TLEF Project – Final Report

Report Completion Date: (2019/04/30)

1. PROJECT OVERVIEW

1.1. General Information

Project Title:	Development of an electronic Chemistry Integrated Resource Package for CHEM 123		
Principal Investigator:	Kayli Johnson		
Report Submitted By:	Kayli Johnson		
Project Initiation Date:	04/01/2016	**Project Completion Date:**	03/31/2019
Project Type:	☐ Large Transformation ☒ Small Innovation ☒ Flexible Learning ☐ Other: [please specify]		

1.2. Project Focus Areas – *Please select all the areas that describe your project.*

☒ Resource development (e.g. learning materials, media)

☐ Infrastructure development (e.g. management tools, repositories, learning spaces)

☒ Pedagogies for student learning and/or engagement (e.g. active learning)

☐ Innovative assessments (e.g. two-stage exams, student peer-assessment)

☐ Teaching roles and training (e.g. teaching practice development, TA roles)

☐ Curriculum (e.g. program development/implementation, learning communities)

☐ Student experience outside the classroom (e.g. wellbeing, social inclusion)

☐ Experiential and work-integrated learning (e.g. co-op, community service learning)

☐ Indigenous-focused curricula and ways of knowing

☐ Diversity and inclusion in teaching and learning contexts

☒ Open educational resources

☐ Other: [please specify]

1.3. Project Summary

We developed an electronic Chemistry Integrated Resource Package (eChIRP) as a custom online textbook which is currently used by all students (1800 annually) in CHEM 123 (pilot in W2015-W2017, full implementation since W2018). Throughout the text, the eChIRP integrates interactive activities, practice questions, and videos to help students immediately check their understanding of new concepts. Each section of the eChIRP incorporates key points, content, practice questions, and a feedback section. We chose to create an electronic resource rather than a printed resource to (1) save students money and (2) offer a more interactive experience. In particular, in the organic section of CHEM 123 students often struggle to switch between different 2D molecular representations and relate each representation back to the true 3D shape of the molecule. The eChIRP allows us to present 2D representations side-by-side with 3D molecular models that students can spin to help them relate each 2D representation to a 3D structure. The eChIRP helps support active learning outside of the classroom for all students registered in CHEM 123.

1.4. Team Members – *Please fill in the following table and include **students**, undergraduate and/or graduate, who participated in your project.*

Name	Title/Affiliation	Responsibilities/Roles
Kayli Johnson	Instructor, Chemistry/Vantage	PI; co-author of eChIRP text, videos, and practice questions
Glenn Sammis	Associate Professor, Chemistry	Co-author of eChIRP text, videos, and practice questions
Noureddine Elouazizi	LT Team Lead / Teaching and Learning Technologies Strategist, Skyllight	Led eChIRP IT strategy
John Hsui	Programmer, CTLT	Maintained website and wrote xAPI statements to track student use of eChIRP
Takahito Kasahara	Post-Doctoral Fellow, Chemistry	Co-author of eChIRP organic chemistry text and practice questions
Erin Lindenberg	Post-Doctoral Fellow, Chemistry	Co-author of eChIRP physical chemistry text
Alina Cook	Undergraduate Academic Assistant	Extensively reviewed eChIRP, monitored and acted on student feedback, and created additional interactive questions
Robin Jhatu, Jessica Booth, Sarah Luo, Shani Norte, Risa Fox, Rayyan Saiyed, Viktoriya Li, Elliot Gee, Tyne Eckmyn, Khushi Dabla, Sophia Li, Michael Jhouree, Arveen Gogoani, Sambina Islam Aninta, Lin Shuan Tu, Shannon Lawrence, Hannah Yang, Shannon Lo, Kevin	Undergraduate students, CHEM 123	Reviewed eChIRP text, videos and questions

Wang, Sophia Provenzano, Simran Ruppala, Brandon Chai, Raphael Roberto, Paige Smallman, Dara Wong, Declan Taylor, Mishali Patel, Jack Cheng, Jinny Choi, Megan Toi, Arielle Hulsman, Rebecca Tsow, Sherri Sadr Karimi		

1.5. Courses Reached – *Please fill in the following table with **past**, **current**, and **future** courses and sections (e.g. HIST 101, 002, 2017/2018, Sep) that have been/will be reached by your project, including courses not included in your original proposal (you may adapt this section to the context of your project as necessary).*

Course	Section(s)	Academic Year	Term (Summer/Fall/Winter)
CHEM 123	201, 202, 203, 210, 211, 222, 266, 299	2016 – ongoing	Winter
CHEM 123	V01/V02	2017 – ongoing	Summer
CHEM 123	921	2017 – ongoing	Summer
VANT 140	V01/V02	2017 – ongoing	Summer

Some students in 2nd year chemistry courses have continued to refer to the eChIRP for review, though there is no formal association with 2nd year chemistry courses.

2. OUTPUTS AND/OR PRODUCTS

2.1. *Please **list** project outputs and/or products (e.g. resources, infrastructure, new courses/programs). Indicate the current location of such products and provide a URL if applicable.*

Product(s)/Achievement(s):	Location:
Developed an online WordPress site to host the eChIRP	https://chirp1.chem.ubc.ca
104 Written Textbook (eChIRP) Sections (18 section introductions, 30 Physical Chemistry sections, and 56 Organic Chemistry sections)	https://chirp1.chem.ubc.ca
101 Interactive practice questions for Physical Chemistry eChIRP Sections (covering 27/30 sections)	https://chirp1.chem.ubc.ca
15 Worked example videos for Physical Chemistry	https://chirp1.chem.ubc.ca
254 Interactive practice questions for Organic Chemistry eChIRP sections (covering 50/56 sections)	https://chirp1.chem.ubc.ca
9 Worked example videos for Organic Chemistry	https://chirp1.chem.ubc.ca
12 Interactive video tutorials for Organic Chemistry	https://chirp1.chem.ubc.ca
8 Interactive 3D chemical models for Organic Chemistry	https://chirp1.chem.ubc.ca
9 Animations to demonstrate 3D Organic Chemistry concepts	https://chirp1.chem.ubc.ca
xAPI statements written to track students' interactions with the eChIRP, such as h5p practice questions	

2.2. Item(s) Not Met – *Please list intended project outputs and/or products that were not attained and the reason(s) for this.*

Item(s) Not Met:	Reason:
Create a bank of adaptive practice questions	The only adaptive question bank tools that we could find that would integrate well within the eChIRP would not have allowed us to use the wide range of interactive question types available through h5p. Action taken: Without the resources to create our own tool, we opted to prioritize using an existing tool (h5p) that allowed us to create several different types of interactive question types (with students choosing question difficulty themselves) rather than one that adaptively selected the question difficulty for a student with simple multiple choice question types only.
Create a video-based step-by-step worked example for each question type	When developing the eChIRP we found that for many question types a video was not the most efficient way to show a worked example. Action taken: While we still created worked examples for concepts across the eChIRP, we opted to use whichever medium (video, text, image, animation) most effectively demonstrated the given concept.
Create a guided tutorial for each question type with video hints for each step	After creating prototype pages, students and faculty feedback suggested that the way in which we had to integrate video-based hints was too cumbersome. Action taken: We instead opted to create interactive questions using h5p, with integrated feedback to guide students to the correct answer.

3. PROJECT IMPACT

3.1. Project Impact Areas – *Please select all the areas where your project made an impact.*

☒ Student learning and knowledge

☒ Student engagement and attitudes

☒ Instructional team teaching practice and satisfaction

☐ Student wellbeing, social inclusion

☐ Awareness and capacity around strategic areas (indigenous, equity and diversity)

☐ Unit operations and processes

☐ Other: [please specify]

3.2. What were you hoping to change or where were you hoping to see an impact with this project? – *Please describe the intended benefits of the project for students, TAs, instructors and/or community members.*

In creating the eChIRP, we aimed to:

(A) Create a cohesive, easy-to-use resource for physical and organic chemistry that would help save students money. Historically, a custom textbook from a publisher required the amalgamation of two separate, disjointed texts and cost $125.

(B) Create a resource that encourages active learning outside of the classroom.

(C) Benefit students with varying backgrounds in chemistry.

(D) Enhance 3D visualization skills.

(E) Provide a helpful resource for students to use when preparing for and reviewing course concepts.

3.3. Were these changes/impacts achieved? How do you know they occurred? – *What evaluation strategies were used? How was data collected and analyzed? You are encouraged to include copies of data collection tools (e.g. surveys and interview protocols) as well as graphical representations of data and/or scenarios or quotes to represent and illustrate key themes.*

We evaluated each of the aims outlined in 3.2 above in turn:

(A) We successfully met our goal of creating a cohesive, single resource that covers both the physical and organic halves of CHEM 123 by offering the full pilot eChIRP for the first time in W2017. Since this time, the eChIRP has been offered for free as the primary text resource in CHEM 123 (all sections, all terms), saving students significant money compared to the traditional combination of textbooks ($125) which were historically offered in the course. After the W2016 pilot of the organic chemistry half of the eChIRP in CHEM 123, we surveyed students about their experience using the eChIRP. These survey results suggest that we successfully created an easy-to-use resource, with students (n=1102) rating the ease of navigation 75/100 on average (0=very difficult to navigate; 50=neutral; 100=very easy to navigate) and 90% of students rating the ease of navigation above 50 (neutral). After the full release of the eChIRP in W2018, we surveyed students again (n=967) and the average rating did not significantly change. While there is still room to improve the ease of navigation, these results suggest that we were generally successfully in creating an easy-to-use resource.

(B) To encourage active learning, we created (1) over 350 interactive practice questions using h5p, an open-sourced html5-based tool, (2) 8 interactive 3D models to help students visualize how shape affects the properties and reactivity of molecules and (3) 12 interactive videos that guide students through challenging questions, asking for input along the way and branching based on their responses. We wrote xAPI statements to track how students use the eChIRP, including how they interact with and answer h5p questions, interactive models, and interactive videos. We know that students were actively engaged with these components because we recorded an average of over 15,000 xAPI statements per day (50 interactions per active student) and up to 90,000 per day before the final exam (see figure 1, below).

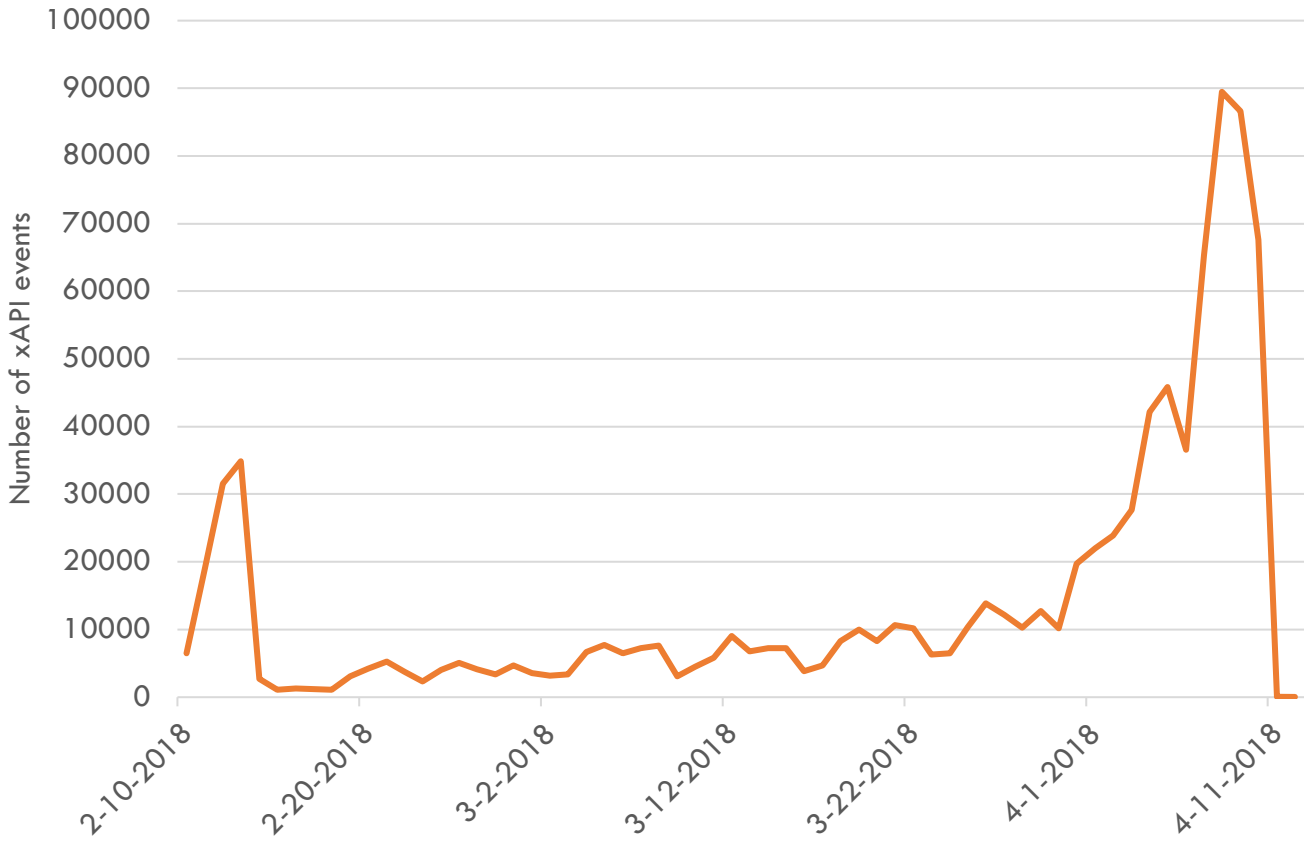

Figure 1: xAPI usage in W2017 from just before the midterm exam to just after the final exam.

In W2016, students (n=1102) also self-reported on a scale of 0 = *very unhelpful* to 100 = *very helpful* that they found the interactive practice questions (average rating 88/100), interactive models (average rating 83/100), and interactive videos (average rating 84/100) particularly helpful resources in CHEM 123.

In W2017, we ran a controlled study comparing interactive videos to their traditional counterparts. We found that students who watched the interactive video self-reported that they felt significantly more engaged ($p<0.001$) compared to students who watched the non-interactive videos (see figure 2, below).

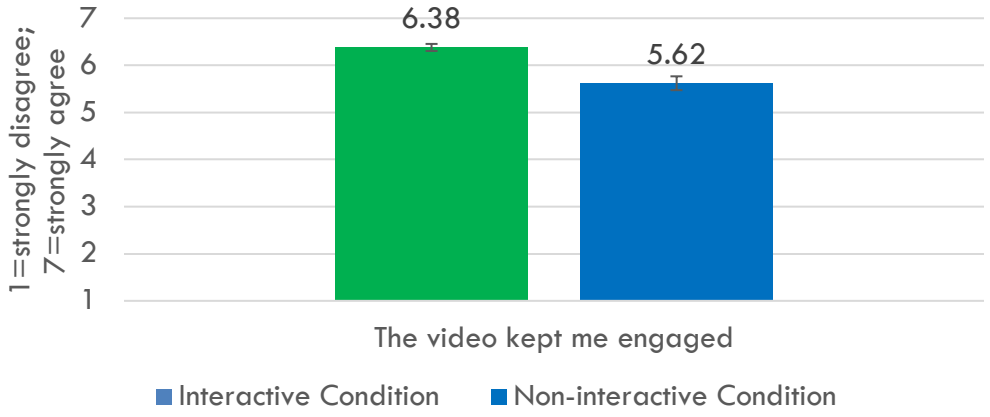

Figure 2: Self-reported engagement when watching interactive vs non-interactive videos

Students also indicated a strong preference for interactive videos over non-interactive videos, as shown in figure 3 below where 1=strong preference for non-interactive videos (left) and 7=strong preference for interactive videos (right).

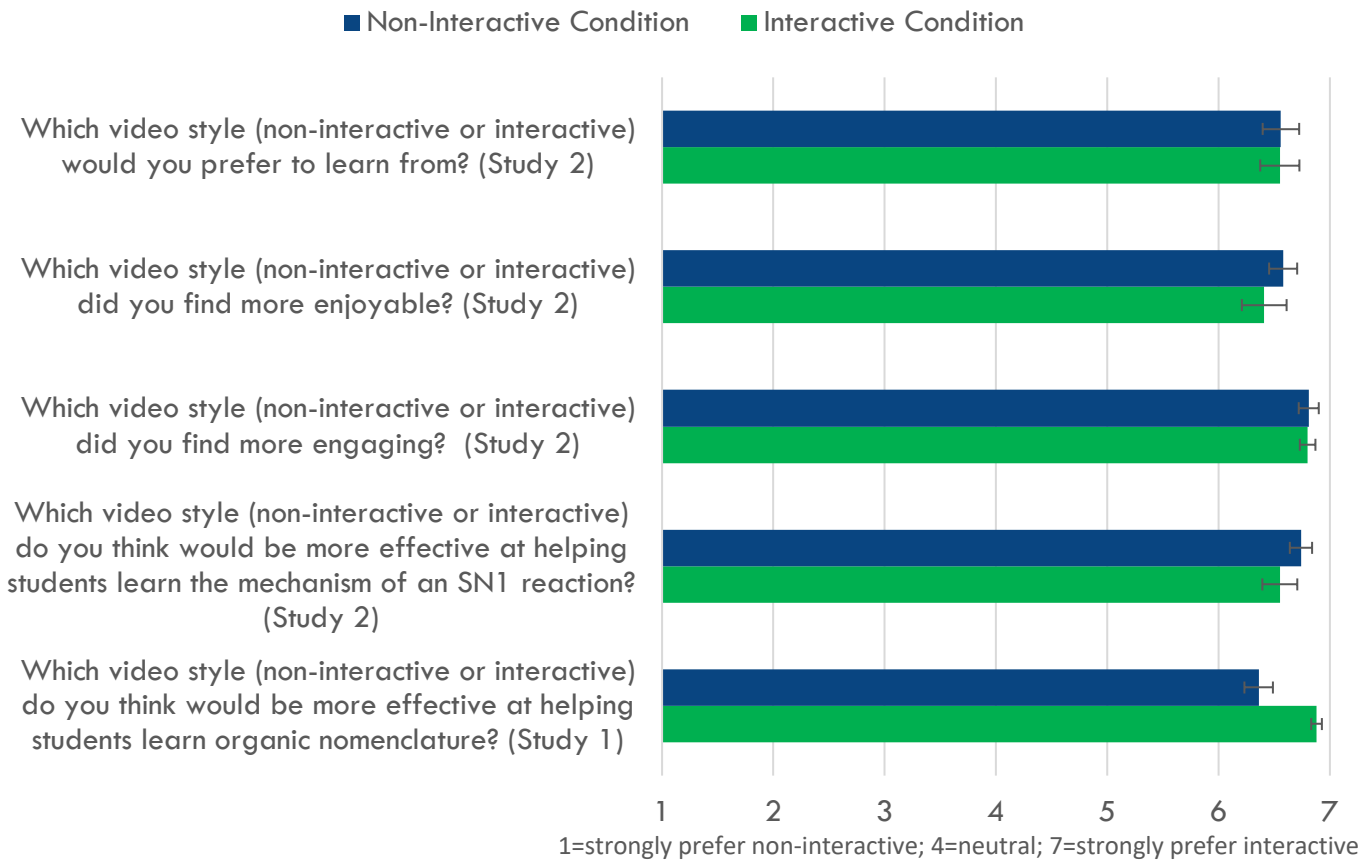

Figure 3: Student preferences for non-interactive vs interactive videos

(C) To help accommodate students with varying academic backgrounds, we incorporated optional expandable sections in the eChIRP that include either review of background material for students who may not have covered a pre-requisite topic in high school or enrichment for those who may want to study beyond the scope of the course.

We have some evidence that the eChIRP has been particularly helpful for students at risk of failing CHEM 123. For example, failure rates in CHEM 123 at Vantage College have dropped since the introduction of the eChIRP. In S2015 (before the introduction of the eChIRP), 9% of students failed. After a small pilot release of the organic in S2016 the failure rate dropped to 6%. In S2017 after the full organic half of the eChIRP was released, the failure rate decreased again to 4%. Finally, after the full pilot release of the eChIRP in S2018 the failure rate was just 1.5%. This trend suggests that having a resource such as the eChIRP may be helping more students successfully complete CHEM 123.

The early results of our interactive video study have also suggested that watching interactive videos instead of traditional videos can help significantly improve academic gains for students with midterm scores in the

lower quartile. We did not see any academic differences in watching interactive vs non-interactive videos for students in the top quartile.

(D) In a W2018 survey of CHEM 123 students (n=805), 68% indicated that the 3D models in the eChIRP helped them relate 2D representations of organic molecules on a page with their 3D shapes. One of our key motivations in creating an online textbook for CHEM 123 rather than a printed text was the ability to integrate 3D models, so it is promising that many students report finding these models helpful in improving their 3D visualization skills.

(E) Overall, in creating the eChIRP we aimed to provide a helpful resource for students to use when preparing for and reviewing course concepts. Based on survey results from W2016 (n=1102) and W2018 (n=1152), we can see that students primarily used the eChIRP to review after class, practice new concepts, read further on tricky concepts, and prepare for exams.

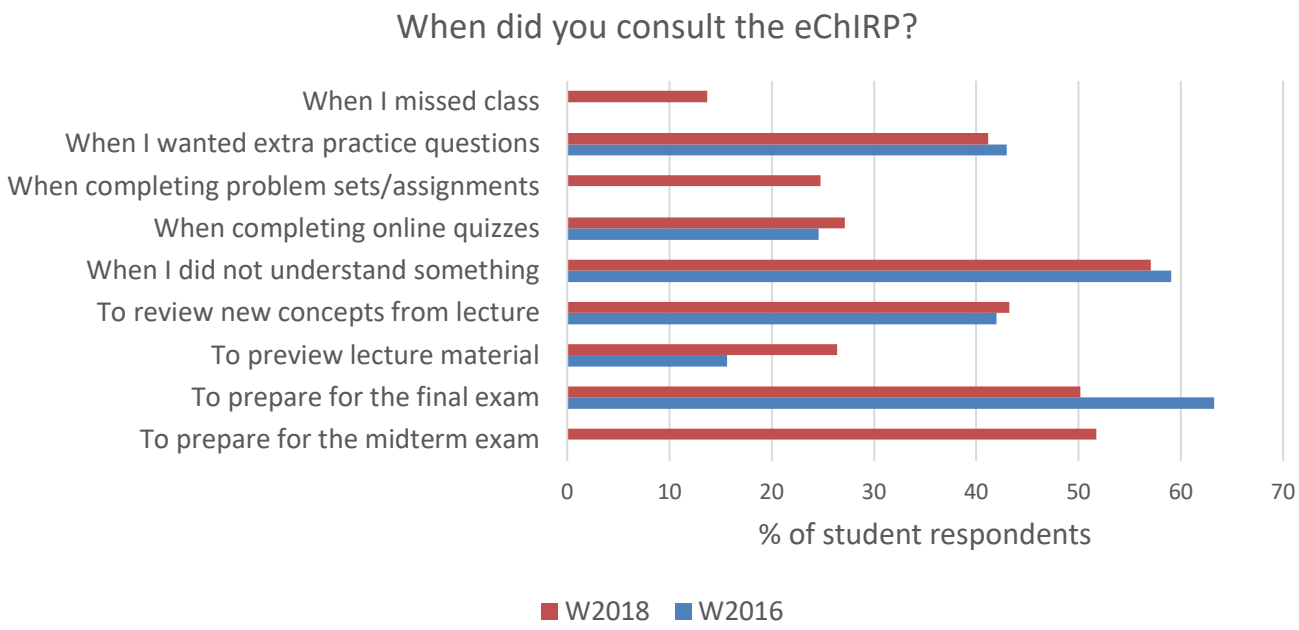

Figure 4: Self-reported eChIRP use

Our xAPI and usage data suggests that when self-reporting, students underestimate how much they use the eChIRP. For example, in W2018 69% of registered students consulted the eChIRP the day before the final exam, while only 50% self-reported that they used the eChIRP to prepare for the exam. The usage data does, though, indicate clear spikes in usage before exams. For example, in W2017 an average of 300 students used the eChIRP each day (approx. 20% of registered students) while up to 70% used the eChIRP just before exams. Figure 5 below shows the usage data from just before the CHEM 123 midterm exam until just after the final exam.

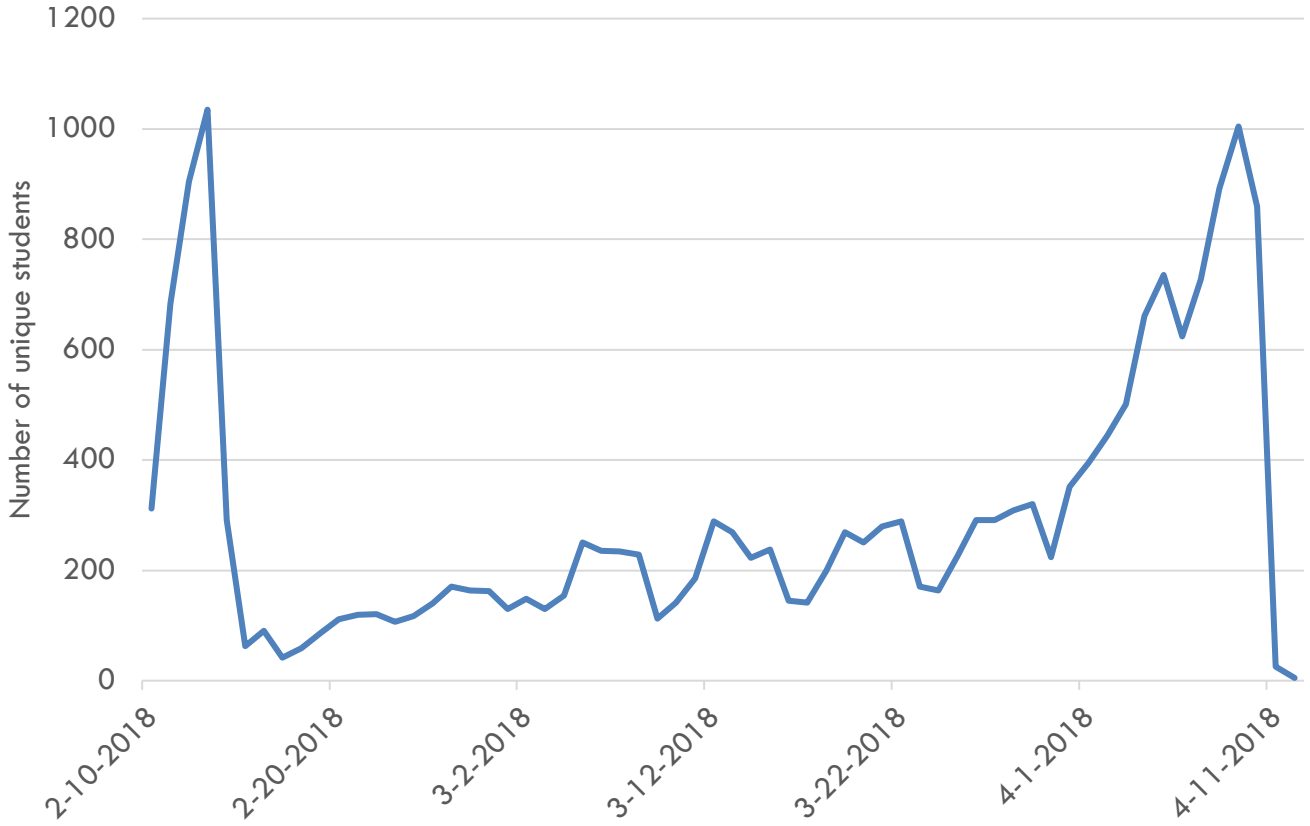

Figure 5: Unique eChIRP visitors in W2017 from just before the CHEM 123 midterm to after the final

Finally, in our W2016 survey of students (n=1102) we asked how helpful students found each component of the eChIRP on a scale of 0 = *very unhelpful* to 100 = *very helpful*. Pleasingly, students rated all components of the eChIRP as helpful (see Figure 6). Students reported the interactive components of the eChIRP (practice questions, 3D models, and interactive videos) as particularly helpful. These results help confirm that using an online platform to enable the use of interactive features has helped contribute to students finding the eChIRP helpful in CHEM 123.

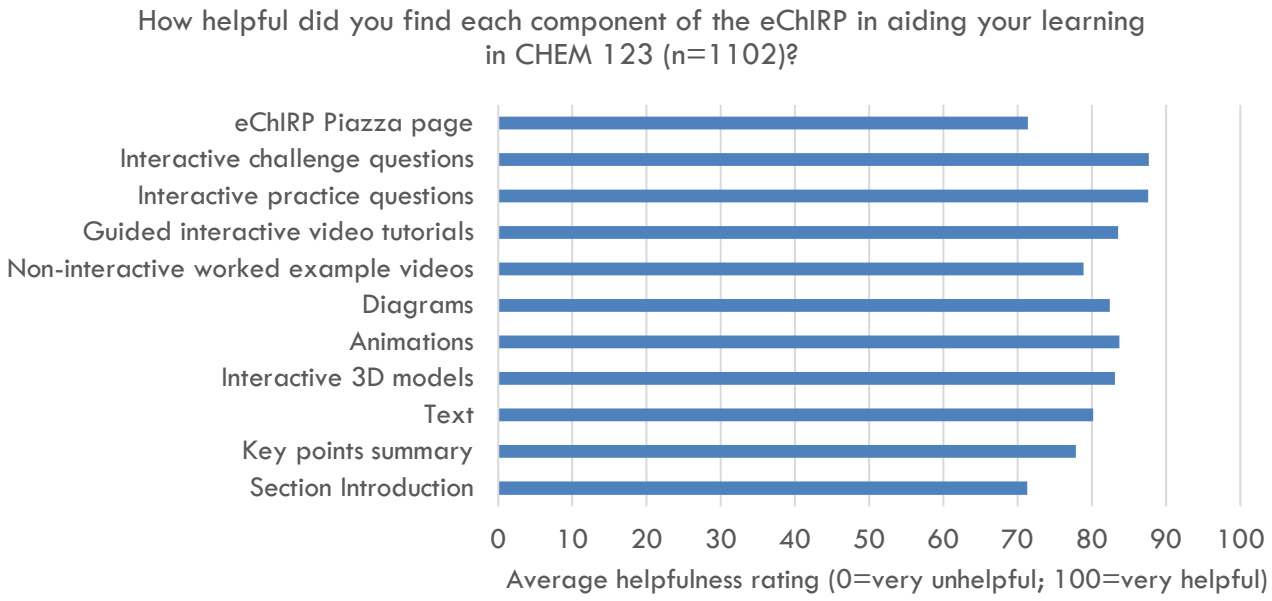

Figure 6: W2016 student-reported helpfulness of each eChIRP component

3.4. Dissemination – *Please provide a list of **past** and **upcoming** scholarly activities (e.g. publications, presentations, invited talks, etc.) in which you or anyone from your team have shared information regarding this project.*

Past

04/2019 Interactive videos to support active learning beyond the classroom (Kayli Johnson)

Presenter at UBC Science Education Open House

10/2018 Personalizing education to engage students from small groups to large first-year chemistry classes (Kayli Johnson)

Presentation at UBC Department of Chemistry Lectures in Modern Chemistry Series

05/2018 Interactive videos to support active learning beyond the classroom (Kayli Johnson)
Presentation at UBC-Okanagan Learning Conference

03/2018 Using h5p to create interactive practice question and interactive videos (Kayli Johnson)

Workshop at Shasta College, California, USA

12/2017 Electronic chemistry integrated resource package for CHEM 123 (Kayli Johnson)

Poster at UBC Teaching with Technology Showcase

08/2017 Active learning activities to bring evidence-based techniques into the classroom (Kayli Johnson)

Workshop at Shasta College, California, USA

Upcoming

Manuscript in preparation

Authors: Johnson, K.M., Lolliot, S.L., and Elouazizi, N.

Title: Adding interactivity to chemistry videos enhances engagement and perceived competency

Degree of completion: Studies complete and student survey data has been analyzed. Manuscript is in preparation. Waiting on further analysis of xAPI data (digitally recorded analytical data on student interactions with videos) before submission.

4. **TEACHING PRACTICES** – *Please indicate if **your** teaching practices or those of **others** have changed as a result of your project. If so, in what ways? Do you see these changes as sustainable over time? Why or why not?*

The main goal in creating the eChIRP was to change how students interact with course material outside of class time, rather than to change teaching practices. However, we did foresee the eChIRP as providing the opportunity for faculty to have the option to transition some knowledge transfer to out-of-class time.

I have used the videos created as part of the eChIRP project as pre-reading assignments in my section. Several course concepts in Chemistry 123 review standard high school topics that 70% of students have seen but 30% of students have not. This can make it very challenging to engage all students during lecture at the same time. By assigning a pre-reading assignment using the eChIRP, I have been able to ensure all students have base competency in a concept before coming to class. This has freed up time during class for more active learning activities and allowed me to dedicate more time to challenging topics. Faculty in all other sections of CHEM 123 refer their students to the eChIRP for pre-reading, review, and practice questions. Students across multiple sections do actively refer to the eChIRP on their own devices during class time to help clarify course concepts.

Chemistry 123 is a large, team-taught course with new or sessional faculty often cycling into the course. An additional benefit of the eChIRP is that it provides a clear outline of the breadth and depth of concepts covered in Chemistry 123, which is a valuable resource for incoming faculty and helps ensure consistency between sections.

5. **PROJECT SUSTAINMENT** – *Please describe the sustainment strategy for the project components. How will this be sustained and potentially expanded (e.g. over the next five years). What challenges do you foresee for achieving the expected long-term impacts listed above?*

The eChIRP was intended to be a living document, which can be continually adapted and updated based on feedback and curriculum changes. While the base of each eChIRP section is complete, we intend to continue to revise and expand these sections by improving explanations, adding additional details where feedback suggests

this might be helpful, and developing further practice questions each year. With the eChIRP existing on a WordPress site, this allows for easy maintenance and expansion of the material in the eChIRP.

Going forward, we will continue to collect live feedback from students via the 'feedback' section on each eChIRP page. I will continue to work with undergraduate student volunteers to monitor and make changes in response to this feedback. I will also reach out to the Chemistry 123 teaching team each year to solicit feedback on which sections require changes, additions, or revisions for the next course offering. Glenn Sammis and I will work with faculty assigned to teach Chemistry 123 to implement these updates.

The videos on the eChIRP are currently hosted via Kaltura, which is centrally supported by UBC. The eChIRP is currently hosted via WordPress on an eduCloud server. We intend to migrate the eChIRP to UBC's instance of WordPress once h5p support has been fully implemented to allow for more sustainable site maintenance.