

Developing Innovative Technology Based Mathematics Learning Resources

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Abstract

It is the mission of Western Governors University to improve quality and expand access to post-secondary educational opportunities by providing a means for individuals to learn independent of time and place. Technological advances facilitate this mission. While all degrees are based entirely on the demonstration of competency, candidates come to their programs with varying skills. Online pre-tests, transcripts, and interview results are used to recommend learning resources to help candidates attain the required competencies for program completion. Programs are individualized in a manner consistent with candidate's learning style. Many ways are provided for students to interact with educational materials, facilitated by technology. Typically, we work with education providers to design online (or CD-ROM based) learning experiences that align to the competencies. We present a variety of the learning resources we have had developed and discuss the effectiveness of these non-traditional, technology-based mathematics education resources.

University and Teachers College Vision and Mission

“The vision and mission of both the University and the Teachers College were spelled out in our recent submission of our Conceptual Framework, as part of our NCATE accreditation application. Briefly, Western Governors University's (WGU) vision is to deliver exemplary, lower-cost higher education opportunities; and, as a result, be recognized as the premier competency-based, online, and truly national university. The mission of WGU is to improve quality and expand access to post-secondary educational opportunities by providing a means for individuals to learn independent of time and place and to earn competency-based degrees and other credentials that are credible to both academic institutions and employers. The vision/mission of the Teachers College (TC) of Western Governors University is to prepare teachers who are: competent and caring; respectful and embracing of diversity; reflective practitioners; collaborative professionals; technologically proficient; professional leaders and change agents; and as a result, both to be recognized as the premier competency-based, online, and truly national teachers college, and to develop a cohort of teachers who meet the nation's need for highly qualified teachers.” (WGU NCATE Conceptual Framework, 2005)

“All WGU degrees are based entirely on the demonstration of competency. Each candidate is required to pass multiple assessments in areas of knowledge recognized as essential by U.S. institutions of higher learning. In a traditional educational system, time (the credit hour) is the unit of progression. In a competency- or outcome-based system, the unit of progression is demonstrated mastery of competency through multi-dimensional assessment of performance. Because competency-based education focuses on mastery of integrated knowledge, skills, and abilities that enable the candidate to perform successfully in a given profession, assessments are designed to ascertain both candidate knowledge and the ability to apply that knowledge in a professional setting. A hierarchical structure of domains, subdomains, competencies, and test objectives defines a broad range of knowledge and performance elements for each program.” (WGU NCATE Institutional Report, 2006) WGU maintains a database containing over 40,000 national, state, and professional organizations' standards. The domains, subdomains, competencies and objectives are derived from and aligned to those standards. The assessments found in each Teachers College program are designed to measure students' mastery of those competencies deemed essential to highly qualified teachers.

Mathematics teacher preparation programs at WGU Teachers College include initial licensure programs at both the 5-9 and 5-12 grade levels. We offer BA and MAT degrees in Mathematics.

WGU's TC offers mathematics endorsement and MA in Mathematics Education programs in these areas for already licensed teachers as well. The resources our students use while preparing to take assessments help them to both become technologically proficient, and to master the appropriate content knowledge. Technology based resources allow students to learn on their own, at their own pace, and then to demonstrate their acquired competencies to us when they are prepared to do so. Thus, the need to be in the same place, at the same time, in order to have knowledge imparted, is eliminated via the use of technology-based learning resources which form the backbone of the WGU distance learning experience.

WGU Teachers College Student Characteristics

The average age of WGU TC students is approximately 36. We have students from all over the country. In fact, all fifty states are represented in our student body, as is the District of Columbia, two U.S. Territories, and nine foreign countries. The majority of our students work full-time, and many have family commitments as well. WGU's mission includes expanding access to post-secondary education to those who would otherwise not have said access, and thus, our admissions policies are quite liberal. Consequently, our students' abilities and backgrounds vary widely. We admit students who have never attended college before, students with Associates degrees, some who are returning to finish a once-started but never completed Baccalaureate degree, and even some who seek a second or even third Master's degree. Many students are career changers, and we also have a fair share of existing teachers as students, who seek either formal licensure, or else a Master's degree in order to maintain existing licensure. Some students come to us needing only a brief content review prior to demonstrating their competency. Others require much more support, and need greater interaction with a variety of learning resources in order to gain the required knowledge, skills, and dispositions outlined by our standards-based competencies. They do this in a variety of ways. WGU TC assessments include series of performance tasks; comprehensive, proctored, computerized competency examinations; projects in which students synthesize their acquired knowledge; and in-class observations of student-teaching.

“Candidates come into their programs with varying competencies. They complete diagnostic pre-tests of competencies applicable to their program. Faculty Mentors use the pre-test, transcript, and interview results to recommend a sequence of learning resources to help candidates attain the required competencies for program completion. The University made an early decision not to develop courses, but to contract with Education Providers, i.e., colleges, universities, training companies, museums, and learning organizations already offering online courses aligned to our program competencies. Textbooks, study guides, websites, tutorials, and other independent learning resources also help candidates prepare for assessments. Each degree has a “standard path” identifying learning resources that experience and feedback have shown to be most closely aligned to and most successful in preparing candidates for the competency assessments required by their program. Mentors may also individualize the program in a manner consistent with each candidate's learning style, experience, and competencies.” (WGU NCATE Institutional Report, 2006)

Because WGU decided early on not to “reinvent the wheel” by developing our own mathematics courses, it became necessary to either identify existing resources; or to develop our own, using third party providers. We then had to ensure that the learning resources aligned to our competencies; and then to form agreements that would allow our students access to those resources. The model works as follows. WGU identifies or develops a well-aligned, online or technology based mathematics learning resource, and then contracts with the Education Provider (EP) to make the resource available to our students. WGU then uses the tuition money paid to us

by students to enroll them in that particular resource. Students make use of the resource and only after fully engaging and interacting with the materials, demonstrate mastery of the material via several types of WGU assessments.

Technology Based Learning Resources

WGU Teachers College is free, then, to pursue agreements with a wide variety of Education Providers, and we have done just that. The types of Learning Resources currently available to our students can be divided into three main categories. First, we contract with existing brick-and-mortar institutions who offer online courses of study. Second, we have contractual agreements with commercial educational software and/or courseware companies to make their products available to our students. Third, we make use of educational websites found in the public domain, after reviewing them for accuracy and appropriateness.

Brick-and-Mortar Institutions' Online Offerings

Traditional brick-and-mortar institutions such as Chadron State College (www.csc.edu/); Cochise College (www.cochise.edu/); Rio Salado Community College (http://www.rio.maricopa.edu/distance_learning/); and California National University; (<http://www.cnuas.edu/>), among others, all provide online courses to our students. A formal review process ensures that the courses offered cover the topics on which our students will later be assessed. A brief description of some of the courses offered by the aforementioned institutions follows.

Chadron State College provides Mathematics teacher candidates with such math courses as “College Algebra;” “College Geometry;” “Probability & Statistics;” “Linear Algebra;” “Modern Algebra;” and “Discrete Mathematics.” Rio Salado Community College provides “Introduction to Statistics;” and “Pre-calculus.” California National University offers “Algebra II;” “Pre-calculus;” “Probability & Statistics;” as well as “Calculus I, II, & III.” WGU partners with these institutions which allow us to enroll our students in their courses, typically on an “audit” basis. Students in these courses typically have access to notes, electronic presentations, chat-rooms, and may email their questions to the professors facilitating the courses. We monitor the success of our students on the assessments for which they prepare via these other institutions’ courses, and may cancel our agreement with any that are found to not be preparing our students adequately.

Commercial Educational Courseware Providers

WGU currently maintains contracts with commercial educational software and courseware providers including, but not limited to: Thinkwell (www.thinkwell.com); LessonLab (www.LessonLab.com); and McGraw-Hill’s Professional Development (<http://www.epd-mh.com/>). We have also contracted with Smarthinking.com (www.smarthinking.com) to provide both mathematics and writing tutorial support.

Thinkwell is an education provider whom we use extensively. Thinkwell delivers CD-ROMS which are accompanied by text-based workbooks, and websites through which students can work sample problems, take online quizzes, and receive instantaneous feedback. WGU has contracted with Thinkwell to deliver a variety of mathematics LRs including such titles as: “Algebra;” “Trigonometry;” “Pre-Calculus;” and “Calculus I & II.” The majority of our students thoroughly enjoy the Thinkwell materials, and tend to do well on the assessments for which they prepared using those materials. LessonLab provides CD-ROM based Learning Resources for Mathematics Teaching Methods. The material contained on the disks, and the websites and texts that accompany them, lead students to better understand proper mathematics pedagogy. Again,

digital video of excellent teaching can be found on these disks, and students from all over the country can view these best practices from the comfort of their own homes, and at the time of their choosing. WGU TC also uses McGraw-Hill Professional Development's (MHPD) "Mathematics, Yes!" program in our M.A. in Mathematics Education, K-6 program. The K-6 program utilizes a 10-disk set of CD-ROMS, with an accompanying website through which students submit their electronic portfolios for grading by WGU. This 80-hour professional development module combines grades K through 6 mathematics content with best practice pedagogy that is based on NCTM Standards. We find that this resource prepares our students well to be highly effective mathematics specialists in the elementary school setting.

Public Domain Educational Websites

We also make use of a wide array of free web-based content and reference resources. Some of these include: MIT's Open Course Ware (<http://ocw.mit.edu/index.html>); the Annenberg Media website (www.learner.org/index.html); Computing Technology for Math Excellence (www.ct4me.net/); Math Archives (<http://archives.math.utk.edu/>); and The Math Forum (<http://www.mathforum.org/>), to name just a few. For many of our assessments, faculty mentors, who are subject matter experts in their fields, have developed "Study Guides" or "Job Aids." These documents typically list the competencies covered by the assessment, along with online texts and websites students may wish to reference as they prepare for that assessment. Typically, the study guides are used by students as additional learning resources, in conjunction with an online (or CD-ROM) based course. To better illustrate our study guides, below is a concrete example drawn from an actual study guide covering the Abstract Algebra competencies found in one of the High School Mathematics assessments.

Abstract Algebra

[All websites accessed September, 2006]

Math Archives: Topics in Mathematics. <http://archives.math.utk.edu/topics/>

Topics in Abstract Algebra, from the Mathworld Classroom

<http://mathworld.wolfram.com/classroom/classes/AbstractAlgebra.html>

Mathworld: Algebra, created and maintained by Eric Weisstein.

<http://mathworld.wolfram.com/topics/Algebra.html>

The Math Forum @ Drexel: Modern Algebra. http://mathforum.org/library/topics/modern_algebra/

The Mathematical Atlas, Algebraic Areas of Mathematics, by Dave Rusin.

http://www.math.niu.edu/~rusin/known-math/index/tour_alg.html

JAVA applet to explore all groups of order 1-15.

<http://math.ucsd.edu/~jwavrik/Groups15/Groups15.html#Instructions>

Abstract Algebra, by Joe Mileti. <http://www.math.uchicago.edu/~milet/museum/algebra.html>

Notes on Groups, by Peter Williams. <http://www.math.csusb.edu/notes/advanced/algebra/gp/gp.html>

Group Explorer, downloadable software. <http://www.platosheaven.com/grouexplorer/index.html>

Abstract Algebra Online, by John Beachy <http://www.math.niu.edu/~beachy/aaol/>

Students have several online Abstract Algebra, or Modern Algebra courses from which to choose. If, during the course, they find themselves struggling with a particular concept or topic, they may choose to reference the accompanying study guide covering those topics. Other students may have already taken an Abstract Algebra course sometime in their past, and may choose not to take a course at all. They may prefer instead, to review the material on their own. Such students would likely make use of a study guide, and engage in an independent learning experience rather than an online course.

12 Define group and tell whether a given mathematics object is a group by applying the definition.	http://en.wikipedia.org/wiki/Group_(mathematics) http://www-groups.dcs.st-and.ac.uk/~history/HistTopics/Abstract_groups.html http://www.math.niu.edu/~rusin/known-math/index/20-XX.html http://thesaurus.maths.org/mmkb/entry.html?action=entryByConcept&id=1247&langcode=en
13 Define ring and field and tell whether given mathematical structures are rings and fields by applying these definitions.	http://en.wikipedia.org/wiki/Ring_(mathematics) http://mathworld.wolfram.com/Ring.html http://thesaurus.maths.org/mmkb/entry.html?action=entryById&id=763 http://en.wikipedia.org/wiki/Mathematical_field http://mathworld.wolfram.com/Field.html http://www.math.niu.edu/~rusin/known-math/index/12-XX.html
14 Prove given theorems of important results in abstract algebra. (These theorems will concern groups, including cyclic groups, rings, fields, and integral domains.)	http://www.platosheaven.com/groupeexplorer_v1/documentation/example_cyclicproducts.html http://planetmath.org/encyclopedia/CyclicSubgroup.html http://web.usna.navy.mil/~wdj/tonybook/gpthry/node27.html http://www.math.lsu.edu/~adkins/m4201/cyclicgroup.pdf http://www-history.mcs.st-and.ac.uk/~john/MT4517/Lectures/L4.html http://www.maths.qmul.ac.uk/~pjc/class_gps/ch1.pdf
15 Explain the relationship between abstract algebra and other fields of mathematics, such as geometry and linear algebra.	http://www.smcm.edu/nsm/MathCS/Students/studentProjects/rmtalbot2005/index.html http://www.math.niu.edu/~rusin/known-math/index/15-XX.html http://www.math.niu.edu/~rusin/known-math/index/tour_geo.html
16 Discuss the relationship between abstract algebra and the algebra in the grades 9-12 mathematics curriculum.	http://www.smcm.edu/nsm/MathCS/Students/studentProjects/rmtalbot2005/index.html http://www.cbmsweb.org/MET_Document/chapter_5.htm http://www.cbmsweb.org/MET_Document/chapter_9.htm

Conclusion

Western Governors University's Teacher College is unique in the world of higher education. Not only are we wholly online and competency-based, but we also do not deliver our own curriculum. Rather, we sub-contract that function out to other education providers. Existing Universities, third party educational software producers, and public domain websites provide an array of learning opportunities for our students. Faculty mentors guide students to appropriate learning resources, based upon learning styles, existing competencies, and the realities imposed by students' life situations. Whenever possible, we work to identify existing online or technology based learning resources. When not already available, we work with commercial educational software and courseware developers to design and deliver resources aligned to our standards-based competencies. This we do in an effort to facilitate our mission of improving quality and expanding access to post-secondary educational opportunities by providing a means for individuals to learn independent of time and place. This allows our graduates to earn competency-based degrees and other credentials that are credible to both academic institutions and employers.

References

Western Governors University (2005). *Conceptual Framework*. Unpublished manuscript, Western Governors University, Salt Lake City, UT

Western Governors University (2006). *Institutional Report*. Unpublished manuscript, Western Governors University, Salt Lake City, UT