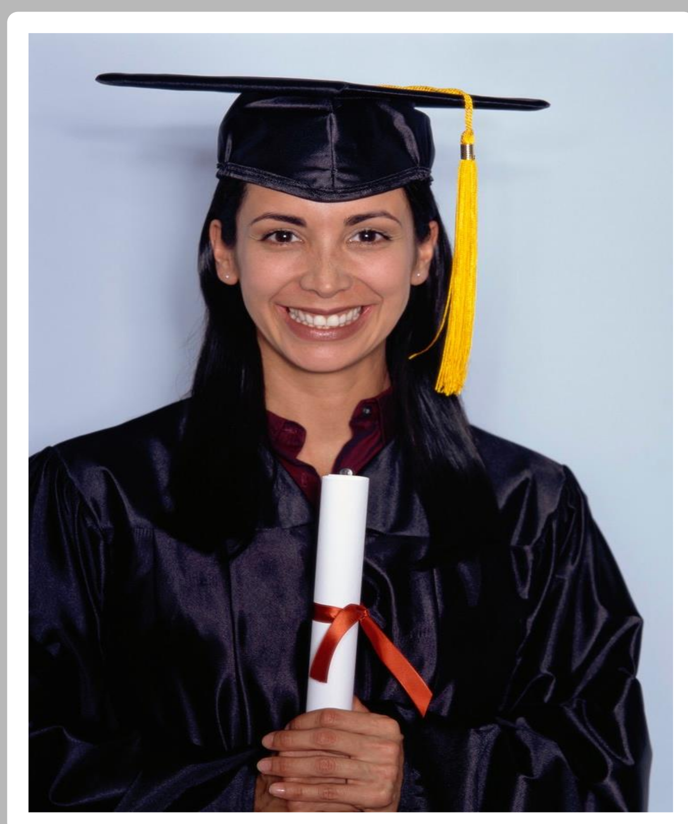
HIGHER EDUCATION COORDINATING COMMISSION

SENATE BILL 1540 (2016):

January 2017



ACKNOWLEDGEMENTS

This Report on Senate Bill 1540 (2016) was prepared by the agency staff of the Higher Education Coordinating Commission with the consultation and contributions of many others. The SB 1540 Workgroup provided research, direction, and many years' worth of insight and experience on the problems and solutions discussed in this report.

SB 1540 Workgroup Members
Mark Freed, Oregon Department of Education
Frank Goulard, Portland Community College and Higher Education Coordinating Commission
Beatriz Lafferriere, Portland State University
Mark Lewis, Chief Education Office
Cristina Negoita, Oregon Institute of Technology
Mahalia Newmark, Higher Education Coordinating Commission
Sean Pollack, Higher Education Coordinating Commission
Mike Price, University of Oregon
Lisa Reynolds, Higher Education Coordinating Commission
Dana Richardson, Oregon Council of University Presidents

Special thanks to others who made key contributions: Kasi Allen (Lewis & Clark College), Andrea Henderson (Oregon Community Colleges Association), Jennifer Klump (REL Northwest), Vern Mayfield (HECC), Dalton Miller-Jones (Portland State University), and Alex Straka.

EXECUTIVE SUMMARY

Senate Bill 1540 (2016) requires the Higher Education Coordinating Commission to investigate methods to increase math degree attainment at Oregon public universities. The methods shall include a cost estimate for tuition grants for math majors.

This report includes that cost estimate and a discussion of several other factors that may increase or hinder math degree production in our state. These factors include:

- Mathematics bachelors' degrees are approximately 1.4 percent of all degrees produced in the state by the public universities.
- There is a strong connection between math course taking in college and the K-12 sector. Students who become math majors generally develop their identity as STEM or math students in middle school or high school. It is unusual for a student who struggles with math early in their education to become successful enough to attain a degree in math in college.
- The state may not have enough well qualified teachers of math in elementary and high school to increase interest in math along the education pipeline.
- The math major is less diverse than the student population as a whole.

Accordingly, this report makes the following conclusions and recommendations:

- If the legislature pursues a tuition grant program for math majors, it be structured to incentivize upper division (300-400 level) college math course taking, rather than all four years of study for a math degree.
- Because the state needs to attract and keep more highly qualified math teachers, especially in rural and underserved districts, a coordinated state response should find ways to attract math students to the teaching profession, either through tuition support or loan forgiveness in return for service in high need areas.
- The relative lack of diversity in the major should be a focus of any coordinated state level response
- There are state level and institutional efforts to reform and align math pedagogy at all levels. These efforts should be supported in any state level coordinated response.

INTRODUCTION: SENATE BILL 1540 AND ITS CHARGE

Passed in February 2016, Senate Bill 1540 (SB 1540) seeks to increase degree attainment in Mathematics in Oregon Public Universities. The bill states that the Higher Education Coordinating Commission (HECC) shall "conduct a study to determine the best method of increasing the number of mathematics majors at Oregon universities." That study must include an estimate of the costs and benefits of "the State of Oregon providing financial support for tuition waivers."[1] That study is contained within this report, and it includes preliminary first year estimates for tuition support for Mathematics majors at the seven Oregon public universities as one method to increase math degree production. The study also includes a first year estimate for tuition grant for students who attain a licensure to teach Mathematics within the primary/secondary (K-12) sector. Cost factors, justifications, and possible effects for both proposals will be explored in subsequent sections of this report.

This report also details other means of encouraging study of mathematics in Oregon's post-secondary institutions. These other means include: incentives to attract qualified math teachers in the primary and secondary education sectors, support for pedagogical reform at all levels of math teaching, support for efforts to attract more diverse students to the study of math, and continued greater cooperation and coordination between the state's K-12 and post-secondary sectors in math teaching and learning.

STUDY METHODS AND PROCESS

HECC staff began work on preliminary research for SB 1540 in summer of 2016. Following recommendations from the universities and other stakeholders, the workgroup consisted of experts from the field of mathematics - in particular faculty from Portland State University (PSU), Oregon Institute of Technology (Oregon Tech), the University of Oregon (UO), and from Portland Community College (PCC). The math instructor from PCC was Frank Goulard, also a HECC Commissioner. In addition, Senator Mark Hass's staff participated in the process, as well as the executive director of the Council of University Presidents. Math and STEM specialists from the Oregon Department of Education (ODE) and the Chief Education Office were involved to bring a statewide and system wide perspective.

Guiding Question for SB 1540:

Before the workgroup convened HECC staff sent members an annotated bibliography of background research and a preliminary set of findings that were used to generate a series of guiding questions based on the content of the bill, our understanding of its intent and the broader public policy goals the bill sought to achieve beyond increased degree production. Research by HECC staff included a search for similar programs, local and national efforts on STEM retention, persistence and completion, the economic impact of mathematics study, research on major choice (i.e. how students choose or do not choose math), math students' attraction to the discipline, and on equity factors: diversifying the major, needs of underrepresented minorities (URM) in math and other STEM disciplines. This preliminary investigation led to the following guiding questions for possible policy responses:

- What policy alternatives are available to increase math degree production?
- Should a policy intervention focus solely on the post-secondary education system, or should it encompass the math education "pipeline" from K-12 to higher education?

[1] Senate Bill 1540 (2016). https://olis.leg.state.or.us/liz/2016R1/Downloads/MeasureDocument/SB1540/Enrolled

- What policy response will increase broader participation in college level mathematics, and specifically increase the participation of minorities and women?

Because the members of the workgroup accepted that math majors typically self-identify as math-adept or enthusiastic about math in middle school and high school rather than college (Burdman 2016),[2] the group reviewed articles and summaries from national literature searches conducted by HECC staff and by the Regional Education Laboratory of Education Northwest (REL Northwest) on current and future needs for K-12 math instructors in the pipeline to replace the anticipated wave of retirements. Furthermore, REL provided a wealth of recent research on current theory and practice for attracting and retaining underrepresented students in math and STEM more generally.

The workgroup met twice, in October and November 2016, with frequent communication and updates online. Each of the ideas and public policy options mentioned above were discussed and refined in some detail, with new questions and data request generated by the process. The tuition grant ideas for math majors and math teaching licensure went through several iterations in discussions and email correspondence among group members. Finally, a draft of this report went out to group members for final discussion and refining of recommendations to the Commission and Legislative Assembly.

PUBLIC POLICY GOALS FOR SB 1540

One of the primary tasks for any legislative workgroups is to understand and agree upon the goals of the legislation -- to frame the problem it addresses, and the intended effects for the legislation and the broader public policy effects it might have (Smith 2013).[3] After discussion with staff, legislators and after reviewing the testimony related to SB 1540 at the time of its passage, the workgroup concluded the bill has several intended short term effects and longer term public policy goals.

Increased persistence to degree. If students majoring in Mathematics at public universities can receive full or partial tuition grants, they are more likely to persist to finish a degree in less time, as we assume that easing the tuition burden encourages to take more credits, which requires them to work less and concentrate on study more. Although this bill's focus is narrow, the goal of increased student persistence aligns with both institutional objectives and HECC's statewide goals for increased degree production (HECC Strategic Plan).[4]

Increased affordability for mathematics students. Affordability for all students is a primary aspect of HECC's strategic plan, and this bill aims to make college more affordable for a specific student group.

Employment and workforce readiness: Legislative testimony on SB 1540 stressed the fact that Mathematics is a "building block" for the technical and STEM jobs of the present and future, and therefore it is clearly within the state's economic interest to encourage math as a field of study at our public institutions. On average math majors score the highest on standardized tests (such as the GMAT or LSAT) because math requires complex reasoning skills. This outlook is borne out by Bureau of Labor statistics figures that predict a 13.1 percent growth in "computer and mathematical occupations" between 2014 and 2024. Comparatively,

---

[2] Burdman, P. (2016). Quantitative Leap: How math policies can support transitions to and through college. Oakland: Learning Works. http://www.learningworksca.org/wp-content/uploads/2012/02/F9_QUANTITATIVE-LEAP.pdf
[3] Smith, C. (2013). *Writing Public Policy: A Practical Guide to Communicating in the Policy Making Process.* Oxford.
[4] Oregon Higher Education Coordinating Commission (2016). 2016-2020 Strategic Plan. https://www.oregon.gov/HigherEd/Documents/HECC/Reports-and-Presentations/HECC-StrategicPlan_2016.pdf

total occupations will grow at a predicted rate of 6.5 percent for the same period (Bureau of Labor Statistics [BLS] 2015).[5]

> **A note on non-teaching employment and career paths for Mathematics majors:** The Mathematical Association of America (MAA) publishes research and information on career opportunities in the field of mathematics and for those with math degrees or extensive mathematical training and coursework. MAA's website lists Finance, Cryptography, Statistics and Actuarial Science as "popular career choices" for math graduates.[6] Similarly, Duke University actively promotes the study of math as a career by citing median annual salaries and career growth (mathematician, statistician, actuary, computer systems analyst, software engineer) that far exceed other careers.[7] Southern Oregon University's Math Department website also touts the benefits of studying math to enter highly specialized, competitive, but non-mathematical fields such as business, law, medicine, science due to its complexity and rigor and fundamental applicability to many fields.[8]

Economic Impact: Analysts have attempted to quantify the economic value of different degrees and majors. Carnevale, Cheah, and Hanson (2015) found that careers in "computers, statistics, and mathematics" (CSM) earned second highest annual wages among college graduates. CSM graduates earning a median starting salary $43,000 compared to $33,000 for all majors. Over time, CSM graduates earn substantially more than almost any other college major group.[9]

Increased diversity and equity in the major. STEM and mathematics are less diverse racially and ethnically than the student population as a whole, and this disparity leads to fewer women and minorities in STEM careers (Aarons 2014, Chang 2002).[10] Demographic data obtained from HECC's Office of Research and Data reveals that the population statewide who received bachelor's degrees in math between 2010 and 2015 were predominantly white and not demographically representative of the state's student population as a whole.

MATHEMATICS DEGREE PRODUCTION IN OREGON AND NATIONALLY

To determine the extent of the need or problem to be addressed by SB 1540, we sought information on Mathematics degree attainment in Oregon and in the nation as a whole. Getting reliable data on mathematics degree production can be somewhat challenging, as math is conflated with STEM or "Math and Natural Sciences," as is the case with recent IPEDS data pulled for the academic years 2005-06 through 2011-12. Nationally, degree production in Natural Sciences and Mathematics has risen over the last decade but no more than other fields. If we group Natural Science, Math, and Computer Science and Engineering together as "STEM," degree production rivals that of the largest fields, Humanities and Social Sciences. But if we track Math by itself for 2011-12, for example, we find Math and related majors are a relatively small part of the whole, roughly 3 percent of baccalaureate degrees nationally.

---

[5] Bureau of Labor Statistics (BLS) (2015). "Economic News Release: Table 4. Employment by major occupational group, 2014 and projected 2024." http://www.bls.gov/news.release/ecopro.t04.htm

[6] http://www.maa.org/careers/

[7] http://math.duke.edu/undergraduate/why-math-major

[8] https://inside.sou.edu/math/index.html

[9] Carnevale, A.P., Ban Cheah, & Andrew R. Hanson (2015). The Economic Value of College Majors. Washington, D.C.: McCourt School of Public Policy. https://cew.georgetown.edu/wp-content/uploads/The-Economic-Value-of-College-Majors-Full-Report-web-FINAL.pdf

[10] Aarons, L. (2014). STEMming Inequities. *In Transit* (6), 25-35. Chang, J.C. (2002). Women and minorities in the science, mathematics and engineering pipeline. *ERIC Digest*, 1-6. http://files.eric.ed.gov/fulltext/ED467855.pdf.

Bachelor's Degrees in US 2011-12

Math and Statistics:	18,842
Math, general:	15,670
Math Education:	2,282

Oregon's contribution to the degree production mix has been (arguably) steady but slow over the last few years (TABLE 1).

Table 1: Math related degrees by Oregon residents at Oregon Public Universities[11]

Year	270101	270304	279999	Total
2010-11	124	5	2	131
2011-12	112	4		116
2012-13	139	5	1	145
2013-14	137	3		140
2014-15	143	2		145
Grand Total	**655**	**19**	**3**	**677**

CIP codes:
270101: Math and Statistics
270304: Computational and Applied Mathematics
279999: Math, other

Table 1 shows degree attainment for Oregon residents only. Over the same period, 206 math degrees were completed by non-residents, for a total of 883.
This figure, 883 math related bachelor degrees in math between 2010 and 2015, represents approximately 1.4 percent of all bachelors' degree production by Oregon's public universities for that same period. While 1.4 percent is a small proportion of the overall degree total, Oregon is about in the middle of the country as a whole in math degree attainment. For example, IPEDS data pulled by HECC Research & Data staff reveals that Oregon has roughly 4.26 people holding a math related degree per 100,000 residents (as of 2014), which ranks 28th in the nation in math degree attainment by the general population.

Oregon Community Colleges and the Math Major Pipeline

Oregon's seventeen community colleges prepare roughly forty percent of the total bachelor's degree graduates statewide, with some institutions like Portland State getting roughly sixty percent. Between 2011 and 2016, nearly one third (32.4 percent) of all Oregon *residents* who attained a bachelor's degree in math from a public university had at least 45 credits from at least one Oregon Community College. So, although SB 1540 is directed at universities, a comprehensive strategy to increase math degree production cannot ignore the vital role played by the community colleges to prepare these students for university study.

[11] Source Tables 1-3: HECC Office of Research and Data, Student Centralized Administrative Reporting File (SCARF) database. All figures on Oregon degree production and graduation rates from HECC Office of Research and Data. http://www.oregon.gov/highered/research/Pages/student-data-univ.aspx

DEMOGRAPHIC CHARACTERISTICS OF MATHEMATICS GRADUATES

In aggregate math bachelors' graduates are predominately white, at a higher percentage than the student population as a whole. Academic literature and national dialogue has drawn attention to the stagnant nature of equity in the science, technology, engineering and math (STEM) field. All along the pipeline students are being lost in the STEM disciplines, and that is especially pronounced among women and underrepresented minority (URM) students. Of all STEM bachelor degrees conferred only eighteen percent are attained by women (U.S. Department of Education), and only fourteen percent are attained by URM students.

These national figures are mirrored in Oregon, where nearly 80 percent of the math baccalaureates are White, about 3 percent Hispanic, and less than one percent are African American (between 2011-2015, TABLE 2). Over the same period of time, Oregon's public university student population was more diverse than the subset studying and graduating with math degrees. A moving average of race and ethnicity for Oregon's public university student population shows whites as a majority whose numbers are declining over time, from 68 percent in 2010-12 to 63 percent in 2013-15. Hispanics showed the largest increase in representation from 6.4 percent to 8.27 percent over the same period.

Gender

Over the same period covered in this Table, Oregon public universities are producing more Mathematics degrees by males (66 percent) than by females (34 percent), which is notably different form the gender ratio of the student population as a whole (47 percent male to 53 percent female for the most recent reporting period).

TABLE 2: Demographic characteristics of Oregon resident Math degree recipients, 2010-2015

Race/Ethnicity (IPEDS)	2010-11	2011-12	2012-13	2013-14	2014-15	Grand Total	Percentage
Race and Ethnicity unknown	10	11	5	6	5	37	5.47%
Hispanics of any race	5	3	5	4	6	23	3.40%
American Indian or Alaska Native	2	2	1		3	8	1.18%
Asian	11	5	6	15	12	49	7.24%
Black or African American	1		3	1		5	0.74%
White	101	90	122	109	113	535	79.03%
Two or more races	1	5	3	5	6	20	2.95%
Grand Total	131	116	145	140	145	677	100.00%

As SB 1540 seeks to increase math degree production as a whole at state universities, an equity lens reveals an opportunity to diversify the population of math graduates as well.

ATTRITION IN THE MAJOR

Attrition refers to the rate or the likelihood that a student will not complete a degree in a chosen major, or make "enrollment choices that result in a likely" math graduate switching to another filed or dropping out altogether (Chen & Soldner 2013). National data show that Mathematics and physical sciences have the lowest national participation rates at two to three percent, while Mathematics as a major has an attrition rate of roughly 38 percent. When math majors leave their degree programs, most switch to different STEM related fields (Chen & Soldner 2013).[12]

Two public universities in Oregon generously provided data on their retention and completion rates for students who major in Mathematics. Oregon Tech, which as a recently launched (2006) Applied Mathematics program, has seen approximately 30 percent of its students finish a degree within six years out of a total cohort of 43 students. Oregon Tech's program in Applied Mathematics frequently attracts students who double major in that and another field such as Computer Science or Engineering, and these may not be reflected in these numbers (Negoita 2016).[13] The University of Oregon's Math Department analyzed their student data from 2005-10 and found that "379 out of 790, or about 48%, of students who were at one point a math major graduated with a degree in mathematics" UO Math Department Co-chair Mike Price added ". . . it appears that when people switch to math later in their college career they tend to stick with it through to graduation," in contrast to those who declare a math major earlier in their studies (Price 2016).[14] Neither of these data points should be considered representative of the attrition levels for math for state as a whole. We do not know, for example, where these students go after leaving the math major. Do they drop out, or do they move to a different STEM or technical major? Statewide, at all seven public universities, roughly 63 percent of Oregon's undergraduates complete baccalaureates within six years of beginning study. What we do know from national research is that students who drop out or fail to complete a degree do so for financial or other non-academic reasons (Johnson et al 2009).[15] There is reason to believe that properly applied tuition assistance could raise the completion rate for math students, at least as much as it would for any major field of study.

FACTORS AFFECTING A TUITON GRANT PROGRAM

Discussion among the workgroup on how to structure a tuition grant centered on several factors: cost to the state general fund, likely effects, and how much of the student's degree credit hour load a tuition grant should cover. HECC staff were unable to find a similar program at the state level for a particular major, so there were no current models to look to and measure against Oregon's policy goals for this bill.

- Cost to the state general fund: Given the relatively low number of math degrees produced by Oregon public universities, the overall cost of a tuition grant program needs to be weighed against other equally compelling student aid priorities, particularly the Oregon Opportunity Grant (the state's only need-based aid grant) and the Oregon Promise, a tuition aid program for Oregon students supporting their first two years of community college study.

---

[12] Chen, X. & Matthew Soldner (2013). STEM Attrition: College Students' Paths Into and Out of STEM Fields. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics. http://nces.ed.gov/pubs2014/2014001rev.pdf

[13] Negoita, C. (November 2016). Email communication.

[14] Price, M. (November 2016). Email communication.

[15] Johnson, Jean, Jon Rochkind, Amber N. Ott, & Samatha DuPont (2009). With Their Whole Lives Ahead of Them: Myths and Realities About Why So Many Students Fail to Finish College. Washington, D.C.: Public Agenda.

- Moreover, Mathematics tends to attract a high-performing subset of the general student population, given its rigor and its pathways into highly challenging and highly compensated fields such as computer science and engineering. Such students are often recruited heavily from Oregon's high school graduates, and many are likely to benefit from institutional aid and scholarships.
- Math faculty and others on the workgroup also expressed concerns that a full-cost tuition might create unintended incentives for students to "major-hop" into Mathematics in order to take advantage of the tuition grant. At most if not all Oregon public universities, students may declare a math major as early as their first year of study. In theory, under such a tuition grant program, a student could declare math as a major for up to two years and receive the full benefit of tuition support, and then switch to a different major. For this and other reasons related to the integrity of the major, faculty and other workgroup members were more inclined to discuss and support a cost model that supported students as they took upper division courses in the major, typically defined as 300- and 400-level courses.

Tuition Grants & Cost Assumptions

As noted earlier, the workgroup considered the fiscal and academic policy options surrounding two possible tuition grant models. The Full Tuition model would cover the tuition cost for a math major from the time of math major declaration. At most Oregon public universities, students may declare a major in Mathematics as soon as their first year. Several questions or issues remain unresolved as of this writing.

- All figures are estimates only and must be refined and updated as necessary by Legislative Fiscal Office.
- Each model discussed is an estimate of first year costs only, using a weighted average of tuition only[16] (not fees or other educational expenses), and does not attempt to account for possible year over year tuition increases. Similarly, cost estimates do not account for possible increases in completion and increased degree production (which is the bill's ultimate goal).
- Any state-level or institution-level tuition grant will likely have some administrative costs related to identifying qualifying students and transferring funds. The workgroup did not make assumptions about who, or how, the tuition grants might be issued or administered – whether via HECC Office of Student Access and Completion, or directly by the institutions.
- While estimating costs can be challenging, it is even more difficult to estimate the benefits of a tuition grant program for a single major that could affect fewer than two hundred students per year, nor can we estimate how much such a grant would increase degree production. We have no current state level models with which to compare.

Full tuition: A full tuition model would cover all tuition, up to 180 credit hours, for any student majoring in Mathematics at an Oregon public university from the point of major declaration.

[16] The weight factor to produce the average was the number of math degrees produced between 2010-15 by each institution. PSU, UO, and OSU produce by far the majority of the math graduates in Oregon, so their tuition costs are more heavily reflected in the final weighted average figure.

180 CREDIT MODEL

Graduates in Mathematics per year	150
Total Credit Hours per Degree	180
Cost per credit hour	$197.75[17]
Cost for one year graduating class	**$5,339,250.00**

As shown on the table above, this model has a cost of nearly $5.4 million per year for fewer than two hundred students. Given the relatively high price tag of this tuition grant model for the number of students it could assist, the workgroup was agreed that a full tuition grant for math majors was not in the students' or state's best interests in a resource-constrained environment. By comparison, the Oregon Opportunity Grant assists over 36,000 students for a state investment of $57.3 million in 2014-15. Similarly, the first year of the Oregon Promise community college tuition grant (2016-17) assists nearly 6,000 students at a cost of roughly $10 million dollars.

Upper division major level mathematics credits: The math faculty on the workgroup suggested and were supportive of a model that offers tuition support for upper division math course taking while in the math major. The number of upper division math credits required varies among the seven public university math departments, with an average of 42-45 upper division credits. Using the same weighted average of undergraduate tuition cost assumption, such a tuition grant program would have a first year cost of approximately $1.3 million.

UPPER DIVISION CREDIT MODEL

Graduates in Mathematics per year	150
Total UD Credit Hours per Degree	45
Cost per credit hour	$197.75
Cost for one year graduating class	**$1,334,812.50**

Members of the workgroup felt such a model protects the academic integrity of the major and does not encourage students to declare a math major for the benefit of a tuition grant, and then switch fields. This model in fact encourages upper division math course taking. Using the weighted average per credit hour tuition figure, a student taking advantage of this tuition grant could save as much as twenty-five percent off the tuition "sticker price" of a degree in math, roughly $8,887. If a student were to leverage other federal, state or institutional aid in the first two years, the degree could be essentially tuition-free.

[17] Using a weighted average of tuition costs, based on Degree Production in Math, 2011-15 as pulled from SCARF database. For reference, a simple average of the seven would be $186.43

Other qualifications: Neither model accounts for other qualifying factors for such a tuition grant, such as GPA, stated income need, or (in)eligibility for other aid. HECC staff were not generally in favor of adding a high GPA as a pre-requisite, as it was felt that the legislative intent was to help as many students as possible given a certain level of financial support from the state general fund, rather than create a new state scholarship for already high performing students.

Mathematics teaching licensure tuition grants. Although tuition support for math teacher training was not part of the original charge of SB 1540, the workgroup in its deliberations and in discussions with Senator Hass and his staff concluded that in order to fulfill one of the bill's main public policy goals -- encouraging math study at the postsecondary level -- it was equally important to encourage students who wish to teach in the K-12 system to teach Mathematics.

Math Teaching Licensure Grant	
Math Teaching Licensure Graduates per year	45
Total Credit Hours per Degree	66
Cost per credit hour	$365.00
Cost for one year graduating class	**$1,084,050.00**[18]

At an annual cost of $1.1 million for the first year such a program could, over the longer term, bring more and better qualified teachers into the system create greater interest in mathematics across the K12 system, resulting in more students majoring in math.

CONSIDERATIONS APART FROM TUITION SUPPORT

The workgroup developed consensus around the general proposition that a long term strategy to increase math course taking and degree production should be a comprehensive, beginning in elementary and secondary education, and should include the community college sector. This report offers the following questions and ideas for consideration by legislators and other stakeholders if this legislative concept should become a bill either in this or a future legislative session.

Are there enough math teachers to meet the demands of the twenty first century?

The pipeline of math majors begins in elementary and high school. There is a persistent shortage of highly qualified math teachers, particularly in rural counties, according to recent reports from state and federal agencies. Oregon Department of Education analyzed teacher licensure data from the TSPC (Teacher Standards and Practices Commission) and found that there has been a dramatic increase in the number of "provisional licenses" issued to teach math, particularly in rural areas of the state.[19] Provisional licenses are issued "primarily in August through October, when school districts scramble to fill any remaining open teaching positions" (Lovett 2016). Math licensures are more likely to be provisional than other subject areas such as Science, Social Studies, or English Language Arts (Special Education has by far the highest number of

[18] Number of degrees produced is an average of the last 2010-15, tuition is a weighted average of the education degree producing institutions.

[19] Lovett, K. (2016). Understanding and identifying teacher shortage areas in Oregon, 2016. http://www.ode.state.or.us/wma/researchteacher-shortage-final-report.pdf.

provisional licenses issued, however). There are notable disparities between urban and rural districts with regard to teacher qualification – rural counties are much less likely to hire "highly qualified" instructors for subjects like math. According to the US Department of Education, Mathematics has been a persistent shortage area for Oregon since at least 2011 (Malkus et al. 2015).[20] Without sufficient numbers of licensed math teachers in the K-12 system, it will be difficult to engage new and emerging populations of students, capture their interests, and help them become math majors at the postsecondary level.

To address current of coming shortages in high need teaching fields such as Mathematics, the state could investigate ways to incentivize college graduates to get licensure and serve as math teachers in rural or otherwise under-resourced districts. Such incentives might be a tuition grant as outlined above, or a loan forgiveness program that rewards continued service in the field in high-need or under-resourced areas.

Can Oregon produce more mathematics majors, even with a tuition subsidy of this type?

What would "success" look like with such a tuition subsidy for the math major? It is unclear, if such a tuition grant program were instituted, whether it would significantly increase the number of students who major in Mathematics and attain degrees, nor could the workgroup members confidently predict what the effect size of such an intervention could be.

How can institutions diversify and grow the mathematics major, apart from offering tuition grants or discounts?

Increasing minority participation and attainment in mathematics is as important as increasing the overall number of graduates in order to address the equity and achievement gaps in STEM and math. Workgroup members identified student outreach and support for entering and continuing mathematics students as a key university-level strategy for increasing math course-taking and student persistence to degree, a finding supported by national research (Goonewardine, et al. 2016).[21]

Education researchers recommend teaching methods that create culturally-specific and world-relevant uses of math (such as statistics) should be taught more in K-12 and postsecondary education (Dierker, et al. 2016; Ferrare & Hora 2014)[22] as part of an "equity pedagogy" (Nasir 2016) that is conscious of the social and economic contexts in which mathematics is used.[23]

Mathematics teaching needs to be enhanced at all post-secondary levels to create a long term increased interest in mathematics among the current and incoming student population.

These current initiatives or ideas should also be considered in any current or future effort to increase math degree production, course taking, or other mode of academic achievement and study.

---

[20] Malkus, N., Mulvaney Hoyer, K. & Sparks, D. (2015). Teaching vacancies and difficult-to-staff teaching positions (NCES-065). Retrieved from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics: http://nces.ed.gov/pubs2015/2015065.pdf

[21] Goonewardene, A. U., Offutt, C. A., Whitling, J., & Woodhouse, D. (2016). An interdisciplinary approach to success for underrepresented students in STEM. *Journal of College Science Teaching*, 45(4), 59–67.

[22] Dierker, L., Alexander, J., Cooper, J. L., Selya, A., Rose, J., & Dasgupta, N. (2016). Engaging diverse students in statistical inquiry: A comparison of learning experiences and outcomes of under-represented and non-underrepresented students enrolled in a multidisciplinary project-based statistics course. *International Journal for the Scholarship of Teaching & Learning*, 10(1). Ferrare, J., & Hora, M. T. (2014). Cultural models of teaching and learning in math and science: Exploring the intersections of culture, cognition, and pedagogical situations. *Journal of Higher Education*, 85(6), 792–825.

[23] Nasir, N.S. (2016). Why should mathematics educators care about race and culture? *Journal of Urban Mathematics Education*, 9 (1), 7-18.

- **Support for "Active Learning" reforms**: Recently the Conference Board of the Mathematics Sciences, a national organization that promotes "the increase or diffusion of knowledge in one or more of the mathematical sciences" released a statement on Active Learning in Post-Secondary Mathematics Education. Active Learning refers to a set of teaching practices that encourage direct student participation and engagement in "investigation, communication, and group problem-solving" that incorporates "feedback" from the instructor and other experts.[24] Several math faculty attached to the workgroup voiced strong support for pedagogical reform of this type.
- **Math Pathways initiative in Oregon to better connect Math instruction between K-12 and higher education.** At the state agency level, staff from ODE, HECC (CCWD and Public Universities), and the Chief Education Office are meeting to discuss means and methods for greater P-16 coordination of Math (known as "Math Pathways"). This effort includes a discussion of how to better align the math curriculum of the secondary sector with the community colleges and universities.
- **Reform of developmental education and math placement.** Recently a "Placement Policy Workgroup" led by the Oregon Community Colleges Association met between 2015-16 to learn about and better align community college math course placement policies. While no single solution was developed, there was broad consensus around a "multiple measures" approach (GPA, course taking history, non-cognitive factors) instead of the historical practice of using one high stakes test to appropriately place incoming students into math classes. Students who spend more than a year in developmental math courses seldom if ever become math majors, and many never get in to college level credit bearing math courses (OCCA 2016).[25] More accurate placement practices will encourage more students to do more college level math coursework.
- **Math identity.** Along with the encouragement of new and promising practices, teachers and faculty at all levels should be made aware of recent and emerging research on the phenomenon of "math trauma" – emotional and psychological barriers related to anxiety about math instruction – that can hinder student learning and success in mathematics (Allen & Schnell 2016).[26] With instructor assistance, students are often able to move past these barriers to re-conceptualize themselves as successful learners and practitioners of math, developing a new "math identity." For students to learn to love math, perhaps enough to major in it in college, they must develop a passion for it in middle school or high school.

CONCLUSIONS AND RECOMMENDATIONS

Math is of course a foundational liberal arts discipline, one that encourages and even demands that the student engage rigorously with abstract reasoning, computation, analysis of data, and application of theory. HECC and the workgroup attached to this report support the bill's public policy goals of increased access, affordability, and equity. In fulfillment of the charge of SB 1540, this report makes several recommendations

[24] Conference Board of the Mathematical Sciences (15 July 2016). "Active Learning in Post-Secondary Mathematics." Washington DC: Policy Statement.
[25] OCCA. (2016). Redesigning Developmental Education for Student Success: A third annual report. http://occa17.com/data/documents/Redesigning-Developmental-Education-for-Student-Success-Report-June-2016.pdf
[26] Allen, K. & Kemble Schnell (March, 2016). Developing mathematics identity. *Mathematics Teaching in the Middle School* 21 (7). 398-405.

and offers ideas for consideration to increase the number of students studying Mathematics at Oregon's public universities.

1) **Partial tuition grants for upper division mathematics classes (40+) hours.** ($1.8M per year). If the legislature pursues a grant or scholarship idea, we recommend it be structured to support upper division math coursework and completion of the major. We favor this approach over the full tuition model both to protect the integrity of the math degree and to encourage completion of the baccalaureate.
2) **Bonus for degree completion**. To further encourage math study, the legislative assembly might also consider "bonuses" or other financial incentives for degree completion both the university and to the individual student. A $1000.00 "bonus" to both institution and individual student would definitely add to the program's final cost (approximately $300,000 per year) but could serve as further incentive to increase degree production.
3) **Financial support for Math teaching licensure**. Because post-secondary math study depends heavily upon the pipeline of K-12 students, and because there is evidence of persistent shortages of qualified math teachers, particularly in rural or underserved districts, the legislature might consider further financial support for students who attain math teaching licensure. Such support might come in the form of tuition grants or loan forgiveness in return for service in a high need district.
4) **Outreach, academic and social support for math majors who are female or URM.** The legislature might consider not only increasing the number of math majors, but also the increasing the diversity of the major itself, which does not reflect the demographics of the general population. Efforts to increase diversity and equity in Mathematics could be undertaken at the institutional and departmental levels, and include advising, academic and social supports for under-represented minorities and female mathematics students.
5) **Support for math pathways.** The State Board of Education and the Higher Education Coordinating Commission have agreed to collaborate and better coordination and alignment in math instruction and curriculum. The success of this continued effort will not only help math majors but all students better prepare for college level math at state universities and community colleges
6) **Support for pedagogical reform in math instruction.** A growing body of research is pointing to new approaches in teaching math across all education sectors. This report has briefly introduced Active Learning and culturally relevant math pedagogy as just two elements that could be included in a more comprehensive strategy to increase math degree attainment and successful math study overall, beginning in the earliest grades.

REFERENCES

Aarons, L. (2014). STEMming Inequities. *In Transit* (6), 25-35. Chang, J.C. 2002. Women and minorities in the science, mathematics and engineering pipeline. *ERIC Digest*, 1-6. http://files.eric.ed.gov/fulltext/ED467855.pdf.

Allen, K. & Kemble Schnell (March, 2016). Developing mathematics identity. *Mathematics Teaching in the Middle School* 21 (7). 398-405.

Burdman, P. (2016). Quantitative Leap: How math policies can support transitions to and through college. Oakland: Learning Works. http://www.learningworksca.org/wp-content/uploads/2012/02/F9_QUANTITATIVE-LEAP.pdf

Chang, J.C. (2002). Women and minorities in the science, mathematics and engineering pipeline. *ERIC Digest*, 1-6. http://files.eric.ed.gov/fulltext/ED467855.pdf

Chen, X. & Matthew Soldner (2013). STEM Attrition: College Students' Paths Into and Out of STEM Fields. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics.

Conference Board of the Mathematical Sciences (15 July 2016). "Active Learning in Post-Secondary Mathematics." Washington DC: Policy Statement.

Dierker, L., Alexander, J., Cooper, J. L., Selya, A., Rose, J., & Dasgupta, N. (2016). Engaging diverse students in statistical inquiry: A comparison of learning experiences and outcomes of under-represented and non-underrepresented students enrolled in a multidisciplinary project-based statistics course. *International Journal for the Scholarship of Teaching & Learning*, 10(1).

Ferrare, J., & M. T. Hora (2014). Cultural models of teaching and learning in math and science: Exploring the intersections of culture, cognition, and pedagogical situations. *Journal of Higher Education*, 85(6), 792–825.

Goonewardene, A. U., C.A. Offutt, J. Whitling, & D. Woodhouse. (2016). An interdisciplinary approach to success for underrepresented students in STEM. *Journal of College Science Teaching*, 45(4), 59–67.

Johnson, J., Jon Rochkind, Amber N. Ott, & Samantha DuPont (2009). With Their Whole Lives Ahead of Them: Myths and Realities About Why So Many Students Fail to Finish College. Washington, D.C.: Public Agenda.

Lovett, K. (2016). Understanding and identifying teacher shortage areas in Oregon, 2016. http://www.ode.state.or.us/wma/researchteacher-shortage-final-report.pdf.

Malkus, N., K. Hoyer Mulvaney & D. Sparks. (2015). Teaching vacancies and difficult-to-staff teaching positions (NCES-065). Retrieved from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics: http://nces.ed.gov/pubs2015/2015065.pdf

Nasir, N.S. (2016). Why should mathematics educators care about race and culture? *Journal of Urban Mathematics Education*, 9 (1), 7-18.

Negoita, C. (November 2016). Email communication.

Oregon Community Colleges Association (OCCA) (2016). Redesigning Developmental Education for Student Success: A third annual report. http://occa17.com/data/documents/Redesigning-Developmental-Education-for-Student-Success-Report-June-2016.pdf

Oregon Higher Education Coordinating Commission (2016). 2016-2020 Strategic Plan. https://www.oregon.gov/HigherEd/Documents/HECC/Reports-and-Presentations/HECC-StrategicPlan_2016.pdf

Price, M. (November 2016). Email communication.

Smith, C. (2013). *Writing Public Policy: A Practical Guide to Communicating in the Policy Making Process*. Oxford.

HIGHER EDUCATION
COORDINATING
COMMISSION