

Spring 2016

Survey of Chemistry II

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Grants Collection

Middle Georgia State University



UNIVERSITY SYSTEM
OF GEORGIA

Jonathan Cannon, Estelle Nuckels, Renat Khatmullin,
Andrew Lauer

Survey of Chemistry II





Grants Collection

Affordable Learning Georgia Grants Collections are intended to provide faculty with the frameworks to quickly implement or revise the same materials as a Textbook Transformation Grants team, along with the aims and lessons learned from project teams during the implementation process.

Each collection contains the following materials:

- **Linked Syllabus**
 - The syllabus should provide the framework for both direct implementation of the grant team's selected and created materials and the adaptation/transformation of these materials.
- **Initial Proposal**
 - The initial proposal describes the grant project's aims in detail.
- **Final Report**
 - The final report describes the outcomes of the project and any lessons learned.



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Syllabus

Sample Syllabus for Chem 1152 Survey of Chemistry including links to readings and videos. Students were required to be able to show their notes on either the readings or the videos on unannounced days throughout the semester.

Week:Day	Topic	
1:1	Introduction to organic chemistry, drawing organic structures	Reading: 1.01 , 1.02 Videos: Condensed structures (6:48) Bond-line structures (12:56) 3D bond-line structures (10:57) Structural (constitutional) isomers (9:51)
1:2	Molecular geometry, functional groups	Reading: 1.03 , 1.04 , 1.05 Videos: Functional groups (7:23) More functional groups (8:52) Identifying functional groups (9:18) Memorize the functional group names and structures in their various representations.
2:1	Nomenclature of alkanes, alkenes, and alkynes	Reading: 1.06 , 1.07 , 1.08 , 1.09 , 1.10 Videos: Naming simple alkanes (9:27) Alkene nomenclature (10:38) Alkyne nomenclature (7:08) Other videos in the lists may be helpful when working homework. This is a topic that takes practice and memorization.
2:2	Stereochemistry, nomenclature and stereochemistry of cycloalkanes	Reading: 1.11 , 1.12 , 1.13 , 1.14 , 1.15 Videos: Cis-trans isomerism (5:24) Introduction to chirality (6:46) Chiral examples 1 (11:02) Stereoisomers, enantiomers, and chirality centers (5:28)
3:1	Nomenclature of other functional groups, review	Reading: 1.04 Videos: Do the reading for this day Memorize the functional groups
3:2	Exam 1	Unit Summary 1.16 (under construction)
4:1	Reactions and properties of alkenes	Reading: 2.11 , 2.12 , 2.13 , 2.14 Videos: Intermolecular Forces 8:35 Boiling point of organic compounds 11:06 Solubility of organic compounds 12:20 Balancing another combustion reaction 4:57
4:2	Reactions and properties of alkynes	Reading: 2.21 , 2.22 , 2.23 , 2.24 Videos: Introduction to reaction mechanisms 11:21 Markovnikov's rule and carbocations 9:08 Polymerization of alkenes with acid 12:03

5:1	Reactions and properties of aromatic compounds	Reading: 2.31 , 2.32 , 2.33 , 2.34 Videos: Resonance 11:50 Aromatic Stability I 5:57 Electrophilic aromatic substitution mechanism 6:54 Ortho para directors I 12:57
5:2	Reactions and properties of alcohols and ethers	Reading: 2.41 , 2.42 , 2.43 , 2.44 Videos:
6:1	Review	Review the subjects covered by the Readings
6:2	Exam 2	
7:1	Reactions and properties of amines	Reading: 3.11 , 3.12 , 3.13 , 3.14 Videos: Acid-base definitions 8:30 Organic acid-base mechanisms 5:31 Amine naming introduction 6:50
7:2	Carbonyl chemistry	Reading: 3.21 , 3.22 , 3.23 Videos: Aldehyde Introduction 7:48 Ketone naming 8:43 Physical properties of aldehydes and ketones 10:12 Curly arrow conventions 6:58
8:1	Reactions and properties of aldehydes and ketones	Reading: 3.31 , 3.32 , 3.33 , 3.34 Videos: Reactivity of aldehydes and ketones 10:04 Formation of hemiacetals 10:43 Carbohydrates - cyclic structures and anomers 11:10
8:2	Reactions and properties of carboxylic acids and derivatives	Readings: 3.41 , 3.42 , 3.43 , 3.44 Videos: Carboxylic acid nomenclature and properties 8:51 Nomenclature and properties of amides 8:49 Peptide bond formation 8:25 I recommend you examine the readings briefly as well.
9:1	Review	
9:2	Exam 3	
10:1	Extra review	chemical reasoning and bridge from organic to biochemistry
10:2	Intro to Biomolecules	Reading: 4.11 , 4.12 , 4.13 , 4.14 , 4.15 , 4.16
11:1	Carbohydrates	Reading: 4.21 , 4.22 , 4.23 , 4.24 , 4.25 Videos: Carbohydrates - naming and classification 10:26 Carbohydrates - cyclic structures and anomers 11:11 Carbohydrates - di and poly saccharides 13:00
11:2	Lipids	Reading: 4.31 , 4.32 , 4.33 Videos: Molecular structure of triglycerides 11:03 Saturated fats, unsaturated fats, and trans fats 8:56 Lipid overview 11:30

12:1	Proteins	<p>Reading: 4.41, 4.42, 4.43</p> <p>Videos: Introduction to amino acids 9:53 Peptide bond formation 8:25 Overview of protein structure 9:57 Tertiary structure of proteins 7:27</p>
12:2	Enzymes	<p>Reading: 4.51, 4.52, 4.53, 4.54, 4.55</p> <p>Videos: Introduction to enzymes 6:04 Induced fit model of enzyme catalysis 6:43 Six types of enzymes 7:03 An introduction to enzyme kinetics 4:43 Allosteric regulation and feedback loops 6:04</p>
13:1	Nucleic Acids	<p>Reading: 4.61, 4.62, 4.63, 4.64</p> <p>Videos: DNA 13:01 DNA replication and RNA transcription and translation 15:23 Molecular structure of DNA 13:00</p>
13:2	Exam 4	
14:1	Biochem topics: Concentration scales, osmolarity, electrolyte balance	<p>Videos: Diffusion and Osmosis 18:59 Molarity vs. molality 8:01 Molarity vs. osmolarity 11:31</p> <p>Reference:</p>
14:2	Biochem topics: Energy metabolism and diabetes	Reference:
15:1	Biochem topics: Kidneys, kidney failure, and brain swelling	<p>Videos: The kidney and nephron 18:37</p> <p>Readings: Kidneys and How They Work Acute Kidney Failure</p>
15:2	Biochem topics: course review	

Initial Proposal

**Affordable Learning Georgia Textbook Transformation Grants
Round 2
Summer 2015, Fall 2015, Spring 2016
Proposal Form and Narrative**

Institution Name(s)	Middle Georgia State College				
Team Members (Name, Title, Department, Institutions if different, and email address for each)	Andrew Lauer, Assistant Professor of Organic Chemistry, Andrew.lauer@mga.edu Jonathan G. Cannon, Assistant Professor of Biochemistry, jonathan.cannon@mga.edu Estelle Nuckels, Assistant Professor of Physical Chemistry, Estelle.nuckels@mga.edu Department of Natural Sciences and Engineering				
Sponsor, Title, Department, Institution	Dr. Martha Venn, Provost, Office of Academic Affairs				
Course Names, Course Numbers and Semesters Offered (Summer 2015, Fall 2015, or Spring 2016)	Survey of Chemistry I and Survey of Chemistry II CHEM 1151, 1152 Fall 2015, Spring 2016				
Average Number of Students Per Course Section	20	Number of Course Sections Affected by Implementation in Academic Year 2016	15	Total Number of Students Affected by Implementation in Academic Year 2016	300
Award Category (pick one)	<input type="checkbox"/> No-Cost-to-Students Learning Materials <input type="checkbox"/> OpenStax Textbooks <input type="checkbox"/> Course Pack Pilots <input checked="" type="checkbox"/> Transformations-at-Scale				

List the original course materials for students (including title, whether optional or required, & cost for each item)	<p><i>[Material Title, optional or required]</i></p> <p><i>OWL with Introduction to General, Organic, and Biochemistry, req</i></p> <p><i>Hardcopy with OWL access code, opt</i></p>	<p><i>[Cost]</i></p> <p><i>\$126/student</i></p> <p><i>Or \$258/student</i></p> <p>Total Cost</p> <p>\$37800 - \$77400</p>	
Plan for Hosting Materials	<input type="checkbox"/> OpenStax CNX <input checked="" type="checkbox"/> D2L <input type="checkbox"/> LibGuides <input checked="" type="checkbox"/> Other <u> Sapling Learning </u>		
Projected Per Student Cost	\$40	Projected Per Student Savings (%)	68-84%

1. Project Goals

- Reduce the costs to students of textbooks and online homework software.
- Align course outcomes more closely with the goals and programs of the majority of the students, particularly the Nursing Program.
- Assemble independent, free, or low cost resources typically provided by textbook publishers to support professors in course preparation in conjunction with the selected, open textbook.

1.1 STATEMENT OF TRANSFORMATION

- *Describe the transformation*
Students are required to purchase electronic access to a textbook with the purchase of their online homework system. Being required to purchase a specific publisher's textbook artificially inflates the cost of course materials.
- *Identify stakeholders affected by the transformation*
Survey of Chemistry is a primary requirement for students desiring to enter the Nursing Program, and recommended or required for some other healthcare related professions. It also serves as a core curriculum lab science elective, with more than 200 students taking the first semester course each year, and approximately 130 taking the second semester.
- *Describe the impact of this transformation on stakeholders and course success.*

With the current digital textbook, students lose access to the text after 6 or 24 months, while a hardcopy of the book is more than twice as expensive. In addition, the current course has been designed with little input from the programs which provide the majority of the students. This makes the course primarily a dreaded, gateway course rather than a valued, core skill building course for many of our students. Direct feedback from the programs requiring this course will improve the applicability of the skills learned. Students would benefit from continued access to and knowledge of online resources. Textbook and homework system changes will save up to 84% per student and provide continued access to frequently updated materials without fees.

- *Describe the transformative impact on the program, department, institutions, access institution, and/or multiple courses.*

We propose to replace the current textbook with a free textbook or textbooks, and to replace the online homework system with a less expensive, textbook independent system. We will also align the topics emphasized in the course more closely with the needs of Nursing and other health care students. Thus students will save money, have continued access to course materials after their old subscriptions would have expired, and experience a course more in line with the core skills and knowledge the hope to use in their lives.

1.2 TRANSFORMATION ACTION PLAN

- Meet with Nursing Program (and other program) representatives
- Select any new emphases for course topics
- Select a book or books (at least 3 relevant, free, high quality books are available online, but will require correlation to our particular course)
- Collate video lectures with class topics, either for viewing to prepare for class or as review (selections from Khan Academy and other respected sources have already been correlated with the current course by Dr. Cannon)
- Select a homework system (Sapling Learning, WebAssign, and Quest are options)
- Redesign syllabus
- Find pre/post tests for content knowledge (Use current departmental exams based on learning objectives as an internal reference, but look for other, externally verified tests to compare to state or national averages)
- Find questionnaires for measuring student engagement from current scholarship of teaching and learning
- Collect DFW data from previous years and simultaneously in unmodified sections during Spring (Available for our school in Blackboard Analytics)

1.3 QUANTITATIVE AND QUALITATIVE MEASURES

Every semester we give assessment quizzes, we will give these same quizzes to our students that take the new courses to make sure that the Student Learning

Objectives (SLOs) are still being met. We will utilize pre/post tests to also test content knowledge. We will use blackboard analytics to compare the drop, withdraw, and fail (DWF) rates. Finally, we will survey student opinions of the free materials and the current materials, including student preferences and frequency of use, to make sure that the no cost materials are at least as effective as current materials and materials used in comparable classes.

1.4 TIMELINE

January / February	Consult with representative of the School of Health Sciences. Select textbooks from among candidate OER textbooks.
March	Plan calendar of modified curriculum for Fall. Correlate textbook and video lectures with curriculum. Develop student surveys for evaluating textbook effectiveness.
April	Select assessment tools for content outcomes and student engagement. Collect available data from previous courses.
May	Provide assessment tools to all professors teaching course in Fall. Assess student opinions of current materials. Create Desire2Learn course with access to all planned materials. Collect assessment data from students completing Chem 1151. Submit Progress Report.
August	Implement new course in approximately half of our sections.
December	Collect final assessment data and provide second progress report. Provide new course materials to all faculty to sustain and expand the reduced cost textbook changes into the upcoming year.

1.5 BUDGET

\$5,000 each to Andrew Lauer, Jonathan Cannon and Estelle Nuckels. Our department does not have sufficient faculty to cover release time for essential courses, so overload is required.

\$200 for external tests for comparison to state or national averages.

\$600 for miscellaneous supplies, materials, and travel.

1.6 SUSTAINABILITY PLAN

We will develop the course materials and curriculum changes using materials maintained by established organizations so that they will continue to be available for many years (e.g. Khan Academy, Sapling Learning, FlippedChemistry). We will provide course materials to other colleagues in Desire2Learn (Brightspace) and other readily accessible online formats to assist them in curriculum and course material changeover with a minimum of duplicated labor.

1.7 REFERENCES & ATTACHMENTS

December 8, 2015

To Whom It May Concern:

From: Dr. Marti Venn, Provost
Middle Georgia State College

RE: Letter of Support for Affordable Learning Georgia Award

I am pleased to provide this letter of support for Dr. Andrew Lauer, Assistant Professor of Chemistry, Dr. Jonathan Cannon, Assistant Professor of Biochemistry, and Dr. Estelle Nuckels, Assistant Professor of Physical Chemistry. Drs. Lauer, Cannon, and Nuckels are proposing to address the “Transformations-at-Scale”. They are targeting two science courses in AREA D- CHEM 1151 and CHEM 1152 and potentially impacting in one year **over 300 students** at a savings to students of approximately **\$77,400** in one year (for students taking both science courses)! This has not only the potential savings for the first survey course it may in fact encourage students to take the second CHEM sequence course and thus boost science progression rates. Over 70% of Middle Georgia State College students are on financial aid and could not afford to come to college without that support. This fall convocation, I challenged the faculty to “Imagine a new teaching scholar model” and to align with the institution’s values of service, adaptability, engagement and leadership. This RFP dovetails well with this new call to serve our students in new and transformative ways. My office is committed to sustainability of this project after this year. Through our Center for Teaching Innovation we can provide faculty professional development to assist them in this project. The college is open to providing faculty course release to sustain as well as transform additional courses based on the results of this project. If funded, my office stands ready to support, champion, and publically recognize the trail that Drs. Lauer, Cannon, and Nuckels are blazing for our students and the college!

Final Report

Affordable Learning Georgia Textbook Transformation Grants
Final Report

Date: May 10, 2016

Grant Number: 111

Institution Name(s): Middle Georgia State University

Team Members (Name, Title, Department, Institutions if different, and email address for each):

Jonathan G. Cannon Assistant Professor of Chemistry Department of Natural Sciences Jonathan.cannon@mga.edu	Estelle Nuckels Associate Professor of Chemistry Department of Natural Sciences Estelle.Nuckels@mga.edu	Renat Khatmullin Assistant Professor of Chemistry Department of Natural Sciences Renat.khatmullin@mga.edu
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Project Lead: Jonathan G. Cannon

Course Name(s) and Course Numbers: CHEM 1151 and 1152

Semester Project Began: Spring 2015

Semester(s) of Implementation: 2

Average Number of Students Per Course Section: 21

Number of Course Sections Affected by Implementation: 7

Total Number of Students Affected by Implementation: 150

1. Narrative

Chem 1151 Survey of Chemistry I

The comparison of the data before and after the transition in CHEM 1151 revealed that there was no overall impact on student learning. However, students spend significantly less money on course materials, making the transformation positive. Additionally, faculty found the new homework system more user-friendly. Both homework platforms used were received positively by students. The OWL platform (before) is approximately triple the cost. The quality of the product does not justify the additional cost.

The textbook prior to transformation was not well received by students. Many of the students did not realize the Openstax book was available, so most of the reviews after transformation were neutral. In the second semester of implementation, faculty repeatedly encouraged students to use the Openstax book. However, student's comments showed that students still did not utilize this resource, still commenting that there was no textbook available for the course. Depending on student and faculty opinion, we will either continue with this resource or move to Chemwiki for CHEM 1151 as well. The Openstax book is better suited for the principles sequence than for survey.

At this point, it is difficult to draw conclusions on the DFW rates. DFW rates Individual instructors have their own rates, and the instructors teaching the course have changed. Additionally, the entrance requirements for the institution and core requirements are different, causing a shift in demographics of students. If we look at the data we currently have, the failure and withdrawal rate has increased dramatically, from 8% (Spring 2015) to 38% (Fall 2015) to 24% (Spring 2016). We hope that the drop in DFW rate in the second semester of implementation is the beginning of a trend, as faculty and students become more accustomed to the new materials.

The delivery method and instructional techniques did not change significantly, however reference materials changed. Time was used to set up homework problem sets, and lecture materials which are reusable in the future. Additional instructor resources (test banks, etc.) were not available, increasing the time required to set up quizzes and exams.

Chem 1152 Survey of Chemistry II

While Openstax provided a textbook that adequately matched our departmental course outline for Chem 1151, no similar OER textbook existed for Chem 1152. We opted to construct an online textbook using pages selected from Chemwiki hosted by the University of California at Davis, and to supplement lectures with short, topical videos provided by Khan Academy. We were able to construct adequate materials, increase student use of these materials over the previous, purchased textbook, and save students between \$70 and >\$200 dollars each.

Before beginning to construct the syllabus, we met with faculty from the Department of Health Sciences since most of our students in this sequence are Health Science majors. The first hurdle

was to make modifications to the emphasis of the course to better match the needs of Health Science majors without departing from the agreed upon Chemistry department curriculum and standards. This required a de-emphasis of certain topics typically emphasized in textbooks for this course, and an increase in emphasis on biochemical topics. We found Chemwiki topic pages and Khan Academy videos that matched every topic for the course. The videos and wiki pages were mostly short enough and specific enough that many students found them useful references. The most typical complaint was that they were more in depth than what was expected for class, and that they didn't line up perfectly with what was tested. The second most common problem was that the resources didn't spend enough time on or give enough examples of the most basic concepts appropriate for the level of preparation of the majority of our students. This was particularly true of the biochemistry topics where the available pages dedicated most of their space to giving facts and vocabulary--much of it highly technical and not of lasting use to non-specialists--and little space tying the concepts back to organic chemistry and the chemical reasoning we attempted to teach in the first half of the semester.

The flexibility allowed by constructing a textbook from individual topic pages gave greater choice in the organization of topics in the course, and greater adaptability to the needs of the students. However, using a new relatively new resource that has undergone less editing and carried with it fewer instructor resources was challenging. While many topics had good examples on the Chemwiki pages, some topics had few or completely lacked examples of problem solving. Others only had problems more difficult than the level of a survey course. Chemwiki provides no lecture slides or test bank. The quality and quantity of figures are frequently lower than in textbooks. But while these seem like significant drawbacks from the perspective of a professor, it should be remembered that: 1. the majority of students never used the textbook they purchased, 2. we found it easy to adapt or borrow old, or create new, lecture slides for the material, and 3. it was possible to acquire and adapt exam materials simply by asking colleagues who had taught similar courses.

Three factors constrained our changes. Some faculty were willing to change to an OER textbook as long as it didn't significantly change what they teach. Consequently, changes had to be minimal. Second, the faculty implementing the changes (Dr. Cannon and Dr. Khatmullin) were inexperienced in teaching this course. Third, we had to use the already existing departmental assessment test which was geared toward the previous curriculum, and not to the emphasis suggested by the Health Sciences faculty.

We were able to modify the assessment test during the Spring 2016 semester in an attempt to better test fundamentals common to all instructors' choices in course emphasis. Students using the open resources scored much better than their counterparts; however, we fear that this was a function of the revised questions and not the abilities or learning of the students.

In summary, the cost savings to students provided by the changes, and the absence of negative impacts on learning outcomes, are sufficient reasons for us to contribute to further development and improvement of OER materials. Dr. Cannon has made contacts and plans to

be involved with development of interactive sample problems and ancillary instructor materials for the Chemwiki project. However, the lack of fully developed resources for the organic and biochemistry portions of the course, and the needs of some of our faculty to have a print textbook, preclude our continuing with Chemwiki as the primary text for these courses *at this time*. Nevertheless, as a consequence of our exploration of low cost textbook options, we have plans as a department to switch to an intermediate cost, primarily electronic text and tutorial system with an optional print book.

2. Quotes

Chem 1151

- The textbook is helpful when looking for a worked example in order to figure out a complex problem.
- I enjoy being able to reference the textbook anywhere I have an internet connection without toting a bulky book around, although I seem to comprehend the material better with a physical book.
- The textbook is easy to understand. I think it was an extra bonus that we didn't have to pay for it. As far as the helpfulness for studying, I really didn't use it for that. I used it more as a supplemental source when I couldn't figure something out from old exams, or my notes, homework, or the internet.

Chem 1152

- [Sapling Learning] was very easy to use. I used it to study some, but some questions proved to be quite difficult.
- The textbook was easy to navigate but I found it had a lot of information that we didn't use for some topics.
- I did not like the textbook. However the videos were nice.

3. Quantitative and Qualitative Measures

3a. Overall Measurements

Student Opinion of Materials

Was the overall student opinion about the materials used in the course positive, neutral, or negative?

Chem 1151

Total number of students affected in this project: 93

Homework Opinion

- Positive: 70 % of 72 number of respondents
- Neutral: 22 % of 72 number of respondents
- Negative: 8 % of 72 number of respondents

Textbook Opinion

- Positive: 6 % of 72 number of respondents
- Neutral: 75 % of 72 number of respondents
- Negative: 19 % of 72 number of respondents

Chem 1152

Total number of students affected in this project: 51

Homework Opinion

- Positive: 48 % of 31 number of respondents
- Neutral: 35 % of 31 number of respondents
- Negative: 16 % of 31 number of respondents

Textbook Opinion

- Positive: 39 % of 29 number of respondents
- Neutral: 32 % of 29 number of respondents
- Negative: 23 % of 29 number of respondents

Total

Total number of students affected in this project: 134

Homework Opinion

- Positive: 60 % of 103 number of respondents
- Neutral: 25 % of 103 number of respondents

- Negative: 15 % of 103 number of respondents

Textbook Opinion

- Positive: 15 % of 101 number of respondents
- Neutral: 56 % of 101 number of respondents
- Negative: 29 % of 101 number of respondents

Student Learning Outcomes and Grades

Chem 1151

Choose One:

- Positive: Higher performance outcomes measured over previous semester(s)
- Neutral: Same performance outcomes over previous semester(s)
- Negative: Lower performance outcomes over previous semester(s)

Chem 1152

Choose One:

- Positive: Higher performance outcomes measured over previous semester(s)
- Neutral: Same performance outcomes over previous semester(s)
- Negative: Lower performance outcomes over previous semester(s)

Student Drop/Fail/Withdraw (DFW) Rates

Drop/Fail/Withdraw Rate:

Chem 1151

32 % of students, out of a total 115 students affected, dropped/failed/withdrew from the course in the final semester of implementation.

Choose One:

- Positive: This is a lower percentage of students with D/F/W than previous semester(s)
- Neutral: This is the same percentage of students with D/F/W than previous semester(s)
- Negative: This is a higher percentage of students with D/F/W than previous semester(s)

Chem 1152

__7__% of students, out of a total __57__ students affected, dropped/failed/withdrew from the course in the final semester of implementation.

Choose One:

- Positive: This is a lower percentage of students with D/F/W than previous semester(s)
- Neutral: This is the same percentage of students with D/F/W than previous semester(s)
- Negative: This is a higher percentage of students with D/F/W than previous semester(s)

3b. Narrative

Chem 1151 Survey of Chemistry I

In comparison to previous semesters, students seemed indifferent to the change in homework systems. The previous opinion was 64% of 22 students thought that the OWL homework system was positive. Student opinion is slightly improved with 69% of 72 students having a positive opinion of Sapling Learning. Sapling Learning is significantly cheaper for students, significantly easier for faculty to use, and students are marginally in favor of the change.

The textbook was less well received by students, but students were less polarized. In previous semesters, 29% of students liked the textbook while 67% disliked it. The open source textbook was neutrally received by students, where 75% were neutral towards the textbook and 20% dislike it. Many students commented that they did not know of the textbook.

We had a dramatic increase in the number of students that failed or dropped CHEM 1151. Upon a closer look, we were unsure if the increase was due to the change in course materials, or other changes. The data collected prior to transformation had a FW rate of 8%, but it was a different instructor. If we pull data for the same instructor, the FW rate is 9% compared to her 34% for the fall semester and 24% for the spring semester. However, the data collected before transformation for the same instructor was collected shortly after the school was consolidated. Consolidation caused many of the core requirements to change, so the demographics have changed. Prior to consolidation, the vast majority of students were pre-nursing majors. The current courses include more non-science majors. At this point, we are unable to determine if the considerable increase in FW rates are due to the textbook transformation, the change in the demographics of students, the instructor, or some combination thereof. It is also possible they are ordinary statistical fluctuations, since FW rates for introductory science courses at our school are often 30% or more.

Student success for learning objectives seems to be nearly the same. Prior to transformation, students averaged 73.6% correct on our assessment questions. After transformation, there was

a slight drop to 69.5% correct. With the limited amount of data, we attribute this change to variation in the class demographics. Learning was not hindered by the transformation.

For CHEM 1151, the transformation retained a positive opinion on the homework system, removed the negative opinion on the textbook, but may have contributed to an increase in FW rates (though more research would need to be done to make sure).

Chem 1152 Survey of Chemistry II

The measurable impact on the students was primarily in the form of improved opinions about the textbook. Our objective assessment remained the same. Fewer students withdrew or failed, but it is likely within the range of statistical fluctuations for only 57 students. The departmental assessment had almost exactly the same average and standard deviation of scores between the spring 2015 and fall 2016 courses before and after the textbook transformation. The modified assessment given in spring 2016 showed much greater success for the students using OER materials, 65% correct vs. 40% for students using our previous textbook. This is worth further examination, but is not a convincing indicator of improved student outcomes. It indicates that the test better matches the course expectations for students using the OER, but matches the expectations of students using the previous textbook no better than the unmodified assessment test.

We had proposed doing a pretest to measure improvements over the course of the semester. We were unable to do so because of limited willingness to participate of faculty who were not directly involved with the project. We looked into using past scores and grades from Chem 1151 to compare them with outcomes for the same students in 1152, but we had insufficient overlap between the students involved in both semesters of the study to draw any meaningful conclusions.

Both the students and professors noticed the imperfect fit of the Chemwiki textbook and Khan Academy videos to the course; however, 73% of the students used Chemwiki more than once a week compared to only 39% with the previous textbook. 48% of students used Chemwiki 3-5 times per week, while only 6% used the previous textbook that often. Student opinions of the textbook shifted from 6% positive and 61% negative with the previous book to 39% positive and only 23% negative with Chemwiki. The increased textbook usage is likely partially the result of differences in teaching methods between Dr. Nuckels and Dr. Cannon. Dr. Nuckels relies heavily on lecture slides to convey the material expected of her students. Dr. Cannon employed a flipped classroom approach, requiring students to have watched videos or read and taken notes before attending class. Dr. Nuckels's students ranked class notes and previous exams as the most important materials for success in the course with the textbook being lowest ranked, while Dr. Cannon's students ranked the textbook and course notes equally and only somewhat higher than other resources.

Our change in online homework system was a bigger success. Student opinions shifted from a 6% positive and 71% negative response with OWL to a 48% positive and 16% negative response

with Sapling Learning. While still an imperfect fit for our expectations of the course, we were better able to match problems with the desired outcomes than with the previous system, and there were almost no complaints about the ease of using the system. That is in contrast to frequent complaints about OWL. Also, 52% of the students felt that Sapling Learning was the first or second most important tool for success in the course compared with only 30% ranking the previous system that highly.

4. Sustainability Plan

For CHEM 1151, the textbook is provided on Openstax.org. Updating and maintenance of course materials will be done by the publishers. Additional materials are on D2L.

For CHEM 1152, the textbook is maintained by Chemwiki. We will provide professors with the option of using the specialized textbook map we prepared this semester or one of the Chemwiki textbook maps that aligns with a published General, Organic, and Biochemistry textbook. The specialized textbook map will continue to be adapted by individual professors, while the alternative textbook map will provide a stable reference.

Sapling Learning homework assignments from the study will be provided to professors who can then modify them in conjunction with support staff from Sapling Learning.

Khan Academy videos are maintained by Khan Academy. We used the most stable links available, but links will occasionally require updating when Khan Academy updates topical videos.

Despite all materials being selected or prepared in formats which can be easily distributed, reused, and adapted, the limited amounts of ancillary instructor materials available for CHEM 1152, and the lack of an optional printed text for the same course, make continuation of OER use for this course infeasible for our department at this time.

5. Future Plans

This project has supported our use of Sapling Learning as an online homework system. Students seem to overall be indifferent to the change in systems, and faculty use is significantly easier. However, as a department we have decided that a complete shift to OER is impractical at this time.

Now that we have more knowledge and experience with the available OERs, we have found better developed materials for Organic and Biochemistry courses, as well as the general chemistry course for science majors. We have begun incorporating many of these materials as lower cost options for students in those courses. We have also reexamined the available commercial materials for CHEM 1151/1152 and identified options costing significantly less than our previous textbook, if not as little as the open textbooks. In summary, while our project to shift CHEM 1151/1152 completely to open resources could be described as a failure, we have managed through this process to 1. Educate our colleagues about the improving OER options, 2.

Shift the courses to a less expensive (if not free) textbook and homework system option, and 3. Provide lower cost options for students in several other courses who would otherwise pay \$2-300 for textbooks or try to complete the courses without having any textbook.

Jonathan Cannon and Estelle Nuckels presented our results at the USG Teaching Learning Conference in April 2016. Dr. Cannon has joined the growing team of associate editors on the Chemwiki project, and we plan to help improve and expand on the materials available for GOB Chemistry courses to remove the barriers we experienced for us and for others who wish to provide affordable resources for their students in the future.

6. Description of Photograph

(left-right, back row) Dr. Khatmullin, instructor for Chem 1151 and co-developer of Chem 1152; Dr. Cannon, team lead and co-developer/instructor for Chem 1152; Dr. Nuckels, instructor for Chem 1151 and 1152 and developer for Chem 1151.

(left-right, front row) Delightful distractions.