress in meeting these goals.

Methods

The M-STEM Academy was first launched at U-M in Summer 2008, and the second cohort of students was admitted in the summer of 2009. For both cohorts, students invited to participate in the M-STEM Academy had already been admitted to U-M. As such, these students had been identified as high-achievers, but they had some aspect of their background (e.g., first generation college status or low family income) that is often indicative of inability to successfully transition to a highly competitive research university setting.

The second cohort of students – the group presented in this study – includes 49 students with a broad range of GPAs and scores on aptitude tests (see Table 1), with a diverse set of demographics (see Table 2), and from a variety of settings (37 (76.2%) are from within the state of Michigan, ten are from other states in the continental U.S., and two are from Puerto Rico). As seen on both tables, student characteristics of this cohort do not reflect the typical entering student body in CoE. Although all students admitted to the M-STEM Academy had been admitted to the U-M CoE based on the merits of their high school performance, students in the M-STEM Academy had slightly lower high school GPAs and scores on both ACT and SAT tests than did the general first year engineering student body. Note, too, that the M-STEM Academy comprises a higher fraction of underrepresented students, by far, than does the general first year engineering student body. There are nearly 40% women in M-STEM versus 22% women in the first year engineering student body, 19% versus 2% black students, 35% versus 3% Hispanic students, and 8% versus less than 1% Native Americans. (Asian students are not considered to be underrepresented in engineering). Similarly, family incomes for the M-STEM Academy student body are much lower than for the general first year student body.

		M-STEM Academy students (N=49)			First year engineering students (N=1296)		
		Min	Max	Mean	Min	Max	Mean
HS GPA (recalculated)		2.7	4.0	3.7	2.7	4.0	3.8
ACT scores*	Composite	23	34	28.5	22	36	30.3
	Math	23	35	28.7	23	36	31.4
	English	18	35	27.6	18	36	29.6
	Reading	19	36	29.7	16	36	29.8
SAT scores*	SAT	1000	1410	1252.4	970	1600	1356.3
	Math	510	780	655.9	510	800	717.3
	Verbal	420	720	596.5	350	800	639.0
	Writing	480	720	570.0	350	800	634.3

*Not all students report both ACT and SAT scores. For M-STEM students, 46/49 (93.9%) reported ACT scores while 17/49 (34.7%) reported SAT scores. For the first year engineering students, 1036/1296 (79.9%) reported ACT scores while 625/1296 (48.2%) reported SAT scores.

Table 1. GPA and scores on aptitude tests

		M-STEM Academy students (N=49)		First year engineering students (N=1296)	
		Total	% of valid responses	Total	% of valid responses
Gender	Female	19	38.8%	285	22.0%
	Male	30	61.2%	1011	78.0%
Race	Black	9	18.8%	26	2.0%
	Hispanic	17	35.4%	42	3.2%
	Native American	4	8.3%	6	0.5%
	Asian	2	4.2%	241	18.6%
	White	16	33.3%	925	71.4%
	Not reported	1	--	56	--
Family income	Less than $25,000	4	10.5%	46	5.1%
	$25,000 - $49,999	10	26.3%	89	9.9%
	$50,000 - $74,999	11	28.9%	107	12.0%
	$75,000 - $99,999	7	18.4%	135	15.1%
	More than $100,000	6	15.8%	518	57.9%
	Not reported	11	--	401	--

Table 2. Gender and race demographics and family income

To evaluate the progress of “Crossing the Boundary” in meeting its goals for this cohort, we designed two separate assessment instruments – a *math test* and a *class survey*. Together these instruments included a variety of items pertaining to the four course goals. The math test is the first midterm examination from the Winter 2007 offering of Calculus I at U-M. The class survey is a specially designed questionnaire with items from a typical first year undergraduate Physics text,[21] supplemented by items we wrote, to probe students’ understanding of underlying math and physics concepts. The class survey also includes items about students’ perceived ability to work on teams and succeed as a freshman at U-M.

After obtaining approval for human subjects research from our local Institutional Review Board, we administered our assessment instruments two times. Both the math test and the class survey were administered during the M-STEM Academy orientation in the week prior to the start of the six-week summer transition program. Though the student’s score on either instrument was not used in any way to determine course grade in “Crossing the Boundary,” the math test score was roughly used for placement into one of the two math courses (pre-calculus or calculus) offered during the six-week summer program. The math test was administered a second time during the very last week of the program in both of the math courses (pre-calculus or calculus). Again, the student’s score was not used to determine course grade. Rather, it was intended to serve as a practice exam and the graded exams were returned to students so they could learn from their mistakes. The class survey was administered a second time during the last week of “Crossing the Boundary,” and it was amended to include open-ended items for students to note lessons learned and other opinions about the class.

For our evaluation, we compare student data from before the class (the first administration of the instruments) to similar data from after the class (the second administration) using the paired t-test for significance. Though all 49 students completed the first administration of the math test, only 47 completed it at the end of the class, so only data for these 47 students is analyzed on the math test. All 49 students completed the class survey at both administrations, so data from all of them is analyzed. As previously indicated, items from the math test and the class survey were designed to address the four course goals, and those items are analyzed in the following ways.

Goal 1: to prepare students for the math exams they will encounter during their first college term. Five questions from the math test (taken directly from Calculus I first midterm examination) were scored by a teaching assistant who designed a grading rubric and applied it consistently to all problems (the exam and scoring rubric are attached as Appendices). The overall sum of the five questions (out of a possible 64 points) was used as a measure of students’ preparation for their math course.

Goal 2: to show students the connections between math, science, and engineering in order to provide a deeper understanding of the fundamental concepts. Two items had students identify underlying mathematical principles of different scenarios and categorize interrelated concepts as follows:

- Which of the following represents exponential behavior?
  __________ The total cost of an international phone call if there is a connection fee of $2.95 and an additional charge of $0.35/minute
  __________ The number of bacterium in a petri dish if they reproduce such that their population doubles every twenty minutes
  __________ The velocity of a falling rock
  __________ Your height above the ground as you jump on a pogo stick

- Which of the following represents sinusoidal/periodic behavior?
  __________ Your height above the ground as you ride up an escalator
  __________ Ricocheting the 8-ball off the pool bumper in billiards
  __________ The temperature of a cup of coffee as it cools over time
  __________ Your height above the ground as you ride on a ferris wheel

These two items also ask students to rate how certain they are of their response on a four point Likert scale (1=very uncertain, 2=somewhat uncertain, 3=somewhat certain, 4=very certain). For this study, we analyze the number of students who correctly answer both items as well as the students' level of confidence in their response.

Goal 3: to enhance students' ability to work effectively in teams. Five items ask students to rate their ability to address common team dilemmas using a three point Likert scale (1=not at all, 2=somewhat well, 3=very well). Specifically, the five questions ask: How well could you address an issue if you were on a team:

- where your teammates unfairly assumed you'd take the same role all the time?
- where someone was not doing their fair share?
- with an obvious lack of communication?
- that obviously lacked a clear plan of action for a project?
- where you felt a lack of unity or lack of belonging?

For this study, we compare student responses on all five individually, and we compute an index of overall ability to address team dilemmas by summing the five scores.

Goal 4: to provide an opportunity for students to develop the skills necessary to succeed in college and to improve their self-confidence. Two items use a four point Likert scale to gauge students' self-rated preparation for success. One asks students to indicate how confident they are that they'll succeed in their first term as an undergraduate (1=very insecure, 2=somewhat insecure, 3=somewhat confident, 4=very confident) and the other asks them to indicate how prepared they feel for succeeding as a freshman (1=very unprepared, 2=somewhat unprepared, 3=somewhat prepared, 4=very prepared).

Results

Data from both administrations of the math test and the class survey (before the class and after the class) are contained in Table 3.

		Before class	After class	p-value if significant gain
		Mean and standard deviation		
Preparation	Overall score on math test (64 points)	22.2 ± 13.9	39.1±14.0	*p*=0.000
Seeing connections	Percent answering both problems correctly	31/49 (63.2%)	42/29 (85.7%)	Not applicable
	Confidence in answer[‡]	2.9 ± 1.0	3.5 ± 0.9	*p*=0.001
Ability to work on teams	Ability to address an issue if you were on a team…			
	where your teammates unfairly assumed you'd take the same role all the time.[†]	2.4 ± 0.5	2.6 ± 0.6	*p*=0.017
	where someone was not doing their fair share.[†]	2.4 ± 0.5	2.5 ± 0.6	Not significant
	with an obvious lack of communication.[†]	2.7 ± 0.5	2.6± 0.6	Not significant
	that obviously lacked a clear plan of action for a project.[†]	2.7 ± 0.5	2.7 ± 0.5	Not significant
	where you felt a lack of unity or lack of belonging.[†]	2.4 ± 0.7	2.5 ± 0.6	Not significant
	Overall ability to address team dilemmas (15 point scale)	12.5 ± 1.7	12.6 ± 2.8	*p*=0.050
Skills for success	Confidence in ability to succeed in first term as an undergraduate[‡]	3.1 ± 0.8	3.5 ± 0.7	*p*=0.001
	Feeling preparedness to succeed as a freshman[‡]	2.9 ± 0.8	3.5 ± 0.7	*p*=0.000

[†]Data are reported on a 3-point Likert scale for this item, [‡]Data are reported on a 4-point Likert scale

Table 3. Data from the math test and class survey

Goal 1. Student scores on the five math questions at the end of "Crossing the Boundary" are statistically significantly higher than at the beginning of the six-week summer transition program (mean = 39.1/64.0 versus 22.2/64.0, p=0.000[*]). Though these raw scores may seem low, the mean at the end of the course (62%) is comparable to that of a typical first Calculus I midterm exam in the math department at U-M. And an analysis of the distribution of scores prior to the summer program indicates that only about seven students would likely receive a B or better on the exam, while approximately 26 would do so at the conclusion of "Crossing the Boundary." It's important to note that nearly one-third of the first year students at U-M enroll in a pre-calculus math course their first term, so these demonstrated gains on the Calculus I exam are even more impressive. Further, this experience has reinforced the student's mathematical skills and provided them with the experience of taking an exam that very much resembles the type of exam they will receive in their first math course on campus.

[*] The statistical analysis software package did return the value p = 0.000, meaning p<0.0005.

Goal 2. Data from the two items related to Goal 2 show that students did understand the link between science and math that was integral to "Crossing the Boundary" after completing the class. At the beginning of the class, 63 percent of the students correctly answered both questions which presented a physical situation and asked them to describe the situation mathematically correctly. On the other hand, 85 percent of the students answered both questions correctly at the conclusion of the class. Perhaps more importantly, though, student confidence in their answers increased from 2.9 to 3.5 on a 4-point scale (p=.001).

Goal 3. With regards to Goal 3, ability to work effectively on teams, results are less dramatic. Individually, the differences reported by students in their ability to address five separate common team dilemmas were small, with the only significant difference being in their ability to address unfair treatment on a team (increase from 2.4 to 2.6 on a 3-point scale with p=.017). By combining the five questions into one overall score, we see an increase from 12.5 to 12.6 on a 15-point scale (p=.050). This modest increase in perceptions of the ability to address teamwork situations is likely due to the high level of self-perception – nearing "very well at addressing." However, it also shows a potential point of future program effort.

Goal 4. Data shows that the class does provide an opportunity for students to develop the skills necessary to succeed in college and to improve their self-confidence. On a four point scale, students' level of confidence increased from 3.1 to 3.5 (p=.001) and their feeling of preparedness to succeed increased from 2.9 to 3.5 (p=.000). This is a remarkable and significant shift showing that the program is instilling a sense of self-efficacy in the students.

Finally, themes from the open-ended items on the end-of-course survey provide interesting insight. Students noted that, through making mistakes in "Crossing the Boundary," they learned to ask for help from the teacher and from others, to work more effectively on teams, and to begin homework early (rather than procrastinate). Common recommendations to other students include: "Work with other people on homework so you can talk about it," "Get to know your group as soon as possible," and "Don't procrastinate, the work is not as hard if you break it up." All of these are clearly valuable skills for succeeding in college, and the fact that the students in "Crossing the Boundary" noted them further indicates that class meets Goal 4.

Conclusions

These results indicate that "Crossing the Boundary" does meet the course goals. We show that students demonstrated significant gains in math skills and were better prepared for the first math exams they'll encounter in Calculus I. Further, students were better able to answer questions about the underlying mathematical principles associated with physical situations, and their confidence in their responses increased dramatically. Additionally, students' self-reported ability to function effectively on teams did increase, though these improvements are not as great as those reported for some of the other course goals. This limited reported improvement could be a result of students' false confidence in their abilities at the beginning of the program, and thus may be underestimated by the data. And finally, students reported significant increases in their level of confidence and feeling of preparedness to succeed in college, and they noted gaining important college survival skills.

Clearly, the results we present in this paper cannot be linked explicitly to the "Crossing the Boundary" course, but they point to the efficacy of the overall M-STEM Academy on preparing students to meet the challenges of their first semester at U-M. Students in this program have been shown, historically, to have challenges of building and using effective communities for student support, to be less prepared for the rigors of the college classroom, and to have far more out-of-class responsibility than the traditional student (e.g., financial, familial). Thus, these students have typically been less successful at U-M. Therefore, the gains demonstrated by this student cohort can serve as an outstanding model that other institutions may adapt for their own context.

There are several aspects of the M-STEM Academy that are likely to improve student success and that other institutions can easily adopt. Integrating math and science concepts together in introductory courses, and using inquiry to motivate these ideas, has long been proven as an effective pedagogical approach. Many first semester calculus and physics courses could foster this approach by using relevant (to the student), real-world examples that emphasize the underlying principles. Further, placing students in teams early in their undergraduate career and encouraging students to form study teams for classes that don't have required teamwork components are other ways to provide important experiences for students. This can improve their ability to succeed, both in school and in the workplace.

Designing support mechanisms – possibly by encouraging out-of-class student communities and intense, student-specific academic coaching – is another aspect of this program that can offer critical resources for all students, especially those less likely to succeed. And giving students the opportunity to take risks and learn from their mistakes early, without significant academic consequences, is important. One way to do this could be through structuring classes to offer students an opportunity to drop a low test grade or having an official "clemency" program during the first semester (e.g. the first term's grades are not computed in the cumulative GPA).

The benefits of the M-STEM Academy are many, and they are realized by participants in the program. As one student noted:

> *Take advantage of this HUGE opportunity because you will be one giant step ahead of every other incoming freshman.*

Other institutions could see similar benefits by adopting relevant aspects of the program.

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Appendix 1. *Math Test*

1. According to a survey by the U-M Transportation Research Institute, gasoline prices are projected to reach \$5.00 a gallon by the year 2020.

   a. (5 points) Assuming that the average gas price in 2007 is \$2.00 per gallon (yes, we know that is wishful thinking), find an exponential function, P, that models the average gas price t years after 2007. Show either an "exact" answer or at least 4 decimal places in your answer.

   b. (2 points) What is the *annual* percent change in the average gas price according to this model? (Show to at least one decimal place.)

   c. (2 points) What is the yearly continuous percent rate of change for this model? (Show to two decimal places.)

   d. (5 points) If, instead, gasoline prices grow linearly between 2007 and 2020 find a linear function, L, to model the price t years after 2007.

   e. (2 points) The survey indicates that price may be \$4.00 per gallon eight years from now. Which of the two models best predicts this projection?

2. (13 points) Brian's favorite website is woot.com. This site generally sells one item each and records the number of sales during each hour of the daily special. On Thursday, Brian noted that the day's graph of sales looked sinusoidal. At 1:00 a.m., there were 70 items sold and again at 3:00 p.m. Between those hours, the sales went down (once) to a low of 20 items and then up (once) to a high of 120 items before the last 70 items were sold at 3:00 p.m.

   a. Determine a trigonometric function that would model sales, S, as a function of t in hours after 1:00 a.m., assuming that the graph Brian saw was sinusoidal.

   b. What is the period of your function?

   c. What is the amplitude of your function?

   d. Approximately when were the sales increasing fastest?

3. (12 points) At woot.com the staff has become quite good at predicting the number of items that will be sold based on the brand name, reliability reports, the price, and the predicted popularity of the item. The maximum number of items, N, that they expect to sell during the entire sale period on a given day is a function of what they call the Max Sales Index, i, so $N = f(i)$, where the units of i are referred to as "points."

   a. In the context of this problem, give a practical interpretation of $f(10)$.

   b. In the context of this problem, what is the practical interpretation of $f'(5) = 2500$?

   c. The number of Wooters (registered members of Woot.com) is currently over 500,000. Since there is not a mechanism for "un-registering," and the membership has grown very quickly, assume that the number of Wooters, W in thousands, is an invertible function of time, t in hours, $W= g(t)$. In this context, give a practical interpretation of $(g^{-1})'(200) = .05$

   d. Sometimes woot.com sells bags of junk, "like shopping blindfolded at the Dollar Store." We can't say the exact name here, so we'll call them BoCs. Even these bags sell quickly on woot.com – typically in minutes. A recent BoC sale recorded the following data, where $s(t)$ gives the total number of BoC sales t minutes after the sale began. Use the data to estimate the $s'(10)$. Show your work.

Time (minutes)	6	8	10	12	14	16	18
$s(t)$ (number of BoCs)	40	88	136	184	243	313	436

4. (16 points) State whether each of the following statements are TRUE or FALSE. For each statement, give an explanation. If the statement is false, give an example that shows a contradiction to the statement. If the statement is true, show why it is true. Examples may be formulas or graphs. Explain your reasoning.

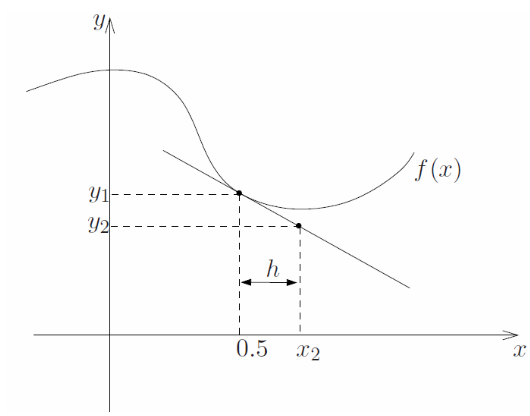
   a. If $f'(x)$ is increasing, then $f(x)$ is also increasing.

   b. If $f'(x)$ not equal to $g(x)$ for all x, then $f'(x)$ not equal $g'(x)$

   c. There is a function which is continuous on [1,5] but not differentiable at $x = 3$.

   d. If a function is increasing on an interval, then it is concave up on that interval.

5. (7 points) The figure below shows $y= f(x)$ and a line tangent to f at $x = 0.5$. Given that $f(0.5) = 2$, $f'(0.5) = -3$, and $h = 0.1$, determine the values of y_1, y_2, and x_2. [Notes: x and y are different scales on the graph.]



Appendix 2. Scoring Rubric for *Math Test*

General rubric

- **No Credit -** Showed no work, no effort, no clarity, and/or total lack of understanding of the material.
- **Partial Credit -** Performed a reasonable attempt at working through the problem or showed understanding of the problem without the full, correct work necessary to get to an answer.
- **Full Credit-** Either calculated/explained a full correct answer or showed complete understanding of the material with minor errors in the final answer.

Problem #	No Credit	Partial Credit	Full Credit
1a (5 points) 1c (2 points) 1d (5 points)	Did not choose the correct equation to use.	Chose the right equation or near to it, but made incorrect calculations or assumptions.	Chose the correct equation and calculated its constants correctly.
1b (2 points)	Final answer off by orders in magnitude.	Some calculations correct, but not enough to end up with a correct answer.	Correct number and units.
1e (2 points)	Made incorrect calculations and chose the wrong option.	Either chose the correct option or showed correct calculations, but not both.	Got both the calculations and correct option choice correct.
2a (6 points)	Did not choose the correct equation to use.	Chose the right equation or near to it, but made incorrect calculations or assumptions.	Chose the correct equation and calculated its constants correctly.
2b (3 points) 2c (2 points) 2d (2 points)	Only showed unclear or incorrect guesses at the answer.	Some calculations correct, but not enough to end up with a correct answer.	Correct number within error.
3a, 3b, & 3c (3 points each)	Only showed unclear of incorrect guesses at the answer.	Gave an incomplete or partially incorrect explanation.	Explained all necessary material for understanding relevant issues.
3d (3 points)	Made incorrect calculations that were irrelevant and/or ignored the data given.	Chose the correct calculations to make, but executed them incorrectly.	Chose and executed the calculations correctly based on the data.
4a, 4b, 4c, & 4d (4 points each)	Chose the wrong option.	Chose the correct option, but gave an incorrect example to explain the option choice.	Chose the correct option and gave a clear, correct example.
5a &5c (1 point each)	Only showed unclear or incorrect guesses at the answer.	No partial credit	Correct number within error.
5b (5 points)	Only showed unclear or incorrect guesses at the answer.	Attempted to use the mathematical properties of a line, but incorrectly.	Correct number within error.

We propose a novel approach that assesses the translated output based on the source text rather than the reference translation, and measures the extent to which the semantics of the discourse elements (discourse relations, in particular) in the source text are preserved in the MT output. The challenge is to detect the discourse relations in the source text and determine whether these relations are correctly transferred crosslingually to the target language -- without a reference translation. This methodology could be used independently for discourse-level evaluation, or as a component in other Contemporary mathematics is a mixture of much that is very old and still im-portant (e. g., counting, the Pythagorean theorem) with new concepts such as sets, axiomatics, structure. The totality of all abstract mathematical sciences is called Pure Mathematics. The totality of all concrete interpretations is called Applied Mathemat-ics. Together they constitute Mathematics as a science. With math, in my opinion, and even more-so than computer science, this approach is crucial. A programmer can make it far in the field without ever formally learning algorithms. A programmer can be very successful taking a top-down approach, albeit lacking an understanding of the fundamentals or lower level structures with which they work. A mathematician on the other hand, cannot dive straight into calculus. As mathematics is the language -- the glue -- that ties literally every other scientific field together: physics, engineering, computer science, chemistry, etc, it's full understandin Assessing A Novel Integrated Math/Science Course Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. 10.18260/1-2--16587. Download Citation. Ã—. APA - LaTeX bibitem. \bibitem{asee_peer_16587} Finelli, C., \& Meadows, L., \& Lorch, D., \& Davis, C., \& Meadows, G. (2010, June), \emph{Are We Really â€œCrossing The Boundaryâ€?Â Cynthia Finelli, Lorelle Meadows, David Lorch, Cinda-Sue Davis, and Guy Meadows. "Are We Really â€œCrossing The Boundaryâ€? Assessing A Novel Integrated Math/Science Course". 2010 Annual Conference & Exposition, Louisville, Kentucky, 2010, June. ASEE Conferences, 2010. https://peer.asee.org/16587 Internet.