Chemistry Vlogs: a Vehicle for Student-Generated Representations and Explanations to Scaffold their Understanding of Structure - Property Relationships

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Abstract

Students in tertiary-level introductory chemistry courses often don't progress beyond poorly structured mental models of chemical concepts since these novice chemistry learners have little time to construct meaning or acquire representational competence during a 13-week content-rich semester. Additionally, many of these students are unmotivated, enrolled only because chemistry is a program requirement.

To encourage engagement, students were required to create 2-3 minute video blogs (vlogs) in which they explained the structure and properties of a molecule/substance that was personally relevant supported by a representation of the structure as a visual aid. The learning design drew on constructivist theories and aimed to enhance student engagement through developing a personal connection to chemistry. The aim was also to strengthen understanding of chemical structures through external representations and explanations.

Twenty-one students consented to analysis of their vlog content. A relationship was identified between the type of representations students adopted and the depth of their explanation. Students who had created and interacted with their hand-made physical models, using hand gestures to highlight features of their structural representation, produced higher-level explanations of structure – property relationships. Lower-level explanations were associated with students who used static graphical images sourced online. Factors related to chemical vocabulary and misconception diagnosis were also explored during analysis.

Introduction

Chemistry is founded on representations. Chemists (and more generally, scientists) utilise representations to depict or explain concepts and to expertly translate between 1D, 2D and 3D representations (Waldrip & Prain, 2012a; Hoffman, 1991). Chemists rely on two forms of representations in understanding concepts and chemical phenomena: internal representations (concepts, principles and mental models) and external representations (elemental symbols, chemical formulae, graphs and equations) (Kozma & Russell, 2005). Internal and external representations are inextricably linked so it cannot be assumed that one can directly influence the other (Zhang, 1997). The extant literature considering the role of internal and external representations is substantial and integrated with the role of models in teaching and learning science. The diverse range of models that teachers can draw upon in chemistry instruction illustrates the complexity of representations that students encounter (Harrison & Treagust, 2010; Harrison & Treagust, 1998).

One clear message that arises from published research is that student learning gains are greater when they generate their own representations than when they engage with those delivered by the instructor (Kozma & Russell, 2005; Wu & Puntambekar, 2012). The benefit of engaging with the construction and integration of multiple external representations is a deeper understanding of concepts and enhanced representational competencies (Harrison & Treagust, 1998). The processes of 'recognising the graphic conventions, manipulating spatial information provided by a molecular structure, and mentally tracking the constraints based on structure' have been identified as a series of cognitive operations in a spatial domain (Wu and Shah, 2004). Indeed, there has been a call for instructors to develop students' visuospatial skills to enhance their success in STEM disciplines (Harle & Towns, 2011).

Ideally, students should be exposed to opportunities to develop representational competence as part of learning progressions that extend over a number of years between secondary and tertiary contexts. The non-ideal situation is when tertiary students undertake an introductory-level chemistry course because they have not studied chemistry previously, or have experienced a substantial break since their prior studies. They are challenged with becoming literate in the symbolic and structural representations of chemistry in a single semester. In many ways, learning chemistry can be considered to be parallel to learning a new language. Thus novice learners need to have sufficient time to assimilate and apply different representations before retaining them in long-term memory (Johnstone, 1991). Introductory courses cover large volumes of content during a 13 week semester and students often have little time to focus on a single chemistry concept. Hence, it is unlikely that they will progress beyond poorly structured mental models of chemical concepts and poor representational competencies due to the time required to understand a new idea and integrate it with their preconceptions to construct new meaning (Driver & Easley, 1978). The challenge for the instructor in this situation is to provide an environment where students can acquire representational competence in parallel with constructing conceptual understanding.

Recent research (Hoban, Loughran, & Nielsen, 2011; Waldrip, Prain, & Carolan, 2010) indicates that engaging students in the triadic model of a sign (semiotic) system for representations in science (Peirce, 1931) offers a route to enable students to construct representational meaning. This model involves three interdependent aspects: the referrant (object/information), the representation, and the interpretant (meaning/concept). The associated explanations indicate the extent of student understanding of the semiotics and underlying concepts (Hoban et al., 2011). An additional consideration is the extent of the interaction with the representational model and evidence suggests that this may be enhanced if there is a haptic element such as kinesthetic manipulation (Bivall, Ainsworth, & Tiball, 2011). This aligns further with research indicating that students who interact with physical models (actional-operational) demonstrate better learning outcomes than those who engage with diagrams (visual-graphical) (Wu & Puntambekar, 2012; Dori & Barak, 2001).

We report here the outcomes of a case study where a video blog (vlog) assessment task was implemented into an introductory-level chemistry course with the aim of engaging students in external representations to support acquisition of chemical literacy and visualisation skills. Students were required to create and narrate a short video in which they were required to include a structural representation as a visual aid. This task was called a vlog task rather than a video task because it encapsulated the student's personal communication of a molecule/substance of personal relevance. Vlogs used in assessment have previously been described as a recorded video of the student speaking while thinking back across their practice or understanding (Parkes & Kajder, 2010). The vlog products of the task were evaluated to consider the nature of the external representation they adopted and level of understanding that students had demonstrated. The purpose of this study was to explore the question: To what extent does the requirement that students engage with a representational visual aid support their explanation of structure-property relationships? Several related questions emerged in terms of the type of visual aid students adopted, the manner in which students interacted with their visual aid and the level of their explanations.

Context

The context of this study was a large, first-year tertiary introductory chemistry course with an enrolment of 365 students in 2012. The enrolled students derived from twenty-seven separate programs of study, including science, arts, engineering, environmental management, health sciences, and exercise and nutrition science. The students typically possess multiple motivations for undertaking the course including: meeting the prerequisite entry requirements of subsequent chemistry courses; program requirements; or gaining some chemistry knowledge for the purpose of sitting medical program entry examinations. The students enrolled in this course have not studied high school chemistry previously or they have experienced a significant break in their studies and as such represent novice learners in chemistry.

The vlog assessment task was developed with the aim of engaging students with structural representations to explain the properties of a molecule or substance that was had a personal relevance for them. Students were required to produce a 2-3 minute video blog (vlog) and were provided with scaffolding in the form of a planning/running sheet template and explicit instructions for editing videos in Moviemaker or iMovie. They were required to appear in the vlog, even if briefly, to enhance personal relevance and authenticate their videos. Submission of the video was achieved by pasting the URL link (and password if required) into the assessment task window in Blackboard (the online learning management system) and attaching their planning sheet. Students were provided with the standards criteria assessment sheet at the beginning of the task and every video was viewed and marked by one academic. This task commenced in week 3 of semester with the aim of engaging students in chemical language and representations. Students were assessed according to a standards based criteria sheet (rubric) that was provided at the beginning of the task. The criteria included: planning (runsheet); communication and explanation; relevance of content; presentation and visual impact; and technical skills (including volume and clarity of sound).

Theoretical framework

In applying the triadic model of a sign (semiotic) system for representations in science (Peirce, 1931), Hoban et al. (2011) examined the processes involved in pre-service teachers generation of Slowmation animated videos. They identified a semiotic progression as the translation of meaning between different representations with multiple steps. Their students moved from the initial content they had researched (referrant) into a creating a storyboard, then generating and sequencing models (representations), taking photographs, and finally narration (interpretant) where they had made meaning of the sequence of their representations. In this study, students followed a similar progression: they sought background information in relation to their molecule/substance (referrant), planned the content and sequence of their video, constructed a visual aid (representation) and explained the structure with links to function in their vlog (interpretant).

Generating an explanation for themselves (self-explanation) is an integral component of the above process (Chi, de Leeuw, Chiu & LeVancher, 1994) in learning. Students are iteratively transferring between internal and external representations (Zhang, 1997) to develop an explanation of links between the structure and properties of the substance they have chosen. Their understanding of the concepts behind the external representations that they adopt becomes evident as they formulate an explanation to communicate to their perceived audience. In doing so, students translate their internal representations and understanding into the language of the audience (Prain, 2002; Yore & Treagust, 2006).

Methodology

In this Case Study, the impact of the intervention in the form of an assessment task was evaluated using data collected from: analysis of vlogs and visual aids as external representations (products of the assessment task) and student perceptions (online post-course questionnaire). Data were evaluated to explore the role of structural representations in supporting explanation and how students' constructed understanding through representation. The language and terminology used by students, and the perceived influence of the nature of the audience on this, was also considered.

Analysis of vlogs and visual aids

Informed consent was sought from participating students for researchers to review the content of their vlogs for the purposes of this study (institutional ethics approval was gained for all data collection) as part of completing the online questionnaire. Twenty-three students consented to their vlogs being reviewed at the end of semester; however two students subsequently removed access to their vlogs before they could be analysed. The subset of participants ($N = 21$) could be regarded as a representative sample of the whole class ($N = 343$) as there was no statistical difference between the mean of their scores and the overall class task scores when compared using a two-tailed t-test assuming unequal variances ($p = 0.11$; $t_{crit} = 2.1$).

Analysis of the videos was completed to evaluate whether there was evidence of any link between the representational models and the level of explanation that students generated. Two researchers separately analysed the contents of each vlog using a deductive coding scheme which was developed, in part, based on the outcomes of the adaptation of the triadic model for a semiotic system for representations in science

(Hoban et al., 2011) to measure students understanding of underlying science concepts. The content analysis included application of the categories: personal relevance, language, information processing, visual aid and explanation of structure which aligned with the assessment criteria that students had been provided with in the assessment criteria standards (rubric). As part of this analysis, three levels of explanation (Table 1) emerged inductively that were subsequently applied to categorise student explanations of structure-property relationships across all the vlogs.

Table 1: Three levels of explanation of structure and properties that were applied to categorise the student explanations in the vlogs

Level	Characteristics	Representational Competences (as per Kozma & Russell, 2005)
1	The structure is described in simple terms using enumeration such as the number of atoms of each type (in molecules) or number of electrons and orbitals (in atoms or ions).	(1) Representation as depiction. (2) Early symbolic skills.
2	The structure was used to explain a physical property such as the shape or polarity of the molecule.	(3) Syntactic use of formal representations. (4) Semantic use of formal representations (applying meaning).
3	The explanation of structure is extended to relate physical properties to the function of the molecule/substance, for example how shape affects binding in a receptor site, solvency or material properties	(5) Reflective rhetorical use of representations.

The categories that emerged were subsequently recognised as aligning with the five levels of representational competence (Kozma & Russell, 2005). The highest-level explanation required that the student was applying their understanding of structure to explain properties in the context that made the molecule/substance relevant to them rather than a generalisation.

The visual aid adopted by students to support their explanations was also categorised according to whether it was a student-generated, actional-operational physical model (hand-made or hand-drawn), or visual-graphical (static printed diagrams or animations sourced online) (Wu & Puntambeker, 2012).

Online questionnaire

The online questionnaire (N = 43, 12% completion) was delivered post-semester through Survey Monkey and contained both items involving Likert scales (learning gains, confidence, perceptions) and open-response questions. The Likert scale items were adapted from the ‘Student assessment of learning gains (SALG)’ instrument, a validated tool for obtaining information on students’ assessment of learning gains and their perceptions on how important aspects of a course are to their learning (Seymour, Wiese, Hunter & Daffinrud, 2000). Open questions asked students to consider the elements of the task that had supported their learning. The aim of our online questionnaire was to explore whether the students had recognised the learning objectives of the vlog assessment task and to what extent the process of the task had enabled them to make any learning gains.

Results and Discussion

Acquisition of chemical literacy and representational competence is very challenging for students in learning environments where chemistry is taught intensively. Students need time to be situated in applications of concepts and be exposed to multiple external representations to develop their mental models. The role of vlogs as a vehicle for enhancing student understanding of chemistry concepts and developing their representational competences by generating explanations was explored in this study. The outcomes from the task have been considered from three perspectives: student acquisition and application of chemical language and terminology; student representation of structures; and student explanations, including the impact of their perceived audience. Overall learning outcomes and students' perspectives of their learning gains were also explored.

Student acquisition and application of chemical language and terminology

The learning objectives for students as a result of the vlog task included anticipated gains in chemical literacy through application of the vocabulary and terminology surrounding explanation of structures and related properties. Students were required to research information to determine the structure-property relationship for a personally relevant substance or molecule. Task assessment weighted the evidence of significant information retrieval as up to 25% of the available marks in comparison to the explanation supported by the use of the visual aid (50%). Thus the focus of assessment was on students translating their information into representations and explanation.

When asked to indicate which aspect of the task had enhanced their learning in chemistry, 60% of questionnaire respondents indicated that it was through researching background information (Figure 1). Fewer than a quarter of students perceived that the use of a visual aid or explaining the structure had been useful in enhancing their learning.

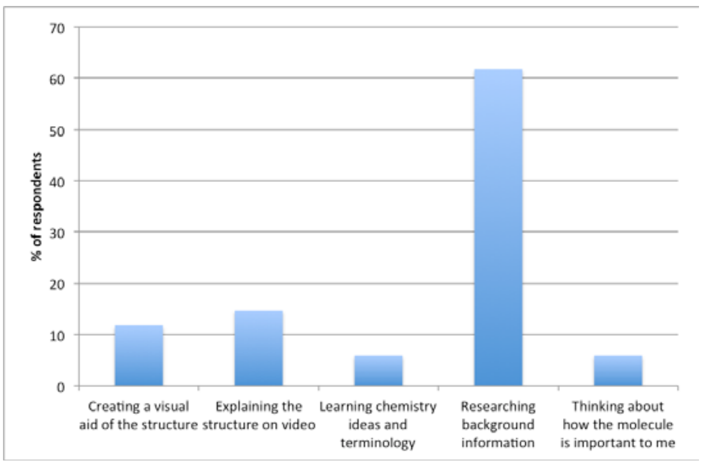

Figure 1: Aspect of the vlog task that students perceived had enhanced their learning in chemistry.

The process of researching information is independent of either the creative process of building a model or the personal relevance of the chosen molecule/substance, and is likely to be associated with surface learning of the information. Creative processes, such as engaging with a physical model, are known to promote deep learning approaches to understanding information (Dori & Barak, 2001). Deeper learning approaches have been found to correlate with higher-quality learning outcomes as they involve active construction of meaning, whereas a surface approach to learning is oriented towards the passive reproduction of information (Ramsden, 2003; Harrison & Treagust, 2010; Biggs & Tang, 2007). Deeper learning also requires the learner to forge connections between pre-existing and new knowledge, which results in improved understanding and retention of information (Houghton, 2004).

The learning approach adopted by each student is not a fixed characteristic of the individual, but rather reflects a choice made in a particular context, especially in relation to the nature of an assessment task (Biggs & Tang, 2007; Ramsden, 2003). Strategies that encourage students to adopt a deep approach include encouraging active engagement with learning tasks (e.g. creative production), assessment which rewards students for understanding and making connections; encouraging students to make connections between the real world and what they already know, and providing students with reasonable choices about what and how they will learn (IML, n.d.). All of these strategies played a role in the vlog task presented in this study.

Students who perceived that researching the background information had been the most beneficial to their learning were still able to generate high quality videos involving static image representations (visual-graphic) supported by detailed explanations. However, these explanations often comprised passive information transmission with no clear evidence that the student had understood the underlying concepts. Several examples were present amongst vlogs where in-depth research by the student was evident through the complexity of information; however, they had made a simple error in their explanation revealing a misconception. This confirms that these students had typically adopted a surface learning approach during the task.

Students who recognised that the process of producing and using a model to explain the structure and properties of their molecule had helped their learning were typically those that generated higher level explanations in their vlogs (discussed in more detail below). This indicated such students had adopted a deeper approach to learning, which in turn had led to improved understanding of the concept. It is clear that there is an opportunity for instructors to support students in developing a deeper understanding by explicitly making them aware of the links between learning and creating models at the start of the assessment task.

Representation of structures

External representations can become a scaffold for thinking and understanding if students have been involved in its construction (Waldrip et al., 2010; Hoban et al., 2011). The resulting explanations, where students interpret their representation and assign meaning, provide important insights into the depth and accuracy of their understanding. In their vlogs, students adopted a wide range of representations of structural models as their visual aids included web-sourced static and dynamic images (Figure 2a &b), hand-drawn structures (Figure 2c) and models that they themselves had created (Figure 2d). Examples of each were identified in the participant subset of the cohort. There were multiple examples of 1D (chemical formulae), 2D (hand drawn structures and printed images) and 3D (hand constructed physical models and virtual pseudo-3D models) representations amongst the visual aids adopted by students.

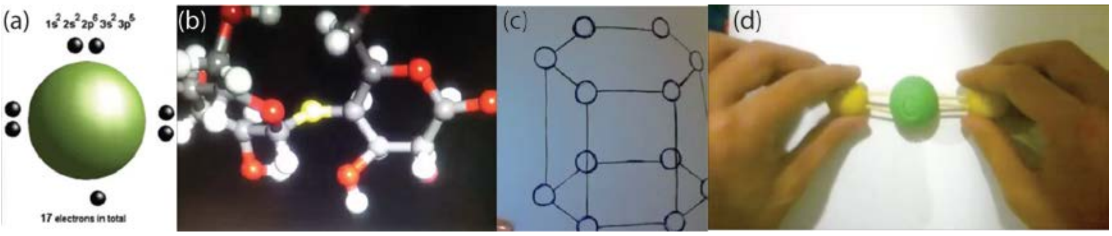

Figure 2: Examples of the visual aids adopted by students in the vlog task. (a) Static images sourced online. (b) Three-dimensional dynamic images sourced online. (c) Hand drawn structures created by the student. (d) Handmade physical models created by the student

The role of structural representations in explanation

Each of the participant student's vlogs was analysed for the level of explanation and the type of representation they used as a visual aid, as categorised above. Analysis of twenty-one vlogs revealed that all except one of the student explanations could be divided into three levels (Table 1), according to the use of a visual aid in the form of a representation of the structure of the substance/molecule. The single exception was where a student had used a hybrid combination of representations and was characterised as a level 2 explanation. Analysis of the videos of the participating students revealed a relationship between higher-level explanations in vlogs and the type of student-generated physical representations (Figure 3), which were either a hand-drawn structure or a physical structural model (actional-operational). Lower level explanations were characterised by the use of embedded static online images as the visual aid (visual-graphical).

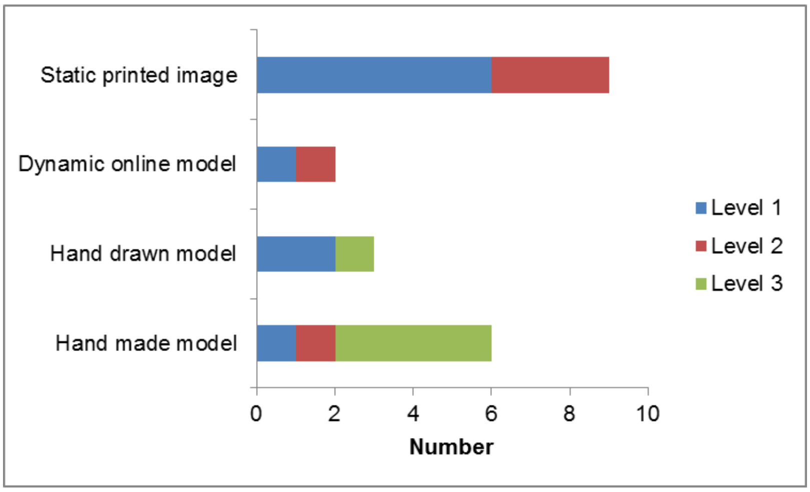

Figure 3: The relationship between the type of the structural representation used as a visual aid and the level of explanation evident in student vlogs

The majority of students in the class adopted an approach where they described static visual-graphical images embedded in their video and these images had evidently been sourced online, probably encountered during the process of information retrieval. Their engagement with their visual aids was typically more passive than those who adopted physical models and resulted in lower level explanations. The students who opted to enhance their explanations through real-time interaction with a physical model that they had created as their visual aid generated higher-level explanations. Further, the most effective use of the visual aid in translated meaning was observed when students supported their explanations through hand gestures regardless of whether they were using a physical model, a hand drawn or static image (Figure 4).

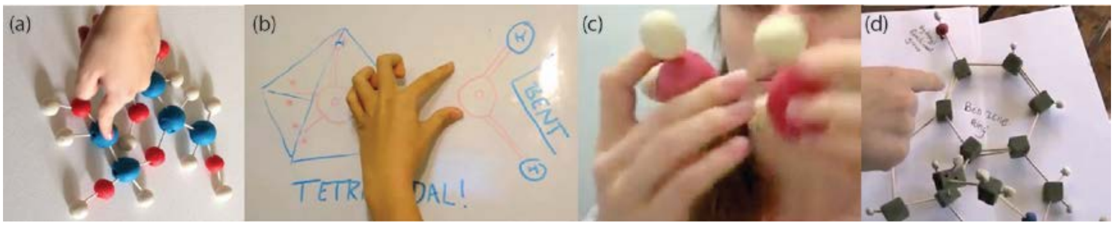

Figure 4: Examples of the role of hand gestures with visual aids adopted by students in the vlog task. (a) Indicating the identity of atoms. (b) Explaining molecule shape. (c) Re-enacting the interactions between molecules. (d) Assigning functionality and linking to function.

Physical models or hand drawn structures both represent actional-operational representations (Wu & Puntambekar, 2012) and enabled students to use gestures to interact with their model to highlight the feature that they were explaining at the time. Examples of these interactions in vlogs included identifying atoms within a structure (Fig 4a) or how lone pairs of electrons influenced molecular structure and polarity (Fig 4b). In another vlog, a real-time demonstration of the interaction between two hand-held clay water molecules (Fig 4c) was used to enhance the explanation of intermolecular forces. The highest level explanations involved clear links between structure and function, as evidenced by the three-dimensional ball and stick model in Figure 4d where the student identified the different shapes of regions of the molecule and explained how these interacted with receptor sites in the action of morphine.

The role of physical structural models, built by students, in providing a concrete, experience that is linked to higher order cognitive learning was reported four decades ago (Talley, 1973). While it is known that this type of representation provides a concrete, kinaesthetic experience, there have been few reported studies that examine the relationship between the process of construction and conceptual learning gains. One key example is where students who engaged in constructing plastic molecular models in parallel with virtual models demonstrated better understanding and spatial ability than students in a control group exposed to graphical representations (Dori & Barak, 2001). There are numerous studies that examine the role of hand drawn representations providing evidence that the process of drawing enhances understanding in science (Ainsworth, Prain, & Tytler, 2011) and that chemists explain and understand structures better when they draw them by hand (Kozma, Chin, Russell, & Marx, 2000).

The results of the current study contribute further evidence that active engagement with external representational models, particularly in a kinaesthetic way (hand gestures and/or drawing), promotes a deeper-understanding of concepts. Students' explanations of their representations also provide insights into their internal mental models and highlights emerging misconceptions.

Construction of understanding through representations

The ability to translate between internal representations such as mental models and external representations such as chemical structures is known as 'visualisation' and forms a characteristic trait of deeper understanding in chemistry (Gilbert, 2008).

In the majority of videos submitted by students they simply gave a descriptive enumeration of atoms and their arrangement in a structure (a level 1 explanation involving syntactic use of chemistry terminology).

> *Glucose is composed of six carbon, six oxygen and 12 hydrogen atoms meaning that it is part of a hexose carbohydrate family. [00:32 VT09 glucose]*

> *the ring is six sided yet as you can see here only five of its six corners are carbon atoms while the sixth is an oxygen. The carbon atom that is outside of the ring is also the only carbon with two hydrogens attached as well as a hydroxide group. But ultimately the backbone of the molecule is hydrogen atoms which are either attached directly to a carbon atom or attached via an oxygen at an angle as a hydroxide group.' [01:28 VT12 glucose]*

> *As can be seen the elements in caffeine are bonded covalently some forming double bonds in order to fill the outer circle of electrons for all elements. [01:02 VT07 caffeine]*

Examples of the level 3 explanations amongst the sample videos contained clear evidence of deeper understanding supported by the student's interaction with their physical structural models (Table 2). Students applied concepts relating to structure to explain the function of the substance that made it personally relevant to them.

Indeed the student-generated explanations, which reflected their process of translating between referrants (information), their representations of structure and their narration provided the instructors with a mechanism for gaining insight into their understanding. It became apparent during analysis of the videos (and assessment of the vlogs for the whole class) that it was possible to identify emerging misconceptions held by students, including: an inability to discriminate between the structure of an atom and that of an ion; inability to discriminate between intramolecular bonding and intermolecular forces; and that energy was conceived as an entity; examples are provided in Table 3.

Table 2: Evidence of deeper understanding in explanations associated with active engagement with the structural representation.

Molecule/ Substance	Representation	Explanation
Water	Hand drawn structures on whiteboard (Fig 4b)	*these lone pairs are very negative and want to stay away from each other as much as possible. These repulsive forces act to push the hydrogens closer together. [02:05] Ice floats because hydrogen bonds hold water molecules further apart in a solid than a liquid [01:11] VT16*
	Clay ball and stick models (Fig 4c)	*The dipolar attraction …. Is known as hydrogen bonding and gives water its characteristic of surface tension. Surface tension is an attractive force which pulls molecules together [01:36]VT15*
Morphine	Hand made ball and stick model (Fig 4d)	*on its own morphine is not very soluble in water, pharmaceutical companies combine it with hydrochloric acid to make it into a salt. The proton binds to the nitrogen making the morphine a positively charged ion, this increases water solubility and makes it more suitable for injections [01:17] … for example the benzene group fits into a flat section of the receptor, and the positively charged piperidine group fits into a negatively charged spot in the receptor. [01:57] VT21*

The external representations used to support the explanations added the dimension of making student thinking visible for instructors and enhanced the ability for diagnosis of any misconceptions which could then be responded to during instruction. Four out of the five examples cited in Table 3 involved students adopting 2D representations or visual-graphical images to support their explanations. Students enrolled in this course had not previously studied chemistry, and therefore the misconceptions relating to ions and bonding are unlikely to have been pre-existing. The misconception relating to energy is known to develop during primary science learning when students first encounter concepts in energy (Wiser, Smith & Doubler, 2012).

When asked in the online questionnaire which aspect of the vlog assessment task had been most useful to their learning students most commonly responded with "researching background information" (Figure 1). Their chemistry misconceptions are likely to have been developed during the process of researching the task and, combined with the lack of active engagement with their representation when explaining, they were not able to transfer information and construct a correct understanding.

Table 3: Misconceptions identified in student explanations and the evidence that was used to identify the misconception

Misconception	Evidence	Explanation
Non-discrimination between atoms and ions in different structures and environments	The application of the metal lattice structure (Fig 1c) to explain the strength of bone and substitution of calcium in nerve tissue.	*The atomic structure of magnesium is a hexagonal crystal lattice structure that is closely-packed (shows structure). [00:55] … nearly two thirds of all the magnesium in the body is found in the bone. The closely packed lattice structure that I've shown you before here (shows structure) of the structure of magnesium is strong enough to provide scaffolding for the bone[01:40] VT06*
	Example of sodium chloride applied after explanation of how elemental chlorine gas irritates membranes in body.	*Together with sodium and potassium, chlorine carries an electrical charge when dissolved in body fluids, these elements are called electrolytes. …. [00:30] Chlorine is a non metal chemical element. …. [01:15] In a 60 kg person there is 81 g of chlorine …. [02:08] When chlorine comes into contact with moist tissues such as eyes, throat and lungs, an acid is produced …. [00:15] VT10*
Intramolecular covalent bonds are explained as hydrogen bonds	The covalent bond between H-F identified as a hydrogen bond.	*And when these two atoms bond, hydrogen shares its one electron in its first orbital with fluorine and this results in both atoms outer valence shells completely full. This is called a hydrogen bond which is a very strong bond and when it polymerises it forms chains such as* H_2F_2 *and* H_6F_6*. This creates a really strong inter-chain attraction [02:45 VT13]*
	The bond connecting glucose monomers together in polysaccharides identified as a hydrogen bond (Fig 1b in yellow).	*Plants store their energy in the form of cellulose and starch, both are polysaccharides made up of a string of glucose molecules formed through hydrogen bonds. This is showing how glucose link together to form cellulose. [02:00 VT09]*
Energy conceptualized as a physical entity	Energy in the form a product in the cellular respiration reaction remains available for use.	*When one of our cells needs energy, it takes some of that glucose and oxygen from within our bloodstream to form a chemical reaction that results in energy, carbon dioxide and water. This energy can then be used to power the cell leaving the other two resultants to be disposed of [01:06 VT09]*

Recent research indicates that actually engaging students with their representations in discussion and encouraging re-representation enhances the construction of conceptual models and this could be a valuable extension of the outcomes of the vlog task in course activities (Waldrip & Prain, 2012b).

Interestingly though, in a separate item on the questionnaire asking students to reflect on which aspect of the course overall had been the most effective in helping them to learn how the structure of a molecule is related to a function, two students identified the course workshops involved construction of plastic Molymod organic molecules as physical models in combination with JMol 3D virtual models.

> *Creating visual and especially physical models in workshops helped the most.*
>
> *Workshops. Because the structures of molecules was learned through a hands-on experience, where a model of a molecule was physically constructed.*

Perceptions of the audience

While students were constructing their vlogs, they were aware that the audience was their instructor but were advised that their explanation should be directed towards an audience of peers. The audience which students write for is important as it impacts the cognitive processes used and affects their learning (Hillocks, 1986; Gunel, Hand & McDermott, 2009). Students were required to firstly translate the language of science into their everyday language in order to understand the concept (self-explaining). Secondly, students then translate the meaning they understand into the language of their perceived audience (Prain, 2002; Yore and Treagust, 2006). Additional cognitive processes are involved in this approach, which ultimately leads to better learning (Gunel et al., 2009).

The task required that student vlogs, while uploaded to Youtube or Vimeo, were set as private or restricted and so could not be accessed publicly. This reassured many students, who expressed concern that someone other than the instructor could potentially view their vlogs. To explore this apparent reticence to extend the audience for their vlogs, several items were included in the online questionnaire in the form of a four point Likert scale (Figure 5).

Overall, participants were not happy for other students to view their videos, with only 26% indicating they would be happy to share their vlog with other students as part of assessment, if peer assessment was used. Peer assessment has been considered as a mechanism to providing feedback and as a strategy to deal with increasing student numbers in undergraduate classes.

Little exists in the literature in relation to students' attitudes towards allowing peers to review their assessment tasks (Hanrahan & Isaacs, 2001). Of respondents, 37% did not want to share their vlog with other students and preferred only the instructor to view to their video. The reasons given by participants in this study for not wanting to share their video were not based on assessment issues, but rather they were hesitant for their peers to see them on video:

> *I don't really mind. I suppose if I did better in it, I'd feel more confident in sharing it. Then again, no one ever likes watching themselves perform.*

I would feel embarrassed about sharing my video.

We don't let other students just out written essays in public forums, why should they now be able to judge not only the quality of our assessment, but also our appearance. In this instance public judgement whether good or bad is not necessary because we are not singers, musicians etc our work is not aimed at public enjoyment.

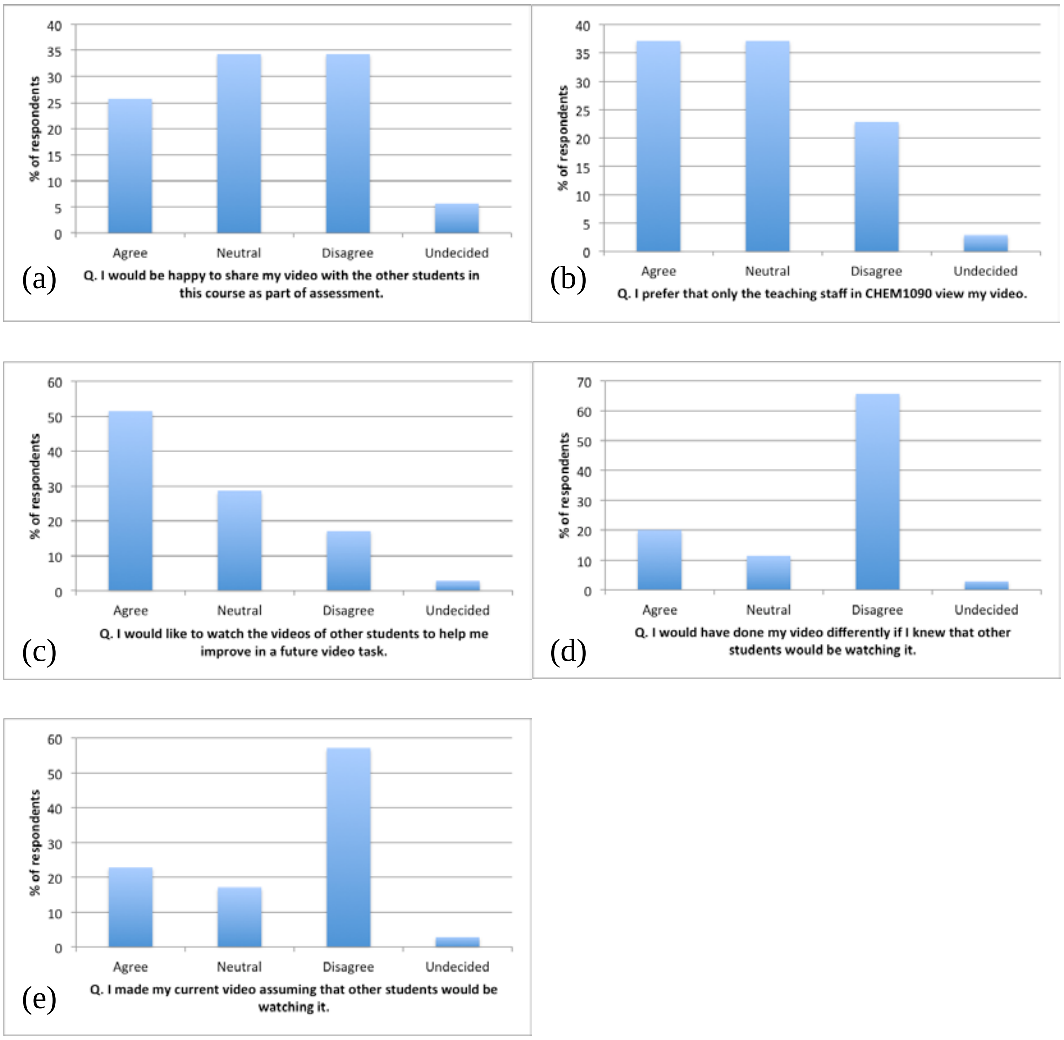

Figure 5: Student perceptions in relation to their audience. (a) in regard to sharing with other students in the course, (b) in regard to the only access being by teaching staff, (c) in regard to feedback by viewing other student's vlogs, (d) & (e) in regard to how they constructed their vlog based on perceived audience

Several participants commented they felt there was value in sharing vlogs between peers, demonstrating they recognized this was a potential learning tool:

I made my current video assuming that other students would be watching it. I believe students viewing videos from previous years which gained high marks would greatly help them gain an understanding on how to create a good vlog.

I am neutral – I feel like providing students with example videos will take away the learning experience because then they are able to just replicate other videos however, if the videos were made available after the due date for everyone to view it would show how your learning experience differs from others.

I would love to view others videos – it would be interesting to see others, as well as learn from others videos and the information that they present.

However, 51% of these students wished to view other student's videos to gain feedback.

Most participants (57%) assumed that other students wouldn't be watching their video when they made it, but, interestingly, at the same time they wouldn't have done their video differently if they had known other students would be watching it.

Learning Outcomes

Evaluation of participant student's videos revealed a range of learning outcomes in terms of relationships between structure and properties/functions. Students were asked 'Was there any particular aspect of using/making this visual aid that helped you better understand the structure of your molecule/substance?' in the online questionnaire at the end of semester and several clearly recognised the role the representation had played in constructing their understanding.

I used an animation video which was created by an IT colleague. I am very much a visual learner and by using an IT student I was able to explain what functionality the animation needed to display. With having to explain the structure and function of the molecule to a lay person it also made it easier for me to understand when I was providing the training rather than receiving the training.

There were students who felt that engaging use of a visual aid was not supportive.

I used an image I found on google. As I learn through listening and writing, visual aids do very little to assist my learning.

Other students did not appear to recognise the role that translating information had played in creation of their visual aid:

Playdough ball and stick model. It did not enhance my understanding of the structure further as I already understood it well.

When asked to respond to the question 'On reflection, was this a useful learning activity in first year chemistry?' students were divided, with 44% of respondents stating 'yes' and 38% stating 'no' (Table 4).

Table 4: Examples of student responses to question: 'On reflection, was this a useful learning activity in first year chemistry? Please comment on the way it was/was not useful'

Category	Response
Positive	*'Yes - I'm now an expert on water! It was useful because by understanding one molecule comprehensively I am now able to apply that learning skill to other chemistry learning activities. It has provided a new way of studying and learning.'* *'I think the Vlog was useful in that it encouraged research, improved learning by making us explain the molecules structure and function. Teaching others is often a very effective way of learning. The downside was that the technical aspect of it did take up some time, and if you wanted to perform well you had to put in a considerable amount of work.'* *'I really enjoyed the process of researching about the element and its properties as well as what it does in reference to being relevant to myself'*
Negative	*'Not particularly, it was only useful for learning about particular molecules. Not chemistry overall.'* *'No it was a ridiculous assignment and I do not know how it passes as a university assignment. I whole heartedly believe more would have been learnt writing an essay, and presenting it orally rather then wasting time editing a video - in a science course.'* *'No. A lot of time was required to complete it, could have acquired the same results from a written assessment of much shorter time. The concepts were simple to understand after a few hours of research, the difficult part was making the video, not a chemistry technique!'* *'I found it useless. I dont find vlog skills will benefit me in the future. If we would of had weekly assignments or more tutorials or even more pass classes i could obtain a better grasp of the subject. i found it was too much for one semester.'*

Several students raised the issue that the process of making a video had been very time consuming and was a skill that was new to them. The negative responses (Table 4) indicated that many did not value acquisition of that skill as part of a science course.

Summary

The role of videos in enhancing student understanding and communication of chemistry concepts was considered from three perspectives – student acquisition and application of chemical language and terminology; external representation of structures; and the nature of the audience for their explanations in the form of videos. Overall learning outcomes and students' perspectives of their learning gains were also explored.

This paper provides evidence that students who engaged in creating physical or hand-made structured representations, and then engaged with these models to support their explanations in videos, demonstrated a better understanding of related concepts, supporting the existing literature that active engagement with material encourages students to adopt a deeper learning approach. Students who actively engaged with their representations, such as through use of hand gestures, produced higher-level explanations, whereas lower-level explanations could be associated with the use of static images (visual-graphical representations) sourced online. This also aligns with previous research whereby the process of translating meaning between the referrant (background information); representation (visual aids and structures) and interpretant (narration) was enhanced through the creative process (Hoban et al., 2011). While the process of creating a video initially daunted many students, the provision of scaffolding in technical skills enabled them to overcome this apprehension and they recognised and valued the learning outcomes of the task. Additional research is required to further explore the relationship between hand gestures and explanations of representations.

Not all students recognised that it was the process of creating and actively engaging with the model that aided their learning the most. Many students responded that researching the background information had been most useful to their learning, although in some cases this contradicts with their answers in other survey questions. For example, some of these students, when asked which aspect of the course overall had been most beneficial to their learning, had answered with the workshops, explaining it was because they had been able to engage with hands-on physical models to construct understanding. This demonstrates that they recognised the importance of models with learning but had not explicitly made the connection for this task.

Overall, students were divided in opinion in regard to whether or not the vlog assessment task had been a useful learning activity. Most of the students who had not found the activity useful had not actively engaged with their representational models or had not recognised the role and importance that the process of translating information to create their model had played. From an instructor's perspective there were multiple benefits for student learning as a result of the task including deeper learning through engagement with multiple representations and generation of visual aids and insights into emerging misconceptions.

Implications for practice

The outcomes from this study indicate that instructors can increase student awareness of their thinking and the role of representations in developing their mental models. To create richer learning activities, instructors can:

- Explicitly raise students awareness of the role that generating models and external representations in support of explanations has on their learning at the start of the assessment task.
- Support students in developing a deeper understanding of the role of representations in science through modelling explanations supported by multiple external representations.
- Enhanced assessment criteria can be developed based on the outcomes of this study for tasks of this format to enhance the focus on deeper learning through engagement with representations.

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