UNIVERSITY OF TORONTO

INFORMATION TECHNOLOGY SERVICES

Instructional Technology Innovation Fund (ITIF) Final Report

Please note that excerpts of this report may be quoted or paraphrased in future U of T Communications from Academic & Collaborative Technologies (ACT).

Guidelines: Please provide responses of 100-250 words to each question area. At the end of this questionnaire we have provided additional space for you to enter information you feel is important but which exceeds the character limitation for a particular question.

Proposal title: Using 3-D Visualization Technology for Enhanced Student Learning
Your name: Shadi Dalili
Co-applicants:

Funding stream –Matched Funding

1. What were the main outcomes of the project? Please describe how you or your students used or applied the technological innovation in your teaching.
If relevant, explain how the project is aligned with the ongoing objectives of your program, department or division.

The goal of the project was to aid students in 3D visualization of molecules and their chemical transformation using 3D animations and an augmented reality (AR) app, called ARchemy. This tool helps students understand chemical interactions by using tactile AR markers to simulate molecular bonds in a 3D digital environment (to be displayed on a screen). Students in the 2nd year Intro Organic Chemistry I (CHMB41H) course at UofT Scarborough used these tools in three separate semesters, to visualize 2D molecules drawn on paper, in 3D. They performed a molecular modelling lab, using both the ARchemy app and traditional ball-and-stick molecular models. They then completed questionnaires to compare and assess the utility of these tools. Analysis of over 300 student responses show overwhelming support for the ARchemy app and its' ease of use, clarity, and ability to help students visualize molecules in 3D. (Data can be provided as charts upon request) Thus the main outcomes of the project have been that students can now visualize molecular conformations not only better and easier, but faster using devices they already use on a daily basis and without the need for textbooks or 2D images.

2. What were the main successes and challenges? Please describe any assessment or evaluation you have undertaken related to the implementation of the project or describe what

factors you considered in determining whether it was a success. Identify key challenges or barriers to success. Is there anything during the course of this project that you would do differently if you had the opportunity to start it over?

Students completed surveys and questionnaires administered through Quercus to evaluate the use of the ARchemy app compared to traditional modelling kits and the positive responses related to its ease of use, clarity, and helpfulness in visualizing in 3D all point to preliminary success of the app. Key challenges have been adding in more content and quizzing features into the app, which require significant developer time and funds. Other challenges faced are determining the best way to assess learning outcomes with this app and to have quantitative measurement of the learning (vs qualitative feedback).
If we could start over, it would be to build all the molecules and structures using the standard color scheme defined for organic structures to avoid redoing them again with the proper color scheme.

3. Who did you collaborate with? Please describe any collaborative work related to the project, especially student involvement and cooperation with colleagues at U of T or elsewhere.

Name: Maryam Abdinejad, PhD student
Academic Unit: Chemistry and Environmental Science, University of Toronto Scarborough
Role: Developing animations for key molecules and reactions of 2nd year organic chemistry courses; lending expertise in organic chemistry to 3D visualization expert and animator

Name: Hossain Samar Qorbani, PhD student
Academic Unit: Digital Media, Carleton University
Role: 3D visualisation expert, animator. Creating digital models of molecules and interactions, preparing digital content for Augmented Reality(AR) phase as well as adding this content into AR app.

Since this initial funding, we have been fortunate to obtain ITIF Support Stream funding and have been collaborating with MADLab and Michael Spears and Tamara Bahr to continue expansion of the app and its testing. They have done a fantastic job in developing the app into a beta testing version now available to all UofT users and implementing needed modifications to existing structures on the platform.

4. What types of supports did you use? Please describe how the project leveraged existing resources (people, institutionally supported tools) and mechanisms, as well as U of T educational technology supports.
If applicable, please comment on how your budget was applied: did distribution of costs change, did you exceed the projected budget or did your project get completed under-budget?

We collaborated with Hossein Qorbani, a 3D visualization expert and programmer to develop the codes for the different molecules and one of our own graduate students listed above for the 3D animations using 3D Max Software. Funds were used to pay for their time in development of the codes and programming into the app platform (Unity). No extra funds were used.

5. How did you share or showcase your project? Please comment on whether the project is shareable, modifiable (for example, through the use of open standards and Creative Commons licensing). Can you think of ways in which the innovation could be used in other disciplines? Are you aware of anyone else who has tried using the same or a similar technology as a result of you sharing your experience? Have you showcased your project (to colleagues or at events such as departmental meetings, conferences, etc.)?

The project is currently being beta-tested through the internal app release platform at UofT and has been tested by UofT students in the Introductory Organic Chemistry I course (CHMB41H) at UTSC. It is available both on iOS through Apple's Test Flight and also on Android devices. This project has the potential to turn into an Augmented Reality visual cyclopedia, starting with organic chemistry concepts and extending to other branches of chemistry (inorganic, organometallic) and even biological sciences for visualizing proteins and enzymes. Within the next 2 years, we anticipate that we will be able to add more than 180 fundamental molecules and their interactions into the AR app.

We are not aware of any other groups or projects similar to ours and we have shared the technology and app through well-attended presentations at conferences (101st and 102nd Canadian Chemistry Conference and Exhibition in 2018 and 2019 respectively), in the form of both oral and poster presentations (copies can be provided upon request), as well as at University of Toronto's AR/VR network.

6. Have you published the results of the ITIF funded project

- **Y** If Yes– please provide details
- No, not yet, but we had submitted a manuscript to a peer-reviewed journal (Journal of Chemical Education) which has gone through two sets of revisions, however has not yet been accepted due to the reviewers' criteria requiring us to fix color schemes of the molecules in the app/3D animations as well as needing quantitative evaluations of learning using the app.

7. Your overall experience with the ITIF award or any additional comments

We are extremely thankful for the valuable support the ITIF award has provided us for this unique project and the opportunities it has brought us to work with a talented and dedicated team at MADLab. We hope we will be able to secure future funding either through ITIF again or LEAF grants to continue and finish this project, such that it is an app that can be disseminated

widely to all the UofT community and across all the chemistry disciplines at different departments. We believe with further funding, we can complete the modifications necessary and requested by peer-reviewed journals, so that we may publish this work and bring further recognition to UofT for its novelty and application.