High School Career Technical Education and New Mathematics Graduation Pathways

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Abstract: Career Technical students in Ohio now have lowered graduation requirements. This has led to many questions about how this change can still create a worthwhile education. Teachers in Ohio Career Tech are worried that lowering the content expectations will lower students' ability to reason mathematically. Data collected leads to the conclusion there is no statistically significant relationship between level of courses taken in high school and mathematical reasoning. Therefore, lowered math course requirements do not hinder students' growth but instead open the door for new approaches to math education. New approaches and new curriculum may improve students' overall understanding. These new approaches should include re-evaluating graduation requirements in Career Technical Education. Requirements for mathematics should be individualized based on each student's intended career.

Introduction

The Ohio Department of Education has recently changed their graduation requirements for career technical high school students. Although they are still expected to take four units of mathematics, Algebra II or advanced computer science is no longer a requirement for students following a career-technical pathway (Ohio Department of Education, 2019a). Unlike their general education counterparts, career technical education (CTE) students can replace Algebra 2 with any career-based mathematics. A career-based mathematics course "addresses high school level mathematics standards relevant to a specific career pathway. This course should focus on the appropriate mathematical practices, fluencies, and content related to the career pathway" (Ohio Department of Education, 2019b). This description does not state what level or how many high school mathematics standards should be covered in this career-based course. Therefore, college bound students are required to take Algebra I and II, whereas a CTE student is not held to the same standard.

Most teachers feel very frustrated by the change in graduation requirements.

> *Imagine spending many years of your career teaching Algebra 2. You have mastered teaching it, you love the content, and you are comfortable. Then, your state decides your school's students no longer need to take Algebra 2. The content you love is no longer a necessity, so you're asked to teach a new class.*

Teaching a new course is difficult, stressful, and can cause burnout. Having recently experienced this at an Ohio career center, many teachers were outraged, confused, and worried about students' well-being.

Can a student who does not learn the skills within Algebra 2 or higher still do well in their future? Are they at a disadvantage because their mathematical skills are lower? In a quest to answer these questions and concerns, a comparison can be made between students' course selection and their mathematical reasoning. Mathematical reasoning can be quantified using test scores from college placement and

entrance exams. Findings from both Showalter (2017) and Bea, Gray, and Yeager (2007) show that there is no statistically significant relationship between level of courses taken in high school and level of ability on placement tests. This data will be presented throughout the evidence portion of this manuscript.

If there is no significant relationship, then teachers must accept the loss of their beloved higher-level course work and start seeing this change as an opportunity. Lowered math course requirements open the door for new approaches to math education that may improve students' overall understanding and mathematical reasoning. The past practice of placing the same expectations and requirements on all students was ineffective. Instead, students' ability and career interests should be taken into consideration. The CTE graduation requirements for mathematics should be individualized based on each student's intended career.

Course Work Compared to Test Scores

State graduation requirements expecting all students to take Algebra II or higher are not helping the entire population. Showalter (2017) argues that CTE mathematics is most effective when it takes students' abilities and interests into consideration by teaching math skills related to their technical field and embedding higher-level mathematics. Showalter (2017) completed research to determine the effect of higher level courses on students' placement out of remedial mathematics classes in postsecondary school. He also took into account factors that would affect a students' likelihood to choose courses like pre-calculus and calculus. Showalter (2017) created a propensity score for each student in order to study the students with the lowest propensity, or interest, to choose higher level course work (p. 675). Showalter (2017) then grouped students homogeneously to make all factors null, forcing the propensity score to be the sole factor in question. The data was plotted to show the estimated effect of propensity on placement out of postsecondary remedial mathematics (PRM). The effect sizes were below minimum effect size, meaning the comparison of propensity to placement scores had no statistical significance (Showalter, 2017, p. 682)

Showalter states (2017), "In other words, [data] provided no evidence that course taking in the algebra-calculus pipeline helped students to place out of postsecondary remedial mathematics classes. Thus, if two students had a similar propensity score, but one ended up taking precalculus and the other did not take any algebra-calculus courses higher than pre-algebra, the two students would have had roughly the same likelihood of placing out of PRM" (p. 682). From this quote, it is important to note Showalter (2017) compared a student who took coursework through precalculus to one that only took pre-algebra. He found that two similar students, with vastly different coursework in math, have the same likelihood of placing out of PRM. His argument is that the level of coursework does not matter, but instead the overall ability and interest of the student. Some of the many factors taken into consideration showing some effect on propensity include initial ability in math, previous test scores, teacher's evaluations, and course recommendations (Showalter, 2017, p. 681).

Bea, Gray, and Yeager (2007) mirror Showalter's (2017) discoveries by comparing CTE students to traditional high school students. They attempted to pre-

dict students' 11th-grade math achievement on the Pennsylvania System of School Assessment (PSSA). According to the data, there is no statistical significance in students who took CTE and their state test scores in 11th grade. Data was presented as a summary of the regression analysis which revealed that 8th-grade math achievement was statistically significant and positively associated with 11th-grade math achievement ($p < .05$). Years of math (algebra I or higher level) taken by grade 11 was statistically significant and positively related to 11th-grade math test scores ($p < .05$). n=55. (Bea, Gray, and Yeager, 2007, p. 16). Like Showalter's (2017) study, this shows a stronger relationship to achievement with their previous test scores and number of years of math taken (Bae et al., 2007, p. 17).

Collectively, Showalter's research and the research conducted by Bea, Gray, and Yeager showed that lowered graduation requirements do not harm CTE students' ability to achieve. The data shows a strong correlation between the students' overall interest in their course work, their mathematical ability, and their consistency of math course work over a four-year period. When developing student schedules, counselors should consider these factors. Instead of setting them on a generic path: Algebra 1, Geometry, Algebra 2, and Pre-calculus, new and unique paths are paved based on each student as an individual. Do they even like math? Will their career require it? Are they college bound? What did their previous math scores look like? These questions are now the center of discussion, and much more valuable than a singular pathway. A call for individualized course requirements calls for a reassessment of the goal of math education so that schools can properly redevelop graduation pathways and curriculum.

Rethinking Curriculum

Mathematics education in the CTE setting should be used to improve students' chances of obtaining and maintaining jobs. Steen (1999) argues that the goal of learning mathematics is "to teach basic skills; to help children learn to think logically; to prepare students for productive life and work; and to develop quantitatively literate citizens" (p. 1). When considering mathematics in the workforce, people may not use formal mathematics from the classroom. Employees may never write formal proofs after Geometry class in their lifetime, but they do need typically mathematical strategies throughout life (Steen, 1999, p. 2). Fitzsimons supports the argument that changing a CTE students' curriculum can sufficiently develop desired skills such as self-management, versatility, critical thinking, process improvement, and information literacy (2001, p. 262). Furthermore, according to the Standards of Mathematical Practice (2020), an in-demand employee can:

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically

6. Attend to precision

7. Look for and make use of structure

8. Look for and express regularity in repeated reasoning

While it is unlikely these practices can be covered thoroughly in a traditional classroom, lowering the graduation requirements may allow educators to reevaluate curriculum and identify essential math skills. By taking away the concern to reach a certain amount of content within four years, teachers can focus on finding ways to teach mathematical reasoning and critical thought. This is possible by developing new classes and rich activities, especially using content students have already been exposed to.

Effects of New Approach

> *Imagine starting your first week of high school at a career center. Instead of being told what courses you must take, you sit down with a faculty member and use your career choice to determine individualized course requirements. Your classes move you toward a job, an income, and a successful adult life. You have a stronger sense of purpose and motivation because there is an obvious light at the end of the tunnel.*

Graduation requirements do not feel like a chore in this approach. Wouldn't you learn the content more actively, knowing it's meant for you as an individual? This approach may develop ownership in each student.

> *Now imagine being a high school math teacher, working at a career center. Students are in your traditional Algebra 2 class because they have all chosen a career path that requires Algebra 2, or requires college in the future. Later, you teach remedial Algebra, but you do not follow a textbook. It took you a lot of work to get your students used to less direct instruction and more student-led tasks, but all the hard work is worth it. Your students start out hating math but are motivated by their career path and the chance to do interesting projects. Students use mathematical reasoning, critical thinking, problem solving, and communication every day. It makes sense to teach these math classes differently because you are teaching two entirely different groups of students. Your focus is on preparing for their future instead of checking off a list of skills or standards.*

There is a nonprofit organization that has researched this topic and developed curriculum with the philosophy of individualization in mind.

The Southern Regional Education Board (SREB) realized the goals of remedial math courses described in the vignette above. This organization has developed a number of new courses, called Math Ready, for the remedial math setting. They have begun to master and implement courses that are student centered and focus on improving previously learned math skills. "SREB's Math Ready course was designed to help students who fall a few points below 19 points on the ACT mathematics readiness benchmarks improve their scores and avoid costly remediation at the postsecondary level" (SREB, 2019, p. 2). They have been developing curriculum for students who may not have always enjoyed or been successful in math classes. Curriculum includes re-learning content students have already been exposed to but

with more exploration and student-led decision making. This curriculum will help students learn to communicate, to analyze others' reasoning and to improve their own reasoning. It is developed with all of the State Standards of Mathematical Practice in mind, growing students' ability to reason mathematically, think critically, and become more employable. SREB's effectiveness in their Math Ready curriculum can be quantified (SREB, 2019, p. 2). SREB analyses of ACT scores of 366 students in 27 high schools who were enrolled in Math Ready and retook the ACT after completing the course showed a significant growth in ACT scores due to the newly developed curricula, proving its effectiveness (2019, p. 2).

Conclusion

Lowering graduation requirements for CTE students that focus less on math content and more on individuality allows educators to better prepare the next generation of workers. With this shift, counselors can meet with students and plan their individualized course work for the entirety of their high school career. Students will understand the courses in their plan of study are essential to enter the workforce within their intended career. This understanding will help students see the relevance in math, and all other subjects, they are required to learn throughout high school. If trained properly, teachers can develop opportunities for students to be more independent in the math classroom and move away from the I-do, You-do approach so frequently relied on. Teachers can embrace lowered graduation requirements as an opportunity to incorporate more relevant content and more unique approaches to learning. Administration can look for ways to have academics required in a career-minded map instead of a universal graduation pathway. By making CTE mathematics expectations individualized, both students and teachers will benefit.

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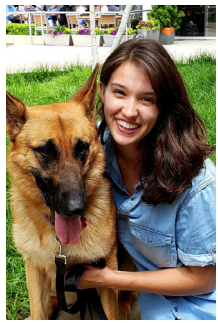

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