Instruction Type, Student Major, and Success in Developmental Mathematics

By Jean Coltharp

ABSTRACT: ***The low success rate of developmental (or remedial) mathematics courses has been a great concern at the higher education level. In this research, student success is considered in terms of final grade, D/F percentage, and withdrawal percentage. The study examines student success at a Midwestern university as it relates to instructional delivery type (online vs traditional) and student major (arts and humanities, STEM, and undeclared). It was found that final grade and D/F percentage were statistically significant, whereas withdrawal percentage was not when the data were analyzed with a two-way analysis of variance.***

Examining students' majors and how they relate to retention rates in developmental mathematics classes can provide a new perspective.

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Across the nation, one of the common themes that two-year colleges and four-year universities alike have been concerned with is student success. High dropout rates continue to be a problem, which has been attributed to the fact that many students are underprepared for college (Bettinger, Boatman, & Long, 2013; Bettinger & Long, 2009; Boylan, 1999; Cafarella, 2016; Fong, Melguizo, & Prather, 2015). The content area in which this is most apparent is mathematics with higher enrollment numbers in developmental mathematics courses (usually Beginning Algebra and Intermediate Algebra) when compared to developmental English and developmental reading. This high enrollment in developmental classes is attributed to inadequate preparation for college from the high school level. It has been estimated that 30% of all incoming freshman will need developmental education in two or more classes (Bettinger et al., 2013; Bettinger & Long, 2009; Boylan, 1999; Cafarella, 2016; Fong et al., 2015). Out of the 12 million first-year college students, this would amount to 3.6 million students enrolled in developmental classes.

Examining students' majors and how they relate to retention rates in developmental mathematics classes can provide a new perspective. Looking at a student's major could give instructors a way to improve student success in developmental education classes if something was discovered about how certain majors succeed in different types of classes. For example, in a certain major, if a majority of the students may score better in online developmental mathematics classes, the university could use this information to better advise future students.

Research has shown that for every developmental class that a student takes, the chance of that student graduating from college drops by 50% (Missouri Department of Higher Education [MDHE], 2016). Students who take two developmental classes are 75% less likely to graduate than students not required to take any developmental classes. To improve success rates in developmental mathematics classes and allow students to persevere to graduation, instructors need to understand what causes them to fail. This is the first step of many in helping students graduate.

Literature Review

When students enter college underprepared, they are required to take remedial or developmental classes to catch up. Nationally, over two-thirds of entering freshmen test into developmental classes with only a third of those passing on their first attempt (Trenholm, 2009). Failing a class in a subject they are already behind in can cause students extra stress and eventually lead to their dropping out (Fong et al., 2001). If these students are able to persist through the developmental mathematics sequence (only about 21% of students are), they are just as successful as students who were not placed into remedial classes (Bonham & Boylan, 2011). Even though the problem may start with students coming in underprepared and needing remedial classes, once they are admitted to college, the focus should be on getting them through the mathematics sequence they need. Thirty percent of students who were referred to developmental education did not enroll in these classes—opting instead, for enrolling in a credit bearing class for which they were not prepared. Of the 70% that did enroll in a developmental course, less than half of them completed the sequence (Fong et al., 2015). Though not the focus of this study, this raises questions as to why students did not enroll in classes that were recommended for their skill level and what can be done to encourage them to take the best route.

When looking specifically at community colleges, only 22% of students who enter earn an Associate's degree. The results are slightly higher for students who are enrolled in developmental education; 24% will receive their degree (Boylan, 1999). However, these low numbers might not be as bad as they initially seem: Some of the students

who didn't earn an Associate's degree could have earned certificates or even transferred to a four-year institution. Looking at the developmental mathematics classes in particular, Basic (or Beginning) Algebra has shown the highest failing and withdrawal rates of any other course across the nation (Bonham & Boylan, 2011). Success rates in developmental mathematics have been found to be as low as 24% in some colleges (Spradlin & Ackerman, 2010). Gerlaugh, Thompson, Boylan and Davis (2007) examined data from 116 colleges to try to identify trends in developmental education. Mathematics classes saw an average withdrawal rate of 20%. Out of the 80% that stayed in the class, only 68% of those students passed (54% of the original students who enrolled).

Because the topic of online education is still relatively new (with online, developmental education—and even online, developmental mathematics classes—being even newer) the literature is still growing. The data are at odds as to whether online delivery is more effective than traditional classes or not.

According to a study done in 2010 by the Sloan Consortium (Xu & Jaggars, 2011), during the fall of 2009, 29% of college students took an online class across the country. There has been more than a 19% increase in enrollment in online classes every year for 5 years (Xu & Jaggars, 2011). Research has found that when comparing online and traditional classes, there is a 10-20% increase in attrition rate for online classes overall (Ashby, Sadera, & McNary, 2011).

Pro-Online

Moving to a study that looked at Beginning Algebra and Intermediate Algebra classes taught online, traditionally, and in a computer lab across one academic year, the results were surprising. When studying the percentage of students who passed the class (C or better), the online section had the highest percentage, followed by the traditional lecture class, and then the lecture that was in a computer lab (Beginning Algebra: 61.5%, 39.4%, and 37% respectively; Intermediate Algebra: 42.1%, 37.1%, and 35.1% respectively). This was true for both courses separately as well in the combination. Interestingly, the online classes also had the lowest withdrawal percentage of the three groups. A previous study analyzed has shown that online classes tended to have a higher withdrawal percentage rates when compared to traditional and hybrid courses. In the online classes, the average student was older, the average grade on the final was higher, and the average grade earned in the class was higher. It is worth mentioning that in the online class, only the final exam was proctored unlike all tests being proctored in the other two classes. This could be used as an argument for why cheating might be a factor on all other assignments but, as already stated, the online students averaged higher on the proctored final as well (Trenholm, 2009).

Anti-Online

Not all studies paint online classes in such a positive light. Weems (2002) looked at Beginning Algebra classes that were taught online and face-to-face. It is important to point out that this study had a very small *n* with only 48 students enrolled. As with most developmental education, the students self-placed into either the online or traditional class. Students in the traditional class had a higher mean score on two out of three exams. It was found that performance declined significantly in the online class as the semester progressed, whereas in the face-to-face class it remained relatively consistent throughout.

Zavarella and Ignash (2009) also looked at a Beginning Algebra classes offered via online, hybrid, and traditional methods. The study took place in southern Florida on two of five campuses (since those are the only campuses that offered all three methods) of a large, urban, multi-campus community college, and included just under 200 participants. However, it looked at withdrawal percentages in particular. The researchers found that the traditional lecture class had the fewest withdrawals, and the hybrid class had the highest percentage of withdrawal. Although fully online classes did not have the highest withdrawal percentage, it was still found that classes that involved a computer had a higher percentage of students withdrawing than the traditional lecture classes.

The smaller the sample size, the more likely that the researchers will find online classes more beneficial.

Mixed Reviews

Not every study has been as cut and dried as those previously presented. Some research is split even within the same study as to whether online or traditional is better. In a study by Spradlin and Ackerman (2010) that took place in a public, eastern university with an enrollment of about 11,000 students, Intermediate Algebra classes had three different types of delivery: traditional, hybrid, and online. The students who were in the hybrid classes had a higher posttest score than the face-to-face class, but the strictly online students had the lowest posttest scores. The students in each class were also asked their opinion about using a computer for education purposes. The students in the online classes responded favorably 97% of the time compared to 71% for the traditional class and 59% for the hybrid students.

In his research, Kinney (2001) took the idea a step further and looked at a traditional lecture and computer-mediated lecture in Beginning Algebra and Intermediate Algebra classes. There were about 900 students who enrolled in these classes each year at the school in which the study took place. No significant difference was found in final grades between the two types of instructional delivery. However, more students withdrew from the computer-mediated class than the traditional class. Students who persisted were also given a survey about their thoughts on the class, and students in both Beginning and Intermediate Algebra reported being more satisfied with the computer-mediated class than the lecture class.

Ashby et al. (2011) have noted that there is limited literature on student success in developmental education. Usually, the smaller the sample size, the more likely that the researchers will find online classes more beneficial (Xu & Jaggars, 2014). As was seen, the available literature regarding the success of online versus traditional lecture in developmental mathematics (or even developmental education in general) is very mixed. In the current age of technology, for students who are busy with their personal lives, online classes have increased in popularity.

Summary: Literature Review

An extensive search through many peer-reviewed journals (e.g., *Journal of Developmental Education, Research in Higher Education,* and *Journal for Research in Mathematics Education*) has found no mention on research about how student major affects success in developmental mathematics. This can even be broadened to developmental education and higher education in general. It raises the question as to why there is such a gap in the research in this area. Researchers may think that it is obvious that STEM majors will do better in STEM classes. However, a layman's argument can be made that students find the class challenging are more conscientious students as compared to students who think the class will be easy. This may lead to the data telling a different story than what was originally thought. As can be seen with the research with online classes, the literature is mixed. Looking at the relationship between student major and developmental mathematics (or any class) may help institutions better support student success. This investigation of the impact of declared major on student success in online versus face to face courses is intended to further illuminate a gap in the research.

Purpose

The purpose of this study is to compare student success (in terms of final grade for the class), the

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average percentage of D/F grades in the class has, and the average withdrawal percentage for each class) in developmental mathematics classes at a small, Midwestern university over the last ten years. Groups to be looked at are determined by delivery method (traditional vs. online) and student major (STEM vs. arts/humanities vs. undeclared). The means for each of these groups will be compared to each other to see whether there is a difference or not. The hypotheses to consider will organize these thoughts.

Hypotheses

Final grade. H_0: There is no difference between the means of the delivery type in regard to final grade in the developmental mathematics classes.

H_1: There is a difference between the means of the delivery type in regard to final grade in the developmental mathematics classes.

H_0: There is no difference between the means of the student major in regard to final grade in the developmental mathematics classes.

H_1: There is a difference between the means of the student major in regard to final grade in the developmental mathematics classes.

D/F percentage. H_0: There is no difference between the means of the delivery type in regard to D/F percentage in the developmental mathematics classes.

H_1: There is a difference between the means of the delivery type in regard to D/F percentage in the developmental mathematics classes.

H_0: There is no difference between the means of the student major in regard to D/F percentage in the developmental mathematics classes.

H_1: There is a difference between the means of the student major in regard to D/F percentage in the developmental mathematics classes.

Withdrawal percentage. H_0: There is no difference between the means of the delivery type in regard to withdrawal percentage in the developmental mathematics classes.

H_1: There is a difference between the means of the delivery type in regard to withdrawal percentage in the developmental mathematics classes.

H_0: There is no difference between the means of the student major in regard to withdrawal percentage in the developmental mathematics classes.

H_1: There is a difference between the means of the student major in regard to withdrawal percentage in the developmental mathematics classes.

Method

This research was quantitative in nature. Data were gathered to examine factors that impacted student success in developmental mathematics classes.

Setting and Participants

The school at which the study took place had approximately 5500 students. When data were collected, about 20 developmental mathematics classes were offered each semester. Over the 10-year window encompassed in the study, roughly 12,500 students were enrolled in developmental mathematics classes (across 422 classes). The public, four-year, rural university was considered small and is located in the Midwest.

The student demographics for the university in which the study was conducted were 61% female, 39% male; overall, 51% were first-generation college students. Within the student body, 73% of students were classified as white; the second highest race recorded was Hispanic at 7.5% (Missouri Southern State University, 2019).

Procedure

Data examined were from the last 10 years. At the university, there were two mathematics classes that were considered developmental: Beginning Algebra and Intermediate Algebra. Students were placed into their mathematics course by ACT score or a placement test (taken if the student didn't have an ACT score or the student believed they were better suited for a higher course). For the sake of this study, the data were not separated by course (Beginning Algebra and Intermediate Algebra). The data that were utilized were from traditional and online developmental mathematics classes. The data were also broken down by student major. The independent variables considered were delivery type (online, traditional) and student major type (STEM, arts/humanities, undeclared) and how they affected the dependent variables of final grade, D/F percentage, and withdrawal percentage. Students' majors were considered at the time of enrollment in the course, not the degree they ended up graduating with (if they graduated).

Analyses

Three dependent variables were considered. The first was the final grade that the student earned in the developmental mathematics class, measured by the traditional 4.0 scale. The average final grade was found for each of the categories of independent variables in each class. The next variable was withdrawal percentage. Students were considered 'withdrawn' if they withdrew 3 weeks or more into the semester (2 weeks in an 8-week summer class), as designated with a W on their transcript. The number of withdrawn students was divided by the total students falling into each of the independent variable categories for that class. Finally, the D/F percentage was calculated in a similar way.

To see if there was a significant difference in the means of grades for class type and student major, a two (class type) by three (major) way analysis of variance was run. Final grade, the dependent variable, was converted from a standard A-F grade to the corresponding number on the 4.0 GPA scale. For each class, the number of students who received a D or an F were added up (no distinction was made between the two grades). The of students in each class with a D/F final grade was then calculated. These percentages were then computed for every class in each category (class type or student major). It should be noted that students who withdrew were included in the total class size. This same process was used to calculate the withdrawal percentage. A 0.05 level of significance was chosen.

Results

Data were broken down by each of the student success outcomes, Table 2 shows the difference between online and traditional classes in each major for that particular student success outcome.

Final Grades

The first hypothesis examined was whether there was a difference in the means of final grades with respect to the instructional delivery type (online vs. traditional). After the overall average was found using SPSS®, a two-way ANOVA was run. The analysis indicated that STEM majors in traditional classes had the highest final grade average, whereas undeclared majors, enrolled in online classes had the lowest. In terms of letter grades, each group (STEM online students, Arts and Humanities online and traditional students, and undeclared online and traditional students) averaged a Din both instructional delivery methods, except for STEM students in traditional sections who earned a C average. All of the *p*-values were less than 0.05, meaning that the null

Table 1

Sample Distribution by Course Delivery Method and Major

Delivery Method	Arts/Humanities	STEM	Undeclared
Online	**1663**	**1070**	**910**
Traditional	**3796**	**3055**	**1991**

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hypothesis (that there is no difference between the means) could be rejected with a low probability (5%) of this being a false rejection.

Table 2 indicates that STEM majors in online classes vary the most from each other in terms of their final grade, with undeclared majors in traditional classes not far behind. The least variation occurred in the data from the Arts and Humanities majors in online classes. However, the differences between these two extreme standard deviations (and all of the standard deviations for that matter) did not vary drastically from each other. Regardless of the three different student majors, the students had lower grades in the online sections. As expected, the STEM majors had the highest scores in both delivery modes. STEM majors in traditional classes received the highest grades (2.074, C) on average, whereas undeclared majors in online classes received the lowest (1.529, D). It is evident that students in the traditional classes, regardless of their major, had higher grades than those in the online classes. All of the *p*-values were less than 0.05, so the data are statistically significant. This suggests the null hypothesis should be rejected, or a significant difference in the means of the final grades for delivery type and student major was found.

Table 2

Online versus Traditional Delivery and Student Major in Terms of Final Grade for Developmental Mathematics Classes

Delivery Method	STEM		Arts/Humanities		Undeclared	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Online	1.647	0.882	1.603	0.656	1.529	0.844
Traditional	2.074	0.781	1.913	0.699	1.833	0.878
	$p < 0.000$		$p < 0.000$		$p = 0.001$	

D/F Percentage

The second hypothesis addressed was the percentage of D/F grades. Recall that the researcher wished to determine if the means of instructional delivery type of D/F percentages were equal, and then whether the means of a student's major of D/F percentage were equal. The number of STEM students in an online class who received a D or F in a class was determined and was divided by the total number of students in that particular class to obtain a percentage. These percentages for STEM majors were then averaged across all online classes. The same procedure repeated with the remaining student majors and traditional classes to find an overall percentage for each of the groups. All of the averages and the *p*-values from a two-way ANOVA were calculated using SPSS®. Arts and Humanities majors in online classes had the highest D/F percentages, whereas undeclared majors in traditional classes had the lowest percentage (see Table 3). Again, none of the *p*-values were greater than 0.05, which means the null hypothesis—no difference in means of delivery type or student major when considering D/F percentage—should be rejected, or D/F percentage by delivery type and D/F percentage by student major have different means.

As with final grades, the online sections for all majors had the higher D/F percentage when compared to the traditional sections. However, this time, the undeclared majors had the lowest percentage of D/F grades, whereas, the arts and humanities majors had the highest. Online classes for all 3 majors had higher D/F percentages than the traditional classes. All of these *p*-values were less than 0.05, so, again, the data were statistically significant.

Table 3

Online versus Traditional Delivery and Student Major in Terms of D/F Percentage for Developmental Mathematics Classes

Delivery Method	STEM		Arts/Humanities		Undeclared	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Online	12.238%	8.394	19.647%	10.505	11.008%	8.305
Traditional	10.471%	7.901	13.355%	8.340	8.560%	7.371
	$p = 0.041$		$p < 0.000$		$p = 0.003$	

Withdrawal Percentage

Withdrawal percentage was the last variable tested. Recall, the researcher was interested in whether or not the means of delivery type and student major were equal in regard to withdrawal percentage. From the

Table 4

Online versus Traditional Delivery and Student Major in Terms of Withdrawal Percentage for Developmental Mathematics Classes

Delivery Method	STEM		Arts/Humanities		Undeclared	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Online	3.183%	3.832	4.653%	4.680	3.113%	3.886
Traditional	3.022%	3.756	4.430%	4.539	2.991%	3.913
	$p = 0.693$		$p = 0.650$		$p = 0.770$	

data, the number of STEM students who withdrew in each individual class was divided by the total number of students in that class to determine the withdrawal percentage. This process was repeated for all STEM majors in traditional classes and also with the other majors. Again, the statistical software package SPSS® was utilized to find the averages across all classes and majors, and the researcher further analyzed the data using a two-way ANOVA for which the *p*-value was calculated. This was the first instance that resulted in a *p*-value greater than 0.05. The results indicated that these data were not statistically significant so the null hypothesis should not be rejected (see Table 4, page 22). This means that rejecting the null hypothesis failed as no difference between the means of the delivery type and of the means of the student major in regard to withdrawal percentage was found. Although there was not a big difference between the online and traditional sections, online sections still had a higher withdrawal percentage. Once again, Arts and Humanities majors had the highest withdrawal percentages in both delivery types and Undeclared had the lowest.

Discussion

The study investigated whether the means of the delivery type and student major are equal in terms of final grade, D/F percentage, and withdrawal percentage. Applying a significance level of 0.05, the null hypothesis is rejected and the alternate hypothesis is accepted in the case of final grades and D/F percentage. In other words, there is a difference between the means in these cases. Analyses have found *p*-values for withdrawal percentages above 0.05, so the null hypotheses are not rejected for this dependent variables. It can be seen that when considering delivery style, students earned higher grades and fewer students earned a D or F in the traditional classes. Students in traditional classes withdrew at a lower rate than online students, but it isn't as large a difference as the D/F percentage. In reference to student major and success, STEM majors show the highest GPAs but not the lowest withdrawal or D/F percentage. Conversely, undeclared majors exhibit the lowest GPAs but also the lowest withdrawal and D/F percentage. arts and humanity majors have the highest percentage of withdrawals and failing grades, and their GPA averages fall between those of other majors.

The goal of this research is to determine if student major or instructional delivery type affects how students perform in developmental mathematics classes at a small Midwestern university. Student success was broken down into three categories: final grade, D/F percentage, and withdrawal percentage. At the 0.05 significance level, it was shown that the withdrawal percentage in each group (delivery type and student major) are not statistically significant. Study findings reveal that neither the method of delivery (online or traditional) nor the student major (STEM, arts/humanities, or undeclared) make any difference in whether or not students withdraw from developmental mathematics classes. It is interesting that final grade and D/F percentage are statistically significant and withdrawal percentage is not. It raises questions about why withdrawal percentage is not affected by delivery type or student major but D/F percentage and final grade are. Notably, the withdrawal percentages of approximately 3-4% in this study whereas are lower than withdrawal rates researchers have reported in the literature of approximately 5-10%, and some even has high as 20%.

Strictly looking at the means of the final grades, it is not a surprise that the STEM majors received higher grades than the arts/humanities and undeclared majors (and the arts/humanities received higher grades than undeclared). One would assume that STEM majors have stronger mathematics skills and background courses. However, when looking at the percentages, it is not so cut and dried: the STEM majors do not show the highest success rates in a mathematics course in all categories. Findings from this study show undeclared majors received fewer D/F grades and withdrew from classes of both types at a lower rate than their STEM and arts and humanities counterparts. This is very surprising and is tough to unpack. One would think that the group of students that received the highest grades in the class would also be the ones least likely to receive a grade of D/F and/or withdraw from the class, not the group of students who received the lowest average grades in the class. One would also assume that STEM majors should have the fewest D/F grades and the lowest withdrawal rates since their majors use mathematics more.

It raises questions about why withdrawal percentage is not affected by delivery type or student major but D/F percentage and final grade are.

Analysis of data from this study shows just how difficult developmental mathematics classes are for students. Low average final grades, regardless of delivery type or student major, support what the literature has said about the low success rate in these classes across the country. The national pass rate (a grade of C or better) for developmental mathematics classes is 49.45% (Twigg, 2011) compared to 53.99% at the institution being studied.

Ideas for Future Research and Practice

There are several extensions that should be examined to further this research. The first suggestion for further research would be to add a mixed methods component. Surveying students could lead to helpful insight that the numbers alone can't show. Questions might include why students dropped the class, what could have been done to help them pass/stay in the class, and what they thought was working in the class already. This could also lead to some helpful insight to what student support models are most successful. The research has been started on ways to help these students, but more focus should be on how to improve success rates across the nation.

Additionally, separating the data by class may bring some information to light that was hidden by grouping Beginning Algebra and Intermediate Algebra together. The only reason the data were not broken apart by class is due to the author's focus on the big picture of developmental mathematics. However, looking at the classes separately may indicate that one class has greater failure/withdrawal rates and needs a redesign to target it first, although Trenholm (2009) found no difference when separating the two courses. Related, comparing students who were placed directly into Intermediate Algebra with students who enrolled in it after passing Beginning Algebra could lead to some interesting findings. An extension of this would be comparing the success of students who were placed directly into a credit bearing college mathematics course (such as College Algebra) to students who eventually enrolled in this course after starting in Beginning or Intermediate Algebra.

Regarding student major, study findings have shown something surprising. As mentioned previously, one would assume that STEM majors would perform better in mathematics classes, even developmental ones, but this study has found that not to be true. This indicates that there is more research to be done in this area.

The data from this research can be used to help enrollment of students, especially at the university in which the study took place. Based on the data analyses in this research, faculty can advise these students about delivery method in which students in their major excel. This can be the basis of similar studies done at other universities to help their students with enrollment as well. At the university in which this study took place, the data show that success rates in developmental mathematics courses are no different than at the national level, which means something needs to change to help the students succeed. Since it was found that traditional classes were more successful than online classes as has been reported in previous research (Hill, 2013;

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Weems, 2002; Zavarella & Ignash, 2009), a rework of the online classes is needed. Online classes are becoming more prevalent (Xu & Jaggars, 2011) and colleges and universities need to work on bringing them up to the level of success of traditional classes. There should not be a difference from a learning outcome point of view whether a student decides to take a class online or in a classroom. Further, placement scores/ACT scores could be used to place students in classes with other students at a similar level.

Conclusion

The goal of this study was to determine student success in developmental mathematics classes based on student major and instructional delivery type. The literature is mixed on whether online or traditional students were more successful in remedial mathematics courses (Hill, 2013; Spradlin & Ackerman, 2010; Xu & Jaggars, 2011). This research can help focus and inform research regarding whether online classes or traditional classes are more educationally beneficial for students. This study can also help with enrollment. If a student is on the fence about whether to enroll in an online math class or not, an advisor can show them this research and help them decide based on the student's major. As was stated, no research had been done on whether student major has an impact on student success. This study has shown that undeclared majors sometimes out performed STEM majors. As online courses in mathematics—and all subjects—proliferate, it is valuable to consider factors that impact student success in online course delivery. Analyzing data for the last 10 years gives one a lot to think about regarding what can be done to help students be more successful. It is clear that there are plenty of good student support options that need to be explored to improve the success rates of students in developmental mathematics classes.

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Faculty can advise these students about delivery method in which students in their major excel.

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