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Chemtunes: a pilot study of setting the rote to music

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Rote learning can be dull! Yet for students to be successful at higher levels of education, there is a large base set of knowledge or vocabulary that must be learned and recognised, despite the absence of any rhyme or reason in said knowledge. This is commonly true of many sciences and languages. Historically, such information has been learned by rote and drills – both quite effective techniques, but not very engaging. The current project investigates the production of musical parodies with lyrics attuned to the knowledge requirements of the student as a means of increasing accessibility, student interest and overall information retention. The success of this work-in-progress venture will be explored through student participation, feedback and results on related examination questions.

Keywords: Chemistry, rote, learning, student engagement, functional groups, music.

Context

Underneath many science disciplines lies factual data that is fundamental to that field of study and usually assumed knowledge once beyond the introductory level. Where would we be if some memorisation or learning of these facts had not taken place? Perhaps with a physician who wasn't sure if the radius bone was in the arm or the leg trying to treat us! A chemist who did not remember the difference between an alcohol and a ketone might be very dangerous in the laboratory.

Many students have difficulty in remembering this type of basic factual data that underpins more advanced material in many scientific disciplines. For first year chemistry students, one such dataset is that of functional chemical groups, for example: alkanes, alcohols, and ketones. These are the workhorses of reactions and all manner of organic synthesis, analysis and other chemical interactions.

This paper explores some ways of helping students to remember properties, associations and limited facts about functional groups, via the medium of music. We suggest that this will enable the fundamental learning of these facts. Our method was to make use of well-known tunes and writing specific lyrics to provide the factual information in a novel and helpful way to aid student learning and recall of this information. We also argue that the vehicle of music and lyrics could be generalised to other science disciplines.

Purpose

We argue that using well-known contemporary music and novel lyrics will aid learning and recall of chemical functional groups.

Literature Review

There's no avoiding it – becoming well versed in the sciences requires some level of rote learning. One area that offers similar challenges to chemistry or science is learning a foreign language. Here vocabulary, grammar and other rules need to be mastered and used with minimal referencing. Paul Pimsleur was a language expert and educationalist that developed a system for learning languages still widely used today (Pimsleur, 2013). He identified the use of "…intonation, rhythm, melody and pronunciation…" to engage students. The focus was a graded presentation of new words and their use (Pimsleur, 2013, p.1). The use of smaller sized portions of information was therefore a recognised method of learning.

In chemistry, the literature is sparse on the topic of using music for chemistry learning. More generally, it appears that music for learning is divided into two streams: that specifically for learning music (which is not particularly relevant for this investigation), and that where music is a tool for assisting learning material in other disciplines. This is particularly noted for the primary school curriculum (for example, Easton 1997, Young and Glover 1998, Bearne 1998, Dyson 2003).

For classroom learning, the use of music is a potent device as there are emotional processes that provide strong links to memory (Wolfe, 2001). The use of 'piggyback' songs – a familiar tune with new words, such as *row your boat* or *happy birthday* – have been documented as successful (Wolfe 2001, Ortis 2008).

Additionally, providing the means for students to easily access the music, tunes, and songs will enhance retention and recall. For example, Ortis (2008. p. 202) reminds us of singing or chanting to learn the letters of the alphabet (ABC), or rhyming "Thirty days has November, April, June and November…" to illustrate the lasting effect of these rhythmic pursuits.

This type of rhyming and singing brings to mind television and radio advertising with its use of short musical grabs, commonly known as 'jingles'. Advertisers know this phenomenon well and exploit it greatly with its repetitive nature until we can all sing along with the current product or service (and more to the point, recall the name of the company, which is exactly the aim of the advertising agency). The research shows that even after a single exposure, individuals made more correct associations with brands and slogans when using a jingle compared to those who had not been exposed to the jingle, but essentially the same visual information (Yalch 1991).

Following on, the use of piggyback songs has been applied in statistics with remarkable success by Wilson VanVoorhis (2002). She utilised tunes such as *Yankee Doodle* and *Coming Round the Mountain* with specific lyrics relating to concepts such as means, and standard deviations to assist students learn basic statistical concepts. The results of this work showed that 55% of students with the songs scored perfect knowledge test scores, compared to only 38% with perfect scores in another group that did not have the songs. Wanda Wallace (1991) demonstrated that for large amounts of information (80-85 words), content delivered via song was more effectively recalled than content delivered by the spoken word.

With chemistry, the use of music has provided some traction in the past with explorations by Flanders & Swann, with *First and Second Law* (nd), relating to thermodynamics and Tom Lehrer with his version of the periodic table, *The Elements* (nd). This style of presentation grew out of university student revues of the 1950s and 1960s, which are rare in current times. More recently, J. G. Eberhart used a blues tune *Brown's Ferry Blues* (2013) with the lyrics rewritten as the *Old P-Chem Blues*, relating to the study of physical chemistry (Eberhart 1995). This was a long piece, typical of the ballad style of blues genre from which the music was taken. His reflection of their being "…an apparent void in the music of science…" which he believed needed filling, was encouragement for our project (Eberhart 1995, p. 1076). More recently, Pye (2004) wrote parodies of modern pop songs in an attempt to re-enforce the concepts taught during a day's classes. Feedback from his work was largely positive, indicating that this approach may be appropriate for assisting in education.

The project is based on the premise that in many disciplines of learning, there is a need for a foundation of knowledge in order to be able to build and expand (Novak, 2002; Johnstone, 1993). Ready and retrievable access to facts and basic knowledge is essential to provide the foundation. In the past, learning drills, or rote learning, has served this purpose (Johnstone, 2000; Sirhan 2007) Rote learning activities are typically not stimulating for the student and go against most good pedagogical practice, where understanding the material is considered to provide deeper learning. The current project follows a similar set of principles to that of Pye (2004), instead focusing in particular on the difficulties that students have with rote learning.

Dillinger and Landrum (2002) showed that people are far more likely to remember musical lyrics than other random bodies of text. Because it is more ‘fun’ this means that students are more likely to engage in the learning. It will provide a memory cue for students, even when they are in a stressful situation like an exam. Music also provides a portable way of learning; you can listen to music while walking, driving, on the train or exercising, whereas memorising a written list is less flexible. This also fits with the Pimsleur approach with its 4 key principles: graduated interval recall, principle of anticipation, core vocabulary, and organic learning (Pimsleur 2013). Our aim was to step away from traditional rote learning and provide engaging ways of learning and recall for the student to use in future advanced work.

Approach (methodology)

Some preliminary work carried out in chemistry in semester one for cations and anions indicated the potential of this type of learning model. Over the semester, 70% of enrolled students accessed the song. A large number of students accessed it within the first 2 weeks of being introduced to the topic, followed by sporadic use throughout the semester and finally, an increase in use in the week before the end of semester exam. Overall, the song was accessed 520 times by 140 enrolled students.

The approach involved several steps. First was to select the chemical functional groups and summarise succinctly their properties (including structure), and perhaps create an *identity*, to be characterised in the lyrics. Second was to brainstorm contemporary, well-known music and songs and select out some with simple *sing-along* properties (more memorable to the authors). The third stage was to try and match where possible the *identity* with the *feel* of the music (blues, rock, ballad, etc.). Lyrics were written to match the metre and feel of the music, and some recordings were made by the authors to test the overall feasibility and logistics of the process. The fourth stage was to record the music and lyrics using fairly simple recording equipment but with a reasonable level of quality and have them ready for implementation in the second semester chemistry class.

The song series was created in two formats as part of the learning material. The first was an audio of either the complete set of Chemtunes, or individual audio files related to each functional group. At the point of writing this paper, songs had largely been largely recorded and uploaded to Blackboard for student access during the teaching period. No feedback on the current status from students has yet been obtained and some will be available by the end of semester in October 2013.

After receiving ethics clearance, we plan to subsequently review the pilot study with student feedback, scores on tests, and other relevant data.

2.1 Why functional groups?

In chemistry, there are several situations where a foundation of knowledge must be remembered and there is little in the way of systematic patterns in the information. The identity and recognition of a variety of organic functional groups represents one such list. Chemists need to be able to identify what type of organic chemical they are working with in order to be able to predict the way that the chemical will behave. While the identifiers are not challenging individually, the range of different functional groups to be recognised means that at least 9-10 different possibilities must be memorised in order to be recognised, and these are clouded by their superficial similarity to the inexperienced. These criteria make the learning of different functional groups an ideal task for the current study.

2.2 What is the intended message?

The aim is that students will be able to recognise a chemical functional group on sight. Traditionally in chemistry students are taught a list of functional groups, as shown in Table 1. It is our intention to use music to help students familiarise and learn this list.

Table 1. List of common organic functional groups and their common abbreviation

Functional Group	Abbreviation
Alkane	R–R
Alkene	R=R
Alkyne	R≡R
Alkyl Halide	R–X
Alcohol	R–OH
Carboxylic Acid	R–COOH
Ketone	R–CO–R’
Aldehyde	R–CHO
Primary Amine	$R–NH_2$

2.3 Selection of music

The selection of music is of great importance – the most appropriate choice would almost certainly vary from one application to the next. Others have written and performed original music as part of a learning activity. For example, Mark Rosengarten (2009) has used original rap music to illustrate some chemical concepts. These are used with a video to describe some chemistry concepts, but miss the feel for *sing-along-yourself* type of tune, as they are the same genre without differing for different concepts. Using original music has advantages in that the pacing, style and lyrical requirements can all be tailor-made to suit the learning activity, but there is a need for variety.

The advantage of well-known music over original music is that if this activity is to help students remember what might otherwise be random information, then stronger memory cues are better. If they can associate their new knowledge with something they already know – a well-known song – then it is likely that their ability to recall the information will be greater (Ortis, 2008). The availability and accessibility of music also provides great opportunity for variety so that different concepts can be illustrated.

The goal of this learning activity is to allow students to be able to differentiate between one organic functional group and another. If a unique song is associated with each organic functional group, students will come to associate that particular functional group with a particular lyric or song, rather than getting multiple options confused. This also means by selecting songs that have a distinctly different sound and feel that easily confused functional groups (e.g. alkane and alkene) can be more easily separated.

Based upon the work of Wallace (1991) in advertising, we decided that songs should be chosen to meet the following criteria:

- Well known by a large proportion of the population (each song selected has at least 2.5 millions views on YouTube, suggesting they are well known)
- Not too modern, so that the music has been around long enough to permeate through society
- Easily coherent lyrics
- Different speeds or tempo to provide variety
- Different driving instruments/sounds to provide variety
- A mixture of male and female vocals to further differentiate the songs

These criteria were adhered to in order to maximise the audience’s ability to recognise the songs, hear the modified lyrics and be able to mentally distinguish one tune from another.

Below is an example of a song modified to introduce the keys to recognising alkenes. Alkenes are compounds that contain a double bond between two carbon atoms. The major learning outcomes that we would like from this song are that students can recognise an alkene on sight and are aware of the fact that their double bond is important.

The lyrics are replacements for those of the song, “Stuck in the middle with you” by Stealer’s Wheel.

I’m an alkene, I’m a double bond
I’m an alkene and I know what I do
I take part in addition reactions
My double bond is easy to use

Carbon to the left of me, carbon to the right
Double bond, stuck in the middle of two (two carbons)
Double bond, stuck in the middle of two (alkenes)

2.4 How to blend the music

Instrumental and vocal tracks can be individually digitally recorded and mixed using any number of software packages such as Steinberg’s Cubase, Ableton Live, Garageband, or free programs like Audacity, Free Audio Editor, Music Editor Free, Power Sound Editor or Wavosaur. Many of these packages come with equalizers and effects to enhance musical creations and some support the use of VST (Virtual Studio Technology) plug-ins – 3rd party audio utilities that can be used to further enhance recordings. We made use of several packages to record and engineer our music.

Previous *mash-ups* and musical compositions by others have been carefully engineered and arranged so that changes in key or pace are smoothly incorporated into the musical score, resulting in a seamless transition from one phase of a musical piece to the next. In the current project, this approach was discussed and abandoned in favour of a more definitive divide between tunes, and this served two purposes: the first to have a distinct cut-off between each functional group for students to learn; and the second to make it easier to join together a series of otherwise unrelated pieces of music.

With this in mind, each short piece (or segment) of music was individually composed, one instrument at a time with multi-track recording and then the desired segments were joined together, using a radio distortion sound to create the feeling of one tuning a radio to a new station while separating one functional group’s song from another.

2.5 Associated resources (video/slides)

To further assist in the goals of the project, associated video content was produced to synchronise with the audio compilation. The video material contained visual images of the organic function groups, placed in time with the relevant features of each song in order to further enhance student recognition of the relevant functional group’s structure.

Colour was also used in conjunction with the video to further distinguish between one functional group and another, providing additional learning material to help differentiate similar structures.

Outcomes

We used the song series as part of the learning material available on mp3 fie to download. This was either the complete set of Chemtunes, or individual files related to each functional group.

Based on this positive early response, we expect that there will be a general interest in the future use of this method by students and other staff within the faculty. We also expect that as a result of the novelty and catchiness of the songs, students will retain more of the factual information and have a better understanding and recall of chemical functional groups. We may be able to judge this partly on comparison of performance in chemistry with previous years and/or comparison of short tests on functional groups over the same time period from the semester 2 results when the functional group learning has taken place.

We will report on the findings from the second semester implementation of Chemtunes, detailing the songs, lyrics and music (with examples) and some indicators of effectiveness based upon a mixture of assessment results, student feedback and comments (subject to ethics committee approval).

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