Webster Educating STEM Teachers Bound for Success (WESTbound Success) Project: Curriculum Revision and Student Success on Missouri STEM Certification Exam Using Expert STEM Faculty as Evaluators

Anton Wallner, DJ Kaiser, Teresa Alvarez, Jennifer Bond, Marissa Cope, Ravin Kodikara

Webster University

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WESTbound Success Project

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- Capacity-building grant (preparing for a Track 1)
- Focus on Pathways, Pipeline, and Partnerships
- Today's presentation:
  - The partnership between Webster University and St. Louis Community College
  - Faculty taking required content exams to inform curriculum for STEM and Education

The Challenge

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- State requirement to pass Missouri Content Assessments (MoCA) before being certified
- Many current candidates (at Webster) do not pass these exams
- The curriculum may not always prepare candidates for these exams

Existing Curriculum (33 hours Education Courses)

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- Unified Science Biology (Secondary Education)
  - Essentials of Biology I & II (+Labs), General Chemistry I & II (+Labs), College Physics I & II (+Labs), Earth and Universe (+Lab), Global Climate Change, Teaching Methods, 20 additional credits in biology [*this has been replaced*]
- Mathematics (Secondary Education)
  - Computer Programming I, Calculus I, II & III, Teaching Methods, one geometry course, one advanced algebra course, four upper level mathematics or programming courses
- Middle School Science
  - Essentials of Biology I (+Lab), General Chemistry I (+Lab), College Physics I (+Lab), Astronomy, Environment (+Lab), Physical Geology (+Lab), Teaching Methods
- Middle School Mathematics
  - College Algebra, Trigonometry, Calculus I & II, Teaching Methods, one statistics course, one geometry course, two upper level mathematics electives
- Chemistry – new degree/no current secondary education degree pathway

Data on Webster Teacher Candidates

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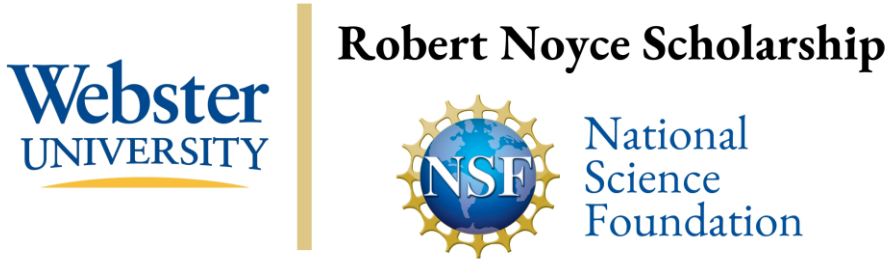
Table 2. Webster University Teacher Certification Completers Based on Title II Data

Subject Area	2014-15	2015-16	2016-17	2017-18
Mathematics	4	2	4	3
Science	6	2	0	2
All Areas (including STEM)	70	52	40	38

Table 3. Webster University Teacher Candidate MoCA Pass Rates (2014– June 2019)

Exam Area	Pass on First Attempt	Pass after Multiple Attempts	Not Passed
Mathematics	7	5	4
Science	3	-	2

Quick Overview of MoCA Exam Frameworks



Missouri Content Assessments (MoCA)[1]

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- **FIELD 016: BIOLOGY TEST FRAMEWORK**
- I. Science & Engineering Practices 21%
- II. Biochemistry & Cell Biology 14%
- III. Genetics and Evolution 29%
- IV. Biological Unity and Diversity 14%
- V. Ecology and Environment 22%

- **FIELD 018: CHEMISTRY TEST FRAMEWORK**
- I. Science & Engineering Practices 20%
- II. Matter and Atomic Structure 20%
- III. Energy and Chemical Bonding 20%
- IV. Chemical Reactions 27%
- V. Stoichiometry and Solutions 13%

- **FIELD 023: MATHEMATICS TEST FRAMEWORK**

- I. Numbers & Quantity 14%
- II. Patterns, Algebra, & Functions 30%
- III. Measurement & Geometry 21%
- IV. Trigonometry & Calculus 21%
- V. Statistics & Probability 14%

- **FIELD 024: PHYSICS TEST FRAMEWORK**

- I. Science & Engineering Practices 23%
- II. Mechanics 24%
- III. Electricity & Magnetism 23%
- IV. Waves 15%
- V. Modern Physics 15%

- COMPUTER SCIENCE
- I. Computational Thinking & Data Analysis 28%
- II. Programming Concepts 36%
- III. Computing Systems, Networks, & the Internet 18%
- IV. Impacts of Computing & Learning Environments 18%

Webster University and St. Louis Community College Partnership

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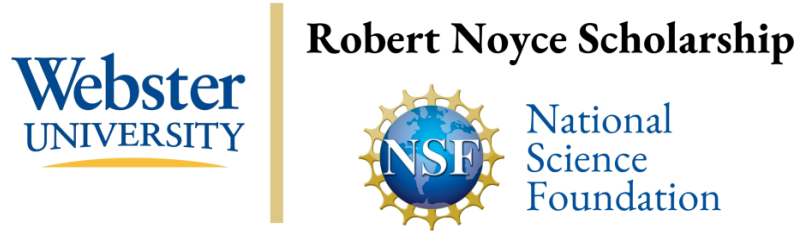
Partnership Aspects of the Project



- Identification of STLCC liaisons
- Visit Days (pipeline)
- Identification of faculty content experts (from Webster and STLCC)
  - 5 biology
  - 5 mathematics
  - 3 chemistry
  - 1 physics
- Articulation agreements

Methods Overview

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- MoCA exams and completed surveys (faculty content experts)
- Creation of a codebook[2] (NVivo)
- Developed research questions
- Revised codebook
- Data analysis
  - Individual coding (6 people)
  - Combined (consensus) coding

MoCA Exams

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- Provided each faculty expert with
  - relevant Webster curriculum/coursework
  - test framework from MEGA (MoCA) website
  - voucher for test cost
  - honorarium for completing test and survey

Survey Prompt

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MoCA Reflection Questions

Thank you for taking the Missouri Content Assessment (MoCA) from your field to help inform Webster's Educating STEM Teachers Bound for Success grant (WESTbound Success). Please note – We Do NOT need to know the score you earned and we DO NOT want to know specific questions from the exam.

Which test did you take? (biology, chemistry, mathematics, physics)

[See survey questions on future slides]

Research Questions

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1. How representative do STEM content faculty find published test frameworks for state content exams for teacher candidates?
2. How well are current STEM/Education degree plans aligned to state content exams?
3. How might STEM content faculty members' reflections on taking state content exams guide STEM/Education curriculum revisions and test preparation for undergraduate teacher candidates?

Reflection Questions Codebook

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1) "After reviewing the test framework document for the assessment you took, does this test framework reflect the content covered on the assessment accurately (e.g., if the test framework estimates that 14% of the test covers Biochemistry and Cell Biology, is this accurate)?" [*R1*]

- ACCURACY (degree of accuracy)
  - Yes Accurate
  - Somewhat Accurate
  - Not Accurate
- EXAMPLES (examples remembered)

2) "Do you think your undergraduate (NOT graduate) education in your STEM field prepared you to take this exam (e.g., if 14% of the exam covered statistics and probability but you did not have a course in statistics, please indicate that)?" [Note: Not all reflected on their own, but rather focused on undergraduate programs in general] [*R3*]

- UG PREP (would your undergraduate degree have prepared you for this?)
  - Yes prepared UG
  - Somewhat prepared UG
  - Not prepared UG
- FOCUS (what did your degree focus on not in the test?)
- MISSING (what was missing from your degree needed for the text?)

3) "What courses would you suggest are essential for an undergraduate to take to be prepared and successful on this exam?" [*R2*]

- ESSENTIAL COURSES (highlight course titles)
- SKILLS (highlight requisite skills)

Reflection Questions Codebook

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4) "What undergraduate STEM courses that you took would you consider not beneficial to topics in this exam?" [*R2, R3*]

- NONESSENTIAL COURSES (highlight course titles)

5) "Are there STEM courses outside of your field that you would suggest students need to take as part of their undergraduate education for this exam (e.g., a biologist should take an undergraduate course in general chemistry to understand some of the topics in the exam)?" [*R2, R1?*]

- OUTSIDE COURSES (highlight course titles)

6) "Does our proposed degree plan prepare the students to be successful on the Missouri Content Assessment for this field? Please use the discipline curriculum plan included in the email to answer this question." [*R2*]

- PROGRAM PREP (would the current plan prepare candidates?)
  - Yes prepared
  - Somewhat prepared
  - Not prepared
- CURRIC CRITIQUE (highlight critiques given of the current curriculum)

7) Please share any other comments you have regarding your experience with the content of this test and how it relates to curriculum. [*R1, R2, R3*]

- EXPERIENCES (highlight relevant experiences shared)
- EXAM CRITIQUE (highlight critiques given of the MoCA exam)

#1. How representative do STEM content faculty find published test frameworks for state content exams for teacher candidates?

After reviewing the test framework document for the assessment you took, does this test framework reflect the content covered on the assessment accurately (e.g., if the test framework estimates that 14% of the test covers Biochemistry and Cell Biology, is this accurate)?

	Yes Accurate	Somewhat Accurate	Not Accurate
Mathematics (5)	4	-	-
Biology (5)	4	1	-
Chemistry (3)	3	-	-
Physics (1)	1	-	-
Total (14)	12	1	-

One Mathematics faculty member did not indicate

#2. How well are current STEM/Education degree plans aligned to state content exams?

Mathematics

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Essential Courses

- a course in problem solving
- a "test prep" course
- math classes up through Calculus 1 possibly Calculus 2
- Statistics Course
- Calculus sequence, Probability, Statistics, and algebra course
- calculus sequence and a sequence of statistics courses
- a capstone (or "Keystone") math course for teachers
- Algebra, Trig, Basic Statistics, Calculus

Non-Essential Courses

- a non-Euclidean geometry course
- abstract algebra
- many of the upper-level mathematics courses
- Differential equations, Calculus 2 and Calculus 3

Biology

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Essential Courses

- biology with conservation biology, ecology and evolution
- global warming
- Evolutionary Biology
- Environmental Biology
- genetics, ecology, evolution, human biology, math, earth science, chemistry, statistics, zoology, botany, biochemistry
- core biology block of classes: Cell Biology, Genetics, Evolution, and Ecology
- research methods course
- an organismal biology or two
- two semester Biology
- Genetics, Ecology, and Evolution
- Microbiology
- Anatomy and Physiology
- Fundamentals of Chemistry I and II, Organic Chemistry, and Biochemistry
- a Capstone class or Research/Topics in Biology

Non-Essential Courses

- Specialty courses on cell biology or anatomy/physiology
- Topics courses or lab courses may not have been as helpful
- physics or chemistry was quite small
- Physics, Organic Chem, and Microbiology
- Calculus I and II;
- microbiology or A&P
- physics course

Chemistry

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Essential Courses

- General Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry, and Biochemistry
- CHEM 1100/1101 CHEM 1110/1111 CHEM 2100/2101 CHEM 3300/3301 CHEM 3500/3501 CHEM 4400 CHEM 4430
  CHEM 2110/2111 CHEM 4300/4301
- General Chemistry (2 semesters)
- three semesters of college or university physics covering mechanics, E&M and modern physics

Non-Essential Courses

- Organic

General Chemistry I & II, Organic Chemistry I & II, Quantitative Analysis, Instrumental Analysis, Physical Chemistry I, Research Methods and Senior Thesis

Mathematics

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Outside Courses

- Physics
- statistics
- a well-rounded liberal arts education

Skills

- problem solving. Developing the ability to read a problem and determine what mathematics to bring to play
- making wise choices
- Or possibly a "test prep" course where students can gain the experience of being barraged with questions that run the gamut so they can develop the flexibility of thought required for success
- how to take a multiple choice math test
- Learning to read carefully and recognize distractors are skills that can be taught
- teaching mathematics in a tangential way
- review secondary mathematical topics from a teaching perspective

Biology

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Outside Courses

- General Chemistry
- Math, stats, chemistry
- General chemistry
- College Algebra
- general chemistry, organic chemistry, and even Biochemistry
- statistics course

Skills

- research methods
- human impact or interaction
- critical thinking skills and research

Chemistry

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Outside Courses

- Biological Sciences
- cellular biology
- A section on data analysis/graphing
- algebra and trigonometry classes

Skills

- [none cited]

Does our proposed degree plan prepare the students to be successful on the Missouri Content Assessment for this field? Please use the discipline curriculum plan included in the email to answer this question

	Yes Prepared	Somewhat Prepared	Not Prepared
Mathematics (5)	3	2	-
Biology (5)	4	1	-
Chemistry (3)	2	1	-
Physics (1)	-	1	-
Total (14)	9	5	-

Responses leading to a critique of Webster's current curriculum

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Mathematics

- I would suggest the inclusion of a Statistics course and/or a unit on measuring and representing central tendency and variation (mean, median, mode, standard deviation, the normal curve, stem-and-leaf plot, box-and-whisker plot)
- Courses like "Modern Geometry" and "Data Mining" could be quite valuable for adding context and depth to the topics they are likely to be teaching as secondary mathematics teachers

Biology

- I don't think 2 semester of college physics is necessary. I think either a biochemistry course or the second semester of A&P would be more beneficial than the 2nd semester of physics.
- I do not think A&P or Microbiology are necessary
- I appreciate the flow of the courses. Taking Biology and Chemistry I and II together makes a great deal of sense. Progressing on to Physics, Ecology, Evolution, Statistics, and Environmental coursework. I also see many of the necessary course I mentioned are built into the program

Responses leading to a critique of Webster's current curriculum (cont'd)

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Chemistry

- Improvement/inclusion of course content is needed for Content Domain I, Science and Engineering Practices
- For the physics exam, they would need a 3rd semester modern physics course. Or the existing courses needed to be modified.

Physics

- [none cited]

#3. How might STEM content faculty members' reflections on taking state content exams guide STEM/Education curriculum revisions and test preparation for undergraduate teacher candidates?

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Do you think your undergraduate (NOT graduate) education in your STEM field prepared you to take this exam (e.g., if 14% of the exam covered statistics and probability but you did not have a course in statistics, please indicate that)?

	Yes Prepared	Somewhat Prepared	Not Prepared
Mathematics (5)	2	2	1
Biology (5)	1	1	2
Chemistry (3)	3	-	-
Physics (1)	1	-	-
Total (14)	7	3	3

One Biology faculty member did not indicate

Mathematics

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What did your degree FOCUS on

- focused on Calculus and beyond, mostly theoretical mathematics with a strong emphasis on proof, little to none of which was covered on this exam

What was MISSING from your degree

- I did not take statistics as an undergraduate
- I never took an official statistics course

Biology

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What did your degree FOCUS on

- My undergrad prepared me for ecology, botany and zoology questions

What was MISSING from your degree

- evolution, plants, organismal diversity and ecology were not emphasized as much
- my undergraduate education was very light in the field of evolution. I learned most of the concepts surrounding evolution in graduate school
- I didn't take biochemistry and very little genetics
- I never took anatomy & physiology or microbiology
- I did not have a statistics course in my undergraduate curriculum
- I feel ecology and evolution courses also would be very beneficial in preparing for this exam

Chemistry

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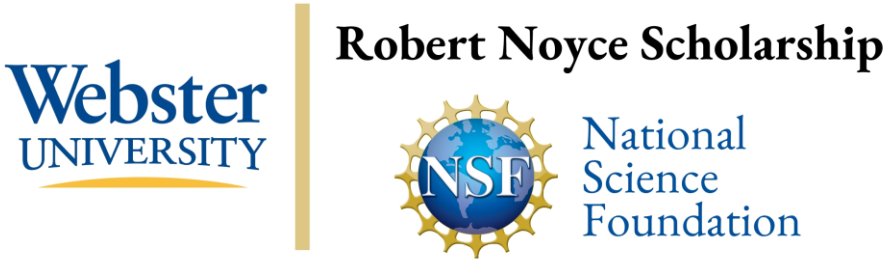
What did your degree FOCUS on

- [none cited]

What was MISSING from your degree

- There were some questions in biology, biochemistry and data analysis that would not be covered in the general chemistry sequence. (Science and Engineering Practices)

Additional Comments



Exam Critique – Mathematics

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- It's a more rigorous exam than I expected it to be
- The exam was not easy. There were several questions that I thought were challenging especially for undergraduates. I'd like to see less of emphasis on algebraic manipulation
- For example, the few calculus questions were not computational in nature, but they tested students knowledge of continuity, basic theorems, etc.

Exam Critique – Biology

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- Many of the questions you did not necessarily have to know the content well but could pull apart what was asked and search the answers that fit (process of those that did not being removed)
- There was a lot more knowledge based questions on this exam than I think relevant to teaching
- but I would love to see the breakout of questions as it relates to Bloom taxonomy. It is unfortunate (IMO) that this exam could make a break a 4 year degree if the student can just memorize a bunch of facts. I expect students could take this exam multiple times but I don't know if this exam is a real good assessment of STEM teaching. I also want to look at how this exam is compared to knowledge on the math and chemistry exams. Did the math and chem people actually do math where the biology people regurgitated facts. There could be a lot more biological application by asking people to apply scientific principles. There wasn't any questions on hypotheses, null hypothesis.
- A few things that frustrated me about the exam were poorly worded questions, bad drawings (especially the [*redacted*] and [*redacted*]--this was terrible with misleading information due to a bad drawing), and inaccurate information that is out of date with modern research... It makes me want to know how often these exam questions are reviewed and updated."
- I see the need for higher order thinking opportunities

Exam Critique – Chemistry

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- I feel (from a very considered and thought-out point of view), that the Chemistry exam should be more focused on stoichiometry and solution calculations that on the theoretical basis of the science. Again, the bulk of graduating chemists are going into applied fields which require a proper understanding of stoichiometry relationships and solution calculations. The average industrial chemist is not that concerned with the energetics of the reactions in their everyday work. This should be the emphasis of the chemistry we are teaching to students
- The questions that deal with science and engineering practice utilize scientific concepts that are NOT covered in any chemistry classes AND the concepts are not clearly explained in the question design. These questions (Though part of the exam) and not appropriate for a chemistry content knowledge assessment
- The questions are not well written nor is the concept explained appropriately enough for the test taker to make an appropriate analysis
- Application of course content to human activities and global relationships could be improved.
- It does not test a deeper understanding of physics or critical thinking but tests the content knowledge.

Experiences

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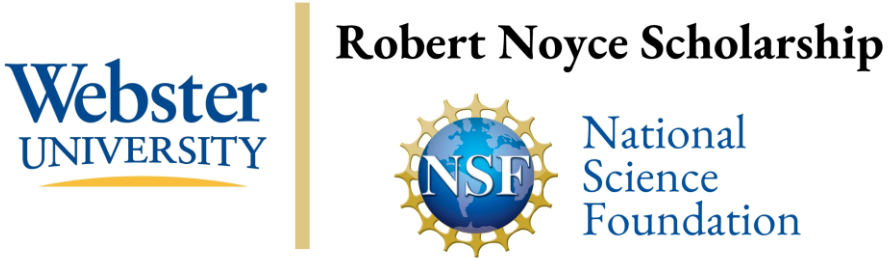
- Mathematics
  - I had fun. It was interesting going into the exam with no anxiety. The first time I took the praxis as a ""young"" undergrad, it was a little more daunting/intimidating
  - I did not review any topics before taking this exam and I should have. It would have been best if I had reviewed derivatives, integrals, velocity, acceleration, and parametric equations
  - I was familiar with all topics but had forgotten some concepts and procedures. I think that if I were currently teaching the Calculus sequence, I would have done better on this exam.
  - It's a more rigorous exam than I expected it to be
  - The exam was not easy
- Biology
  - When I reflect on the exam and the questions I found more challenging, most of them were related to content outside of my immediate discipline in plant biology. I currently teach the Principles circuit, so the questions related to homeostasis and body regulation were fresh in mind, despite not requiring that knowledge in my field. My broad background of courses I teach definitely helped me complete the exam.
- Chemistry
  - This exam is not difficult.

Next Steps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Next Steps with this Research

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- Review required content coursework for degrees based on these results
- Recommend and develop additional support and test prep for teacher candidates
- Publish results to help inform test preparation for teacher candidates and to inform the development of future content assessments

Track 1 Proposal - Outcomes

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- Study Guides[1]
- Practice Tests[1]
- Review Sessions led by content experts
- Articulation Agreements (Webster and STLCC)[3]
  - http://www.webster.edu/admissions/transfer/transfer-credit/txfr-equivalency-database.html
- Realign Curriculum
- Summer Courses (STLCC between second and third year)
- Summer Research Course (Webster between third and fourth year)

References

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1. http://www.mo.nesinc.com/ Missouri Education Gateway Assessment Test Site (accessed May 24, 2019)
2. MacQueen, K.M.; McLellan, E.; Kay, K; Milstein, B. “Codebook Development for Team-Based Qualitative Analysis” *Cultural Anthropology Methods*, **June 1998**, *10(2)*, 31-36.
3. http://www.webster.edu/admissions/transfer/transfer-credit/txfr-equivalency-database.html Transfer Equivalency Database (STLCC and Webster) (accessed October 12, 2019)

Questions?

Anton Wallner antonwallner@webster.edu

DJ Kaiser djkaiser@webster.edu

Teresa Alvarez talvarez@stlcc.edu

Ravin Kodikara ravinkodikara30@webster.edu

Marissa Cope marissacope51@webster.edu

Jennifer Bond jbond@fergflor.org

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