Report of the Houston Mathematics Pathways Task Force

June 22, 2015

The Houston Mathematics Pathways Task Force consists of faculty members and staff from the University of Houston (UH), the University of Houston – Downtown (UHD), the University of Houston – Clear Lake (UHCL), the San Jacinto College District (SJCD), the Houston Community College System (HCC), Wharton County Junior College (WCJC), and the Lone Star College System (LSC). The Task Force was assisted by members of the Dana Center and Complete College America. A complete listing of members and external contributors is available in Appendix A.

The task force was convened to address important issues related to the core mathematics education of college students in non-STEM areas of study, and insure that these students receive mathematics training that is *appropriate* for their intended majors. As a starting point, the task force crafted a charge which was (admittedly) amended over time, but retained the spirit of the original document.

Task Force Charge:

1. Review current transfer data on entry level mathematics courses. Work out a smooth and efficient plan to allow transfers among all participating institutions for the entry level courses.
2. Identify gateway mathematics courses, and create a plan to allow the vast majority of students, to complete gateway mathematics courses during their first academic year. Suggest changes to state leadership to support program and student needs.
3. Support constructive engagement of mathematics chairpersons and faculty to shape curricular policy across institutions, and to bolster student support and advising.
4. Help departments and faculty create plans for advisors to help students progress through their mathematics coursework, to aid ongoing Guided Pathways to Success work.
5. Work with faculty and leadership to identify and/or design and recognize different entry level math courses that link to the meta-majors, and meet state curriculum requirements.

Items 1 and 2 drove the majority of the discussions and actions of the task force. The decisions related to item 2 required immediate action related to item 1, and actions related to items 3-5 evolved naturally from items 1 and 2. As a starting point, the group agreed that there are no transfer issues related to the traditional mathematics pathways, but that potential transfer issues currently arise from new mathematics pathways for non-STEM majors.

History

For over 50 years, most college students have been given mathematics training that flows from College Algebra[1] to other courses depending upon their major. Some, but not all STEM[2] majors, receive mathematics training that moves from College Algebra, to PreCalculus, to Calculus[3] and beyond (see Appendix B for the National Science Foundation listing of STEM areas of study). Other STEM majors take paths from College Algebra to Finite Mathematics[4], and some of the business and social science STEM majors subsequently take a course which is often named “Business Calculus” or “Calculus for Social and Life Sciences.” These paths for STEM majors seem appropriate. Many non-STEM majors are also funneled through College Algebra, and for some of these students, this course appears to be a myriad of mathematical topics that are not related to their majors, and do not have any immediate use in everyday life. At the University of Houston students are then routed into at least one additional mathematics course, which typically has College Algebra listed as a prerequisite, and may or may not be related to their intended major. At several other participating institutions, College Algebra has historically been used as a terminal course for non-STEM majors.

In recent years, efforts have been made to create additional mathematics pathways for non-STEM majors, but the effort has not been uniform across 2 and 4 year institutions. This has hampered the effort, since transfer students who choose a mathematics pathway at a 2 year school, can easily face problems when they transfer to a 4 year school that does not recognize the pathway. This situation arises in the Houston area, where UH has core mathematics requirements which nearly force transfer students to choose a mathematics pathway at their 2 year school which includes College Algebra. The task force recognized this issue, and the need to create a common alternative pathway which could be offered and recognized as completing the mathematics core for non-STEM majors at 2 and 4 year schools, to students who desire an alternative to a traditional pathway that flows through College Algebra.

Action

Clarifying multiple pathways and aligning outcomes

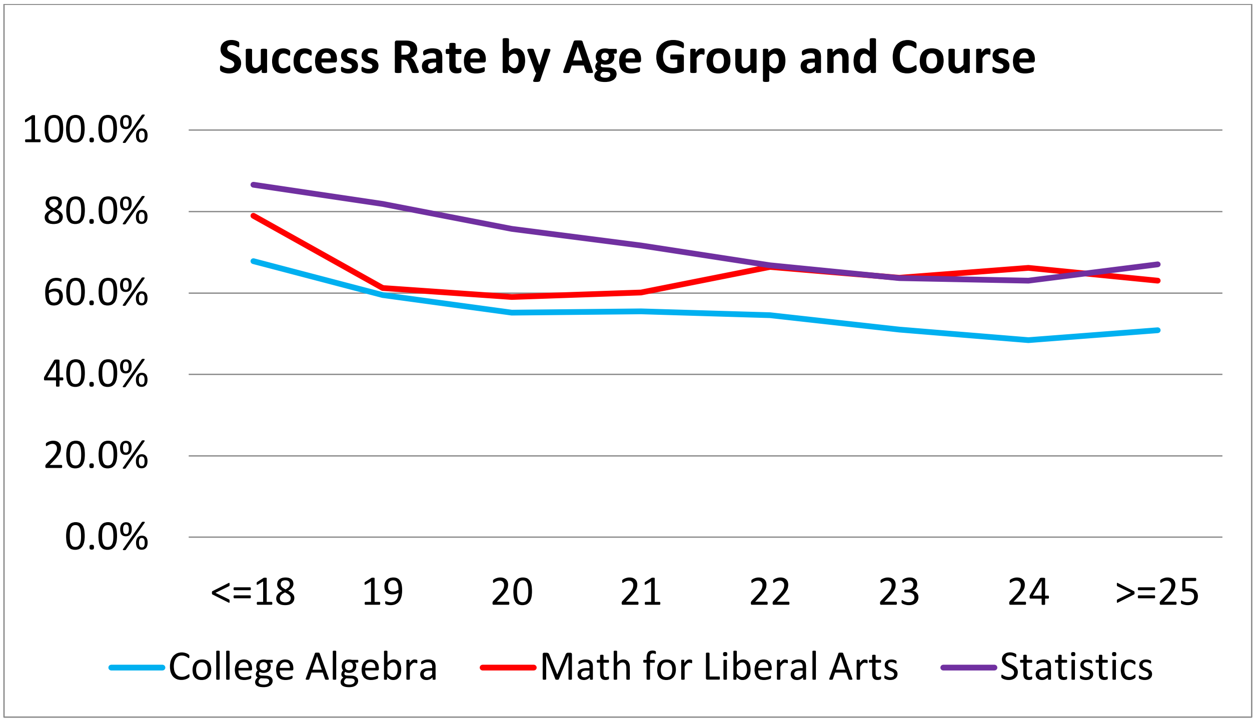
An immediate candidate for an alternative pathway is one that includes a course which is sometimes named “Math for Liberal Arts” (as an alternative to College Algebra) or “Introduction to Statistics” (also recognized by the Dana Center as “Statistical Reasoning”). At UH, students would take these in a two-course sequence. The task force agreed that these mathematics pathways would benefit most non-STEM majors, and also give them access to mathematics that is immediately applicable to understanding a world that is increasingly driven by data, and also more applicable to their non-STEM majors. The major obstacle associated with this pathway was the omission of the Math for Liberal Arts course at WCJC, UH and UHCL. The absence at UHCL is due to the university’s recent transition to include freshmen and sophomore level courses. The absence at UH was more serious, since it caused difficulty for students choosing this pathway at 2 year schools, and intending to transfer to UH. Introduction to Statistics is now offered at all of the schools (with the first offering at UHCL in fall 2015), and transfer agreements are in place. Appendix C shows courses that already existed in this pathway, along with new courses and amended courses that schools have agreed upon as of May 2015. Short descriptions are also given for these courses.

The task force also focused its charge on creating a common offering of “Math for Liberal Arts” at each school, insuring that necessary transfer agreements will be in place, and amending rules at UH to give core mathematics credit for both courses in this pathway[5]. The first of these tasks involved a careful study of the curriculum in “Math for Liberal Arts” at the schools offering the course, followed by an agreement that was reached by each school to teach at least

75% of an agreed upon curriculum, so that each school could maintain some flexibility in its course offering, but teach a common set of materials that would allow students to transfer their credits from one school to another. It was mentioned above that UH did not have this course in their curriculum. However, their course, entitled "Mathematical Modeling" (Math 1311) covered 75% of the agreed upon material, and as a result, minor changes in its curriculum were made to accommodate all necessary items. Paperwork has also been submitted by the Department of Mathematics at UH to request that "Math for Liberal Arts" transfers to UH as this course, counts as part of the quantitative core, and serves as a prerequisite for the second course in this pathway (taught at UH at Math 2311). As a result, after some paperwork has been completed, this mathematics pathway will be common to all of the schools represented by the task force.

Analyzing math course data

There is also the question of whether students can navigate this pathway with greater success than they navigate the pathway that includes College Algebra. Although there is anecdotal evidence to support this notion, the schools in the task force agreed that gathering the performance data for the past 4 years would offer reinforcement, and also possibly give important insight. The graph below shows the success rate by age group in College Algebra, Math for Liberal Arts, and Statistics, for all students in the schools represented by the task force, during fall and spring semesters from spring 2011 to fall 2014.



The success rates by school can be found it the table in Appendix D, and it is clear from this information that students at some schools perform markedly better than students at other schools. In addition, the age demographics at some schools are markedly different from the age demographic at other schools, and at most schools, students have a higher success rate when courses are taken at a younger age.

Course	Number of Successful Students ≤ 19 Years Old	Success Rate Students ≤ 19 Years Old
College Algebra	21,949	64.2%
Math for Liberal Arts	684	68.3%
Statistics	3,563	83.7%

This is particularly troubling when we look at the age demographics at HCC and LSC, where the average age of students is considerably higher than the average age at 4 year schools. Regardless of these differences, it is clear that the *overall* success rate in College Algebra is not acceptable, and although the success rate in Math for Liberal Arts is still not as high as we would like, the overall performance exceeds the overall performance in College Algebra.

Course	Number of Successful Students	Overall Success Rate (independent of age)
College Algebra	38,763	56.2%
Math for Liberal Arts	2,553	63.8%
Statistics	10,624	72.3%

Engaging partner disciplines and advisors

A key role will be played by non-STEM departments and advisors at each school. Discussions with departments have already begun, and will continue. The task force stresses that the key to the success of this initiative is suggesting *appropriate* mathematics pathways to students in non-STEM majors. The task force strongly believes we should *NOT require* all non-STEM majors to choose an alternate to the College Algebra pathway. Indeed, there is a group of students who will always choose to use College Algebra as a prerequisite for Statistics, simply because they learned Algebra II in high school, and as a result, they are extremely comfortable with the topics in College Algebra. At UH, the success rate among FTIC students who take College Algebra during the fall of their freshmen year is over 80%. This also appears to be true for students at WCJC. However, overall, the task force believes that the mathematics pathway created for non-STEM majors from this effort will improve student success rates in the their mathematics core, and equip them with mathematics that is relevant and applicable. As a byproduct, there should be an overall improvement in student attitudes towards the useful nature of the mathematics that forms the core of their education.

Further Recommendations

Based upon the data collected from the schools represented by the task force, it is apparent that requiring students to complete their mathematics core during their first year in college will guarantee higher success rates in mathematics, and ultimately save students a considerable amount of time and money. The task force strongly recommends that all schools represented in the task force adopt and enforce this requirement. For students who do not require mathematics remediation, the pathway suggested by this task force can be completed during the first year.

Footnotes:

1 – College Algebra and High School Algebra II are nearly identical courses. Some college students require remedial mathematics courses prior to taking College Algebra. This report does not address this issue.

2 – STEM stands for "Science, Technology, Engineering, Mathematics." The listing in Appendix B shows that STEM areas of study encompassed a tremendous number of topics that are not immediately communicated by its four word description. We remark that although Business is not included in this list, there are an increasing number of disciplines within Business that require an understanding of rates of change and other advanced mathematical concepts. The number of Non-STEM areas of study is at least as large, if not larger.

3 – A large number of STEM majors are able to place directly into Calculus, or a higher level mathematics course.

4 – Finite Mathematics covers topics related to understanding cost, revenue and profit scenarios associated with linear constraints, linear programing, matrices and systems of linear equations, basic problems in mathematical finance, and basics of probability and statistics.

5 – Math 2311 at UH is entitled "Introduction to Statistics," and it has been approved to satisfy the mathematics core.

Appendix A

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Appendix B

STEM Fields of Study According to NSF

CHEMISTRY

Chemical Catalysis
Chemical Measurement and Imaging
Chemical Structure, Dynamics, and Mechanism
Chemical Synthesis
Chemical Theory, Models and Computational Methods
Chemistry of Life Processes
Environmental Chemical Systems
Macromolecular, Supramolecular, and Nanochemistry
Sustainable Chemistry
Chemistry

COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE)

Algorithms and Theoretical Foundations
Communication and Information Theory
Computational Science and Engineering
Computer and Information Security
Computer Architecture
Computer Systems, Networking, and Embedded Systems
Databases
Data Mining and Information Retrieval
Graphics and Visualization
Human Computer Interaction
Informatics
Machine Learning
Natural Language Processing
Robotics and Computer Vision
Software Systems and Software Engineering
CISE

ENGINEERING

Aeronautical and Aerospace Bioengineering
Biomedical
Chemical Engineering
Civil Engineering
Computer Engineering
Electrical and Electronic
Energy
Environmental
Industrial Engineering & Operations Research
Materials
Mechanical
Nuclear
Ocean
Optical Engineering

Polymer
Systems Engineering
Engineering
GEOSCIENCES
Atmospheric Chemistry
Aeronomy
Biogeochemistry
Biological Oceanography
Chemical Oceanography
Climate and Large-Scale Atmospheric Dynamics
Geobiology
Geochemistry
Geodynamics
Geophysics
Glaciology
Hydrology
Magnetospheric Physics
Marine Biology
Marine Geology and Geophysics
Paleoclimate
Paleontology and Paleobiology
Petrology
Physical and Dynamic Meteorology
Physical Oceanography
Sedimentary Geology
Solar Physics
Tectonics
Geosciences
LIFE SCIENCES
Biochemistry
Biophysics
Cell Biology
Developmental Biology
Ecology
Environmental Science
Evolutionary Biology
Genetics
Genomics
Microbiology
Molecular Biology
Neurosciences
Organismal Biology
Physiology
Proteomics
Structural Biology

Systematic Biology
Life Sciences
MATERIALS RESEARCH
Biomaterials
Ceramics
Chemistry of materials
Electronic materials
Materials theory
Metallic materials
Photonic materials
Physics of materials
Polymers
Materials Research
MATHEMATICAL SCIENCES
Algebra, Number Theory, and Combinatorics
Analysis
Applied Mathematics
Biostatistics
Computational and Data-enabled Science
Computational Mathematics
Computational Statistics
Geometric Analysis
Logic or Foundations of Mathematics
Mathematical Biology
Probability
Statistics
Topology
Mathematics
PHYSICS AND ASTRONOMY
Astronomy and Astrophysics
Atomic, Molecular and Optical Physics
Condensed Matter Physics
Nuclear
Particle Physics
Physics of Living Systems
Plasma
Solid State
Theoretical Physics
Physics
PSYCHOLOGY
Cognitive
Cognitive Neuroscience
Computational Psychology
Developmental
Experimental or Comparative
Industrial/Organizational

Neuropsychology
Perception and Psychophysics
Personality and Individual Differences
Physiological
Psycholinguistics
Quantitative
Social
Psychology
SOCIAL SCIENCES
Archaeology
Biological Anthropology
Cultural Anthropology
Anthropology, other
Communications
Decision Making and Risk analysis
Economics
Geography
History and Philosophy of Science
International Relations
Law and Social Science
Linguistics
Linguistic Anthropology
Medical Anthropology
Political Science
Public Policy
Science Policy
Sociology (except Social Work)
Urban and Regional Planning
Social Sciences
STEM EDUCATION AND LEARNING RESEARCH
Engineering Education
Mathematics Education
Science Education
Technology Education
STEM Education and Learning Research

Appendix C

	Math for Liberal Arts	Introduction to Statistics
HCC	Math for Liberal Arts – Math 1332	Statistics – Math 1342
LSC	College Mathematics for Liberal Arts – Math 1332	Elementary Statistics – Math 1342
UH	Elementary Mathematical Modeling – Math 1311	Intro to Probability and Statistics – Math 2311
UHCL	Mathematics for Liberal Arts – Math 1332*	Elementary Statistical Methods – Math 1342*
UHD	College Mathematics for Liberal Arts – Math 1310	Introduction to Statistics – Stat 2300
SJCD	Contemporary Mathematics I – Math 1332	Elementary Statistical Methods – Math 1342
WJCC	TBD – Math 1332*	Introduction to Statistics – Math 1342

* – New courses.

Agreed Upon Topics for "Math for Liberal Arts"

Set Theory (basic definitions), Combining Sets, Venn diagrams

Probability/Counting methods, Fundamentals of Probability

Statistics Sampling, Frequency Distributions, Central Tendency, Dispersion, Introduction to Linear Regression Using Technology

Functions and Modeling, Linear and Non-linear Graphs

Typical *Detailed* Syllabus for "Introduction to Statistics"

Univariate Data: Types of data, Mean and Median, Standard Deviation and Variance, Range, IQR and Finding Outliers, Graphs and Describing Distributions

Introduction to Probability: Counting Techniques, Combinations and Permutations, Sets and Venn Diagrams, Basic Probability Models, General Probability Rules

Discrete Distributions: Random Variables, Binomial Distributions, Geometric Distributions

Continuous Distributions: Density Curves, The Normal Distribution, Standard Normal Calculations, Sampling Distribution of x and p

Bivariate Data: Scatter Plots, Correlation, The Least Squares Regression Line, Residuals, Non-Linear Models, Relations in Categorical Data

Samples and Experiments: Sampling, Designing Experiments, Simulating Experiments

Estimation: Margins of Error and Estimates, Confidence Interval for a Proportion, Confidence Interval for the Difference of Two Proportions, Confidence Interval for a Mean, Confidence Interval for the Difference of Two Means

Tests of Significance: Inference for the Mean of a Population, Sample Proportions, Inference for a Population Proportion, Comparing Two Means, Comparing Two Proportions, Goodness of Fit Test, Two-way Tables

Appendix D

The table below shows the number of successful students and the percent that this represents among all students enrolled in the course during fall and spring semesters from spring 2011 to fall 2014.

	Success in College Algebra								
	School	**<=18**	**19**	**20**	**21**	**22**	**23**	**24**	**>=25**
	UH	3731	1257	541	376	290	215	160	691
	UH	83.7%	71.5%	64.6%	60.6%	61.3%	62.5%	56.1%	60.4%
	UHD	839	1321	469	210	161	126	112	629
	UHD	68.8%	61.6%	48.1%	38.5%	41.3%	40.5%	45.7%	39.7%
	HCC	327	736	960	938	637	509	421	3131
	HCC	79.4%	70.6%	57.9%	52.6%	46.6%	46.7%	48.8%	52.1%
	LSC	30	120	431	1178	1756	1261	801	3154
	LSC	85.7%	91.6%	84.2%	70.8%	62.2%	53.9%	47.7%	51.1%
	WCJC	1054	1144	663	311	157	108	89	565
	WCJC	80.2%	72.8%	69.1%	62.3%	57.1%	62.4%	69.0%	68.4%
	SJCD	2425	1114	649	479	362	280	229	1616
	SJCD	49.0%	38.2%	36.3%	40.5%	43.1%	43.7%	42.4%	46.2%
All	**College Algebra**	8406	5692	3713	3492	3363	2499	1812	9786
	College Algebra	67.9%	59.5%	55.2%	55.5%	54.5%	51.0%	48.4%	50.9%
W/O UH	**College Algebra**	59.0%	56.8%	53.8%	54.9%	54.0%	50.1%	47.8%	50.3%
	Success in Liberal Arts Math								
	School	**<=18**	**19**	**20**	**21**	**22**	**23**	**24**	**>=25**
	UH	127	69	61	46	31	23	11	51
	UH	85.8%	75.8%	79.2%	86.8%	62.0%	63.9%	68.8%	61.4%
	UHD	75	156	116	66	65	63	57	532
	UHD	68.2%	54.0%	47.2%	41.8%	50.8%	53.8%	50.9%	56.4%
	HCC	1	9	32	44	48	38	43	269
	HCC	100.0%	90.0%	88.9%	86.3%	90.6%	90.5%	87.8%	77.1%
	LSC	0	0	1	9	36	47	51	275
	LSC	0.0%	0.0%	100.0%	64.3%	81.8%	63.5%	76.1%	65.0%
	WCJC	0	0	0	0	0	0	0	0
	WCJC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SJCD	11	19	13	7	8	3	4	36
	SJCD	91.7%	82.6%	72.2%	70.0%	100.0%	75.0%	57.1%	75.0%
All	**Math for Lib Arts**	214	253	223	172	188	174	166	1163
	Math for Lib Arts	79.0%	61.3%	59.0%	60.1%	66.4%	63.7%	66.1%	63.0%
W/O UH	**Math for Lib Arts**	70.7%	57.1%	53.8%	54.1%	67.4%	63.7%	66.0%	63.1%
	Success in Statistics								
	School	**<=18**	**19**	**20**	**21**	**22**	**23**	**24**	**>=25**

	UH	977	1341	1007	624	375	268	135	501
	UH	87.5%	82.3%	75.7%	69.3%	62.0%	61.6%	56.0%	56.0%
	UHD	9	48	52	39	30	9	9	42
	UHD	81.8%	76.2%	67.5%	75.0%	60.0%	42.9%	56.3%	53.2%
	HCC	6	42	150	221	223	188	148	1052
	HCC	85.7%	93.3%	82.0%	72.5%	67.4%	66.2%	66.1%	73.4%
	LSC	1	1	14	45	128	150	117	646
	LSC	100.0%	100.0%	93.3%	71.4%	79.0%	62.0%	65.7%	65.5%
	WCJC	105	262	266	180	96	61	41	305
	WCJC	92.9%	85.3%	81.1%	82.9%	79.3%	82.4%	91.1%	84.5%
	SJCD	81	108	80	82	62	45	28	224
	SJCD	71.7%	69.2%	58.0%	66.1%	62.6%	58.4%	51.9%	59.1%
All	**Statistics**	1179	1802	1569	1191	914	721	478	2770
	Statistics	86.6%	81.9%	75.8%	71.7%	66.8%	63.6%	63.1%	67.0%
w/o UH	**Statistics**	82.4%	80.6%	75.8%	74.5%	70.6%	64.9%	66.3%	70.1%