A new interactive learning tool - MolyPoly2

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Introduction

One of the hardest concepts for students studying organic chemistry is to be able to understand the spatial arrangement of atoms within a molecule (Al-Balushi & Al-Hajri, 2014, Ferk et al, 2003, Barnea & Dori, 1996). This submicroscopic level of chemistry allows a deeper understanding of the macroscopic properties of the chemicals around us. Several pedagogies have been used to learn spatial ability within chemistry where the combination of several visual aids - symbolic, 2D, 3D and computer animations (figure 1) including alignment between teaching materials has proven to have the greatest efficiency (Al-Balushi & Al-Hajri, 2014, O'Dwyer & Childs, 2014).

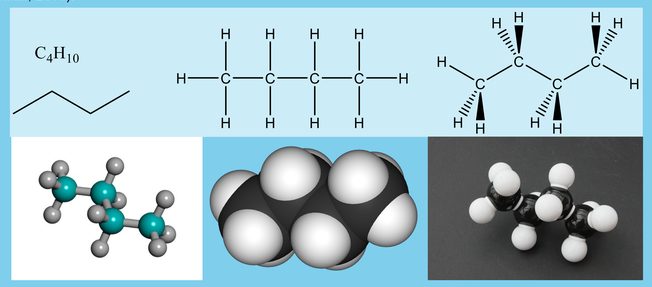


Figure 1: Representations of the same molecule— butane.

Many researchers have created or used new technologies to enhance the visuospatial ability and those using technologies that increase natural gestures and body movement have found it reduces the abstract relations thus decreasing the number of misconceptions conceived (Chinthammit *et al* 2015).

In previous studies undertaken at UTAS in collaboration with the HIT Lab in 2013 (under project codename "MolyPoly" [Chinthammit *et al* 2015]), students that used the 3D immersive environment (figure 2) without expert chemistry guidance instead of using physical models (figure 3) with expert guidance achieved the same visuo-spatial outcomes. This system had space and availability limitations as only one student at a time could use the specialised space that consisted of three large rear projection screens (figure 2).

Figure 2: 3D immersive environment for MolyPoly

Figure 3: Physical model kit used

To overcome these limitations other devices were investigated that could be used with a desktop or laptop computer but enabled the user to use natural gestures. The device that was available and subsequently tested through a summer scholarship in 2014 was the Leap Motion Controller (figure 4). This device through infrared cameras is able to map the user's fingers that are within eight cubic feet of it (figure 5 and 6).

Figure 4: Leap Motion Controller (Hay 2013)

Figure 5: Staff member using the Leap Motion Controller with a computer

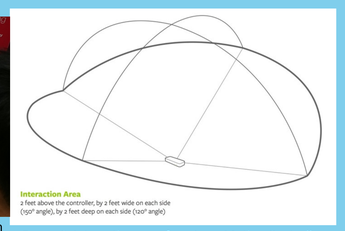


Figure 6: Interaction area for a Leap Motion Controller depicted in the centre (Colgan 2014)

Through the support of a Teaching Development Grant (2015), MolyPoly 2 was developed to incorporate a large range of molecules covered in a first year organic chemistry unit as well as the purchase of a class set of devices.

Figure 5 also shows MolyPoly2 being used by the staff member.

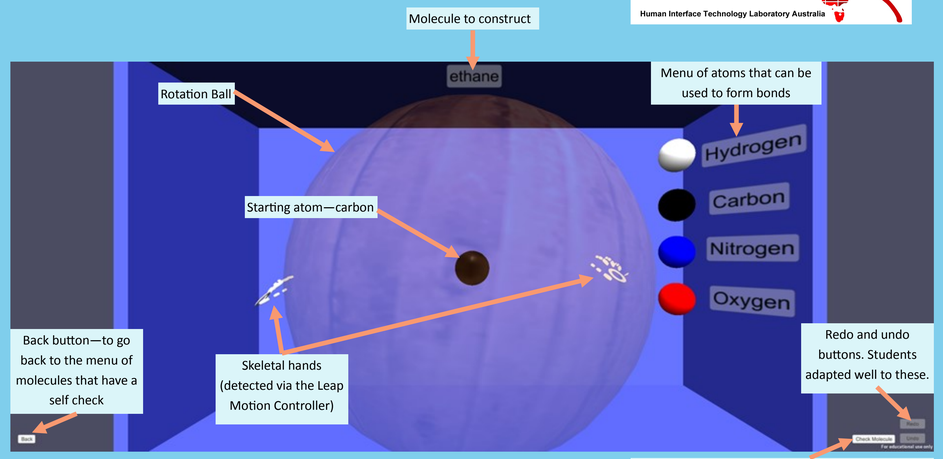


Figure 7: Screen View of MolyPoly

The key design was based on gesture control to build the molecules that would aid in spatial ability training therefore facilitating visuo-spatial reasoning and learning similar to what was achieved with MolyPoly in the HitLab (Figure 2). To enable this hand gestures are detected via the Leap Motion Controller and can be seen on the screen as skeletal hands

The Leap Motion Controller also allows the user to move in and out of the plane of the screen. A mouse will only manipulate an item within the 2D dimensions of the screen. The mouse can also be used with MolyPoly2 to select atoms (once the cursor is over the atom, left click and hold to move) and right click and move to rotate the molecule. The students were shown how both hardware worked and most used a combination from that point on. Using the combination actually allowed for more spatial ability training as the students could not easily bond atoms to bonds pointing into or out of the screen with a mouse reinforcing the 3D nature of the molecules.

Incorporating new technology into an existing unit

At the same time as the development of the system, the logistics and pedagogy of using the system were also being developed.

With the help of ITS personnel and timetabling officers, following a similar steps described to the right of the poster (the logistics of incorporating new technology into an existing unit) the system was available for use during the teaching period—semester 2.

For the students to become familiar with the new technology, more than one session using the system would be advantageous. For the number of face-to face sessions for the students to remain the same, the tutorial sessions were the best scheduled sessions to use. The activities that were previously used were then provided as practice activities for the students to do in their own time.

New activity sheets were developed introducing different aspects of MolyPoly2 that aligned with the different types of molecules introduced in other learning sessions. To begin with there was more time spent on learning how to use the system and then in later sessions activities were planned that showcased how MolyPoly2 could be used in different ways. These activities could be adapted to be used with plastic model kits when the student was off campus. Each activity sheet was also designed with the first part engaging the student in understanding the basics to be followed with an activity that would stretch their understanding as well as further activities that only a few would complete in the sessions but the others could do in their own time. The computer rooms and Leap Motion Controllers were available outside of scheduled sessions for students to continue their studies. Only a few students took up this opportunity in 2015 and 2016.

Initial Outcomes

As part of this unit, a diagnostic test was used to determine the level of understanding. This was updated to include slightly more questions to ascertain the students spatial awareness in context. To evaluate the amount of improvement the students had gained, the questions were completed again at the end of semester. The outcomes were recorded in 2015 and 2016. Overall students did better in their post-test. There was no significant different between students that regularly used MolyPoly2 or not. The group that used MolyPoly 2 regularly was self selected. The tutorials were not compulsory and after the first few tutorials the number of students attending halved and continued to decline to a third of students by the end of the semester in both years. The same trend had been observed in previous deliveries without MolyPoly2. Further analysis of individual questions and comparison with spatial ability activities undertaken at the start of semester 2016 will show how much visuo-spatial learning had taken place.

As part of the study (ethics approval No. H0015043) a usability survey was completed by most students at the end of the semester. In 2016, the first part of the survey asked students to indicate which tools they would use to answer particular exam style questions. The tools included mind only, pen and paper, model kit and MolyPoly2. The initial results show that students that attended regularly would use MolyPoly2 for more types of questions but would also use the model kits just as much. When asked 'Do you prefer using finger-based control (MolyPoly) than using physical molecular kit models in learning the structure of the chemistry molecules?' 36% agreed with associated comments: it was easier to use, easier to see the structure and ne student said 'After using MolyPoly, I didn't need to buy a model kit for the exam as I was able to see the structure in my mind'. 55% of responders stated that they would prefer to use the model kit as they were allowed in the exam, they liked the tactile feel of the models—'they felt more real' and it did not use a computer. There was a small percentage that liked both and one students that did not like either.

For the statement: Overall, MolyPoly helped improve my understanding of the molecular geometry of functional groups. 75% in 2015 and 60% in 2016 of students agreed or highly agreed. Comments from the question 'Please provide any other comments on your experience using the MolyPoly application?' were generally positive about MolyPoly—either suggesting that with further improvement it would become a highly valuable tool or having the experience using different learning tools was beneficial.

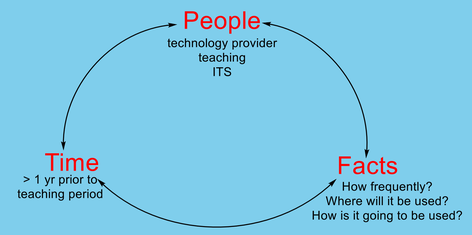
Further analysis of this data as well as the data collected when students used the system will be used to improve the actual system as well as how the system is integrated in the unit and other units.

The logistics of incorporating new technology into an existing unit

The Good, The Bad and The Ugly – a coordinator's perspective (S.Turland)

Over the last few years I have been lucky enough to have the opportunity to incorporate a few new technologies – web based learning systems and now a combination of new software and hardware, into different existing units. The first time many bad and ugly scenarios arose due to poor and unknown judgements. This year knowing what to plan with whom to reduce the number of unexpected outcomes made the experience for all a lot less stressful and enjoyable.

The steps used to incorporate a new technology



Getting the right people together

After deciding that a new technology is going to enhance your unit, contact Information Technology Services (ITS) with as many facts as you have to enquire about incorporating the new technology. If the provider of the technology is available a meeting between you, the provider (or their technologist) and a member from ITS is always advantageous.

After an initial meeting you can then get valuable feedback from your ITS member about how to go about incorporating the new technology into the learning spaces required. They will also be able to provide feedback in terms of what they would foresee working well and what problems might arise.

For example using an online learning tool may not work due the types of plugins it uses and how often they are required to be updated.

Having enough time

The above steps need to occur at least 1 year prior to the teaching period in which the technology is to be used. This leaves enough time for testing the combination of software, the drivers for new hardware, and understanding the intricacies around the new system.

This also allows for timetabling sessions in particular rooms - please contact your timetabling officer and/or the school or discipline if it is a dedicated room.

Knowing as many parameters as possible

Sharing how the technology is going to be used including where and if the session will be scheduled, how frequently it will be used—daily, weekly, fortnightly, once off will help the provider understand how their technology is going to used, the ITS member better understand if the system needs to work in only one room or if they maybe called upon by a student off campus for support.

Showing your team how you will be using the technology and what outcomes you are expecting will help them testing the system and also enabling them to give feedback about what they would foresee working well and what problems might arise.

After the initial period, the ITS might have a pilot system set-up for you to test. This a great time to test out the system in the same manner you perceive for the session during the unit. I have found it valuable to create screen captures after each step to improve a user guide and also have the sequence of events to share when things do not go to plan and can be sorted promptly. This can also be repeated when the system is ready to go before the teaching period for the unit.

During the teaching period

Being able to contact an ITS member that understands the system as well as being able to contact the provider if required will enable you to rectify most problems as they occur. This year with using a new hardware and drivers, the system tried to update the drivers. Within a classroom of 19 computers, four lost the drivers completely and a few others needed to be rebooted (shut down and restarted) - a scenario that was not expected but having a ITS member close by enabled the class to continue with little disturbance.

References

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