BOISE STATE UNIVERSITY
OFFICE OF INSTITUTIONAL RESEARCH

The Relationship of Math Courses and Grades to Success in CHEM 111

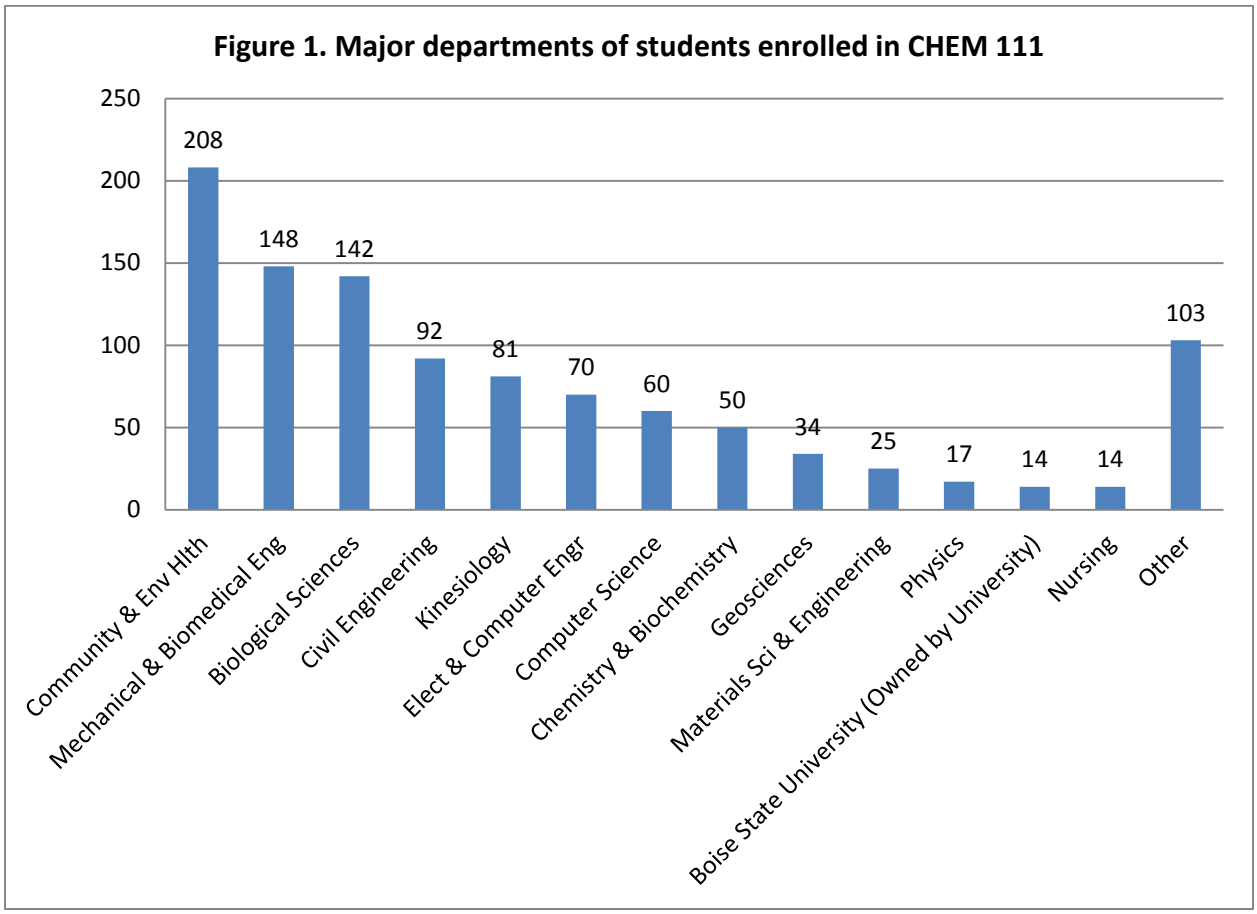
Overview: This study addressed the relationship between math performance and CHEM 111 grades. Students most often began in MATH 143 (27%) though 11% had no math courses on their transcripts. By the time they were in CHEM 111, slightly over 20% had completed Calculus I or a higher course number, 17% had completed the survey of calculus (MATH 160), and 23% had completed MATH 143. Over 70% received an "A" or "B" in their first math course and over 60% received an "A" or "B" in their last math course prior to CHEM 111. Students without any math courses and those who had completed Calculus I had similar CHEM 111 grades, while students who began in MATH 025 or 108 had lower chemistry grades. Using last math class and last grade in math to predict chemistry performance accounted for 24% of the variability in chemistry grades. Although math grade was more important than level of last math course, both were needed to adequately predict chemistry performance. Based on the prediction equation, it appears that students who had not completed calculus I should probably have at least a "B" in their last math course. Students who had completed MATH 170 (calculus I), MATH 175 (calculus II) or MATH 254 (Introduction to Statistics) were likely to pass CHEM 111.

Purpose of the study

This study was requested as part of on-going efforts to help STEM majors successfully navigate the courses they need to obtain a STEM degree. One of the early stumbling blocks has been CHEM 111. Grades in the lecture portion of this course for fall 2013 included 26% "Ds" or "Fs" and 3% "Ws." In spring 2014, 18% had "Ds" or "Fs" and 2% had "Ws". One theory is that math preparation plays a role in CHEM 111 performance.

Who was included in the study?

This study was based on 1,058 students who took CHEM 111 for the first time in the fall of 2013 (n=658) or the spring of 2014 (n=400). Over half (61%) were male, and most (89%) were enrolled full-time. Based on credits earned, sophomores were the largest group enrolled in CHEM 111 (42%), followed by freshmen (29%), juniors (18%), seniors (8%) and second degree students (3%). Figure 1 below shows the departments for the largest groups of students' majors. As expected, most are majors in health-related fields or in STEM disciplines. Overall, 60% were in STEM disciplines and 30% were in health-related disciplines. The average CHEM 111 grade was 2.41; 28% received an "A," 25% a "B," 24% a "C," 10% a "D," and 14% received an "F" the first time they took the course.



What math courses had students taken and what grades had they received?

Table 1 shows the catalog number for the first math course recorded for students on their college transcripts, whether it was taken at Boise State or not. Note that slightly more than 10% of students did not take any math course before enrolling in CHEM 111. For those who had taken math, about 35% transferred in their first math course. Only about 15% of students had a first math course that was calculus-level (MATH 170) or a higher number.

The last math course that students took prior to enrolling in CHEM 111 also is shown in Table 1. Again, relatively few students had completed the first level calculus course before taking CHEM 111.

Table 1. First and last math courses taken by CHEM 111 enrollees prior to taking CHEM 111

Math course number:	Frequency count for first math course taken	Percent	Last math course taken before CHEM 111	Percent
No math course	121	11.4	121	11.4
015	3	.3		
020	3	.3	1	.1
025	127	12.0	2	.2
105	3	.3	1	.1
108	215	20.3	21	2.0
123	8	.8	3	.3
124	14	1.3	1	.1
130	3	.3	1	.1
143	284	26.8	200	18.9
144	23	2.2	219	20.7
147	87	8.2	88	8.3
157	3	.3	1	.1
160	15	1.4	41	3.9
170	97	9.2	160	15.1
175	16	1.5	55	5.2
187	1	.1	3	.3
254	33	3.1	100	9.5
257			2	.2
275	1	.1	15	1.4
333	1	.1	17	1.6
360			3	.3
361			3	.3
Total	1058	100.0	1058	100.0

Table 2 displays the grades received for those who took math. Performance was quite good with 73% receiving an "A" or "B" in their first course and 64% receiving a similar grade in their last course. There were few failures.

Table 2. Grades received in first and last math courses

Grade	Number with each first math grade	Percent of all first math grades	Number with each last math grade	Percent of all last math grades
A	359	38%	292	31%
B	325	35%	305	33%
C	165	18%	223	24%
D	35	4%	54	6%
F	41	4%	56	6%
P	12	1%	7	1%
Total	937	100%	937	100%

What is the relationship between math courses and grades and performance in CHEM 111?

Does the first course a student takes relate to performance in CHEM 111? To address this question, average CHEM 111 grades were compared for five groups: No math taken, MATH 25, MATH 108, MATH 143/144/147 and MATH 170. The results are shown in Table 3 below. The results of the means comparisons using ANOVA were highly significant, $F(4,949)=14.12, p<.000$. A post-hoc comparison of the means using MATH 170 as the comparison group revealed that students who had no math course and students who started in 143/144/147 had similar CHEM 111 grades, but those who began in MATH 25 or 108 had significantly lower chemistry grades.

Table 3. Average CHEM 111 grade based on FIRST math course taken

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
No Math	121	2.75	1.43	0.13	2.39	2.91
MATH 025	127	1.71	1.29	0.11	1.48	1.94
MATH 108	215	2.20	1.31	0.09	2.03	2.38
MATH 147	394	2.50	1.25	0.06	2.38	2.63
MATH 170	97	2.79	1.31	0.13	2.53	3.06
Total	954	2.38	1.34	0.04	2.29	2.46

The last math course students took also was significantly related to CHEM 111 grade, $F(2,785)=10.381$, $p<.000$. Because most students had reached the point of at least taking MATH 143 (see Table 1), the comparison was limited to three groups (1) students without a math course, (2) those who ended in 143/144/147, and (3) those who took MATH 170 as their last math course prior to enrolling in CHEM 111. Post hoc comparisons of the means revealed that the "no math" and the "MATH 170" groups had similar grades, but the MATH 143/144/147 group had lower grades compared to the other two groups.

Table 4. Average CHEM 111 grade based on LAST math course taken

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
No math	121	2.65	1.43	0.13	2.39	2.91
MATH 147	507	2.14	1.35	0.06	2.03	2.26
MATH 170	160	2.55	1.26	0.10	2.36	2.75
Total	788	2.30	1.36	0.05	2.21	2.40

Both the level of first math and the level of last math were related to performance in CHEM 111. But how did the grades in first and last math courses relate to performance in CHEM 111? As shown by Table 5, last math grade correlated more highly with CHEM 111 grade compared to first math grade. In fact, the relationship between last math and CHEM grades was higher than the relationship between first and last math grades.

Table 5. Correlations with first math grade, last math grade, and grade in CHEM 111

		First Math Grade Points	Last Math Grade Points	CHEM 111 grade points
First Math Grade Points	Pearson Correlation	1	.358**	.297**
	N		937	937
Last Math Grade Points	Pearson Correlation		1	.387**
	N			937
CHEM 111 grade points	Pearson Correlation			1
	N			1058

**. Correlation is significant at the 0.01 level (2-tailed).

Knowing the last course that students took and the grade in that course, what grade in CHEM 111 could be expected? To address the question, a regression analysis was run that included students who last enrolled in MATH 143, 144, 147, 160, 170, 175, or 254 along with the grade they received in that math course. The result was a significant prediction of CHEM 111 grades, $F(4,858)=67.307$, $p<.000$, that explained 24% of the variability in grades.

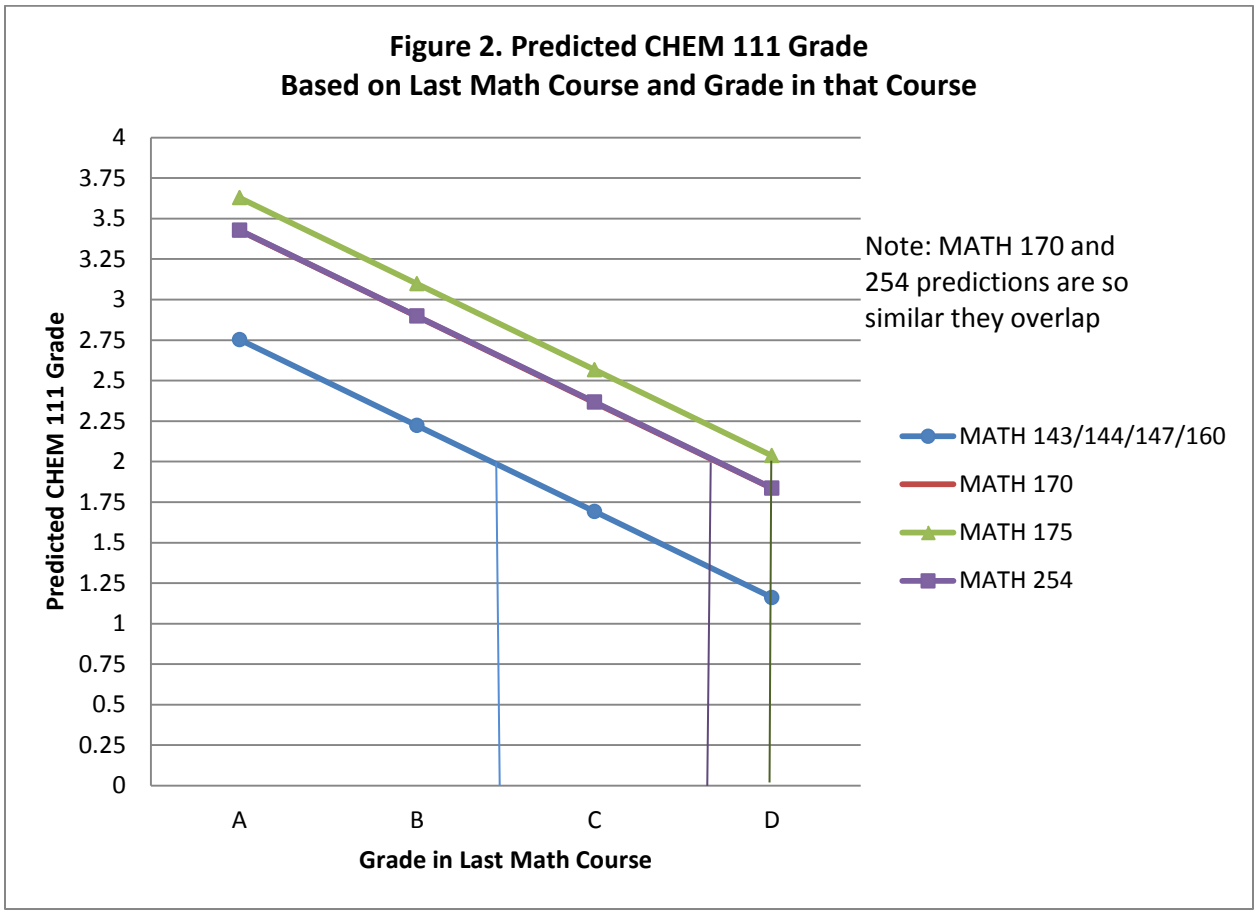
The analysis used students in Math 143, 144, or 147 as the comparison to students enrolled in MATH 160, 170, 175, and 254. When the initial analysis indicated that students in MATH 160 were similar to the 143/144/147 students, they were also added to the comparison group before running the final analysis shown in Table 6. The regression equation in Table 6 shows that chemistry grade improved by .673 points for students who last enrolled in MATH 170 and by an almost equal amount (.676 points) for those last enrolled in MATH 254. Having last enrolled in MATH 175 improved the prediction of chemistry grade by .875 points compared to students in MATH 143/144/147/160. Note, too, that for each one-point increase in math grade (e.g., from a "C" to a "B") the prediction of chemistry grade improved by .53 points. By studying the Standardized Beta Coefficients, which places all of the variables on the same measurement scale and shows how much each variable contributes to the prediction while holding constant the effects of all of the other variables, we see that grades mattered more than level of last math course (β=.45 vs .16-.20).

Table 6. Prediction of CHEM 111 grade points based on last math class taken and grade in last class

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.631	.114		5.546	.000
	MATH 170	.673	.105	.199	6.412	.000
	MATH 175	.875	.164	.162	5.339	.000
	MATH 154	.676	.125	.164	5.391	.000
	Last Math Grade Points	.531	.036	.450	14.770	.000

Note: Students last enrolled in MATH 143, 144, 147 or160 serve as the comparison group

Ultimately, both grades and level of math were important when predicting performance in CHEM 111. Figure 2 uses the prediction equation shown in Table 6 to illustrate the average expected grade based on the level of the course taken and grade in that course. For example, if we were looking for students to get a "C" in CHEM 111, they should probably have at least a "B" if their last course was MATH 143, 144, 147, or 160. If the student last took MATH 170 or 254 and received at least a "C" grade, they would also be predicted to get a "C" in CHEM 111. Students who had completed MATH 175 could expect a "C" in CHEM 111, even if they got a "D" in MATH 175.



Summary and Conclusions

About a quarter of students who took CHEM 111 for the first time during the 2013-14 academic year received a "D" or "F" in the course and needed to repeat it. This study looks at the relationship between performance in chemistry and the math courses and grades taken prior to enrolling in chemistry. Most students' first math course was either MATH 143 (27%) or MATH 108 (20%). Slightly less than 10% began in Calculus I (MATH 170) and slightly more than 10% did not have any college math courses recorded. By the time the students enrolled in CHEM 111, almost half had started or completed the MATH 143/144/147 course set, 15% had taken Calculus I (MATH 170), and about 10% had taken MATH 254.

The first level of math related to CHEM 111 grades. Students who first took MATH 170 or 143/144/147 or no math course at all had similar chemistry grades. However, students who began in MATH 025 or 108 had significantly lower chemistry grades compared to the other group. Interestingly, students with no math performed similarly to students who had taken MATH 170 indicating that perhaps the no-math group had taken calculus in high school. Math grades were also related to chemistry performance; grades in later math courses were more highly related to CHEM grades than were early math grades.

Although grade in last math course was the factor most strongly related to performance in chemistry, students who had completed MATH 170, 175, or 254 outperformed students who had not yet taken those courses. The combination of last math course and last math grade accounted for 24% of the variability in chemistry grades.

June 2014
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Office of Institutional Research