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# A STUDY INTO THE DESIGN OF A PRE-LABORATORY SOFTWARE RESOURCE IN EFFECTIVELY ASSISTING IN THE CHEMISTRY PROFICIENCY OF STUDENTS OF CHINESE ORIGIN UNDERTAKING POST 16 CHEMISTRY IN THE UK

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**Abstract:** This qualitative study indicates that Chinese origin students completing their pre-university education in a British school have particular difficulties related to sociocultural change, pedagogical differences, affective aspects, cognitive demand and language learning. These are discussed. The use of a pre-laboratory software resource to support pre-university practical work in chemistry offers considerable benefits a number of the challenges faced by these students in studying in an English setting, most notably in building confidence and cognition through the use of videos of techniques, simulations and glossaries.

**Key words:** EAL, Chinese learners, pre-lab software, VLE, language learning,

## 1. Introduction

The research considered the key issues that young students of Chinese face when moving to the UK to undertake their pre-university (Post 16) 'A' Level chemistry examinations and how access to software designed to support practical skills as a pre-laboratory resource might be supportive. The software chosen to consider is a dynamic laboratory manual (DLM), devised by Bristol ChemLabS, called 'A Level Chemistry Labskills' (Harrison et al., 2009) might assist in overcoming these and to identify the supportive elements built into the software design and those elements overlooked for this target group.

## 2. The growth in number of school students of Chinese origin in UK schools

The UK has seen a rapid rise in the numbers of Chinese origin students attending UK independent (private) schools. This is an average of 8.8% rise since 2007 (BIS, 2013), which represents the fastest rate of growth amongst all non-British students. The total number of Chinese students, from both Hong-Kong and mainland China, attending independent schools within the Independent Schools Council, a body representing 1,267 of the schools in the UK, stood at 10,468 (ISC, 2015) in 2015. Chinese students represent 38.5% of the total number of overseas students, and the number of students from mainland China is also increasing year on year (ibid), and this trend is expected to continue (ICEF Monitor, 2014).

Given the perception amongst parents and Chinese society that a Chinese graduate holding a foreign degree will have better skills and employability prospects (Davey, 2005), it is perhaps unsurprising that many students go on to apply to UK based higher education institutions, which are seen as providing a higher quality education than that on offer in mainland China (Bodycott, 2009).

## 3. Transitional shock

Transplanting young people into different cultures at both secondary and tertiary levels of education will result in a number of 'shocks'. Adler (1975) describes this transitional experience within a culture-shock paradigm, whilst others detail specific challenges such as changing learning styles (Yamazaki, 2005; Gu and Maley, 2008); the difficulties of engaging in conversational language that is specific to the culture (Agar, 1996); and the sense of ambiguity about one's identity (Hakak, 2014). A

relevant study into the particular problems encountered by Chinese students in a UK independent boarding school (Berry and Williams, 2004) highlights the anxiety generated by immersion in a second language, whilst individuals are trying to acquire competence in that language, and the follow-on effect of this anxiety on learning, supporting findings by Cummins (1996).

Liu, 2002, attributed the silence exhibited by Chinese learners in an American classroom to the multiple interactions of:

- sociocultural factors (e.g. face, showing respect for others by keeping silent, or the norm of being a good listener as a good student),
- pedagogical factors (e.g. teaching styles, participation as a course requirement, and opportunities to speak up),
- affective factors (e.g. anxiety, motivation, or risk-taking),
- cognitive factors (e.g. prior learning experience, background knowledge, or mental readiness),
- and linguistic factors (e.g. proficiency in the target language, communicative competence, or accent).

(Adapted from Liu, 2002, p.38).

Although Liu is clear that it is the interactions of these five factors at play, they provide a useful framework for a discussion on what constitutes a Chinese learner and how a multimedia tool like the A Level Chemistry LabSkills may support learning.

#### 4 Sociocultural considerations

Markus and Kitayama (1991) suggest that there are different culturally acquired conceptions of self; an Asian 'interdependent-self' which is in contrast to American and Western European notions of an 'independent-self'. The authors contend that an independent-self views its core conceptions as immutable, whilst the core conceptions of the interdependent-self are 'predicated on significant interpersonal relationships' (p. 227). In the same paper, Markus and Kitayama suggest that Confucian influences of inter-relatedness and kindness underpin the Chinese interdependent-self, whilst the Cartesian dualist tradition facilitates the construction of an independent-self in western cultures. If this is a useful way of understanding Chinese learners' sociocultural background, then it should be evident in their concept of learning.

Li (2003) compared American and Chinese conceptions of learning terms, finding little overlap between the groups, with the Chinese conceptions emphasising contributions to society and the unity of knowledge and morality, in contrast to a focus on mental processes and internal learner characteristics for American learners; Volet (1999) found an enduring predisposition for interdependent forms of learning amongst Chinese students after years of study abroad. That is not to say Chinese learners are solely collective in their approach; indeed, Lee (1996) puts forward that Confucian principles espouse that 'the purpose of learning is to cultivate oneself as an intelligent, creative, independent, autonomous being' (p.34). What characterises Chinese culture, Lee argues, is that all are able to attain this, irrespective of background. This is an individual, yet collective ideal.

This cultural understanding of one's autonomy then plays out in the interactions between Chinese learners and their teachers and peers. It might be argued that a lack of understanding of these sociocultural drivers has led western educators to perceive Chinese learners as passive recipients of knowledge and rote learners, being overly reliant on the textbook and the direction of their teachers (Cortazzi and Jin, 1996; Jones, 1999), as they are expecting students to ask more questions and challenge more, which is encouraged in western classrooms (Auyeng and Sands, 1996). However, speaking out would potentially conflict with a collective concept of 'self' and preserving 'face', which is 'how an individual thinks his or her character or behaviour is being judged or perceived by the people around him or her in that community' (Liu, 2002, p.41).

Work by Jackson (2002) shows how important maintaining face is to a student, but, additionally, how important it is for Chinese students to preserve 'face' for their teachers, one research participant

commenting 'If I like the course very much or admire the professor, I would not want to embarrass him so I would remain silent' (p.75).

#### **4.1 A multimedia resource and sociocultural considerations**

The design of the practical software resource means it can be used on a school's virtual learning environment (VLE) outside of lessons, allowing a learner to (virtually) practise practical work and so build-up own understanding. This may not suit Chinese learners in that it is not a collective task; on the other hand, the practising of tasks would allow learners to save 'face' when completing practical work, as they would be more confident of undertaking tasks in a manner that is acceptable to those around them.

#### **5. Pedagogical considerations**

Examining the literature on pedagogical approaches, it is clear there are significant differences in approach between a western and eastern classroom, yet too often the interpretation of these approaches has been portrayed from a western understanding of 'good' versus 'bad' practice, with Chinese practice in the latter camp (Biggs, 1994). However, the attainment of Chinese learners has outstripped western counterparts (OECD, 2014) and there is an apparent paradox, as, whilst commentators talk of the difficulties of learning in large classes, Biggs argues that Chinese teachers achieve greater contact percentages than their western counterparts and are better able to achieve deep learning even where classes contain over 40 students (Biggs, 1998). Other researchers have agreed, considering Chinese students equally as willing as native-speakers to engage in active learning, self-directed study and autonomy (Cheng, 2000; Gieve and Clark, 2005; Saravanamuthu, 2008; Stephens, 1997).

There is, therefore, a clear mismatch in expectations that may be rooted in distinct pedagogical histories, with western practitioners using quick and snappy whole class questioning as a way of driving the learning of all those present (Hess and Azuma, 1991), and Chinese students viewing this pushing forward of one's own opinion as rude, avoiding being in the limelight in this way (Jackson, 2002). However, Cheng (2000) argues this inhibition is, in part, situational and that a lack of linguistic ability lies at the heart of the students' reticence, and Jackson (*ibid*) suggests that successful strategies are ones that allow students more time to engage with the material, often in smaller groups where a student then becomes the representative speaker, a role that is not equated with being a 'show-off' (p.80).

Given the value placed on educational attainment by Chinese society, particularly by parents, there is pressure on both students and teachers in China for learners to do well in the Gaokao or National College Entrance Examination, as these annual tests are used to judge the quality of the school (Fu, 1996, cited in Rao, 2006, p.503). Davey et al. (2007) report that 'the exam questions...only require students to solve problems theoretically, and practical work is limited' (p.393). However, the Gaokao is currently under reform to address the shortage in advanced technological knowledge (Zhang, 2014), which is likely to increase the amount of practical work in the future.

#### **5.1 Multimedia resource and pedagogical considerations**

##### **5.1.1 Addressing gaps in practical knowledge and awareness of hazards**

A Level Chemistry LabSkills provides students with the opportunity to encounter and practise GCE A level practical work virtually, prior to undertaking the real practical in a laboratory. Given that Chinese learners typically have limited experience of practical work in China, there was a benefit to allowing students to familiarise themselves with, not only the specific practical work of the course, but also general practical techniques. In addition, the DLM highlighted safety aspects of the practical work to students, and so reduced risks (Harrison et al., 2011).

##### **5.1.2 Promoting self-directed study**

The software, by virtue of it being accessible on the VLE or being available as a stand-alone purchase for an individual student, promotes self-directed study and the autonomy of the learner. Although related to language learning, rather than using this type of resource, Oxford (1990) found learners who

believe teachers are the authoritative source of knowledge are more likely to avoid self-directed strategies; there was some evidence for this (O'Sullivan, 2014), as Chinese learners stated they would use the software independently where a teacher did not demonstrate a technique prior to practical work.

### 5.1.3 Examination focus

Hart et al. (2009) suggested the software would benefit from linking explicitly to the examination board specifications to promote the adoption of the software by teachers. This would be useful for teachers, but also helpful in promoting the use of the software amongst Chinese students who are highly focused on examinations.

## 6. Affective considerations

A key consideration is the impact that moving to the UK has on the level of motivation shown by Chinese learners. Salili (1996) found that Chinese learners closely allied academic and career success with that of their family and social standing. Gieve and Clark (2005) comment on the motivating factor of parental financial sacrifice, whilst Niles (1995) reports social approval to be a potent motivating force, all of which put pressure on students to perform academically whilst in the UK. Despite this, Gu and Maley (2008) found younger students struggled to cope with the freedoms afforded by the UK Higher Education system, with a number failing to attend class and hand in work on time, which lecturers found surprising given the cultural stereotyping, commenting that 'they don't know how to study independently' (ibid, p.235).

Notwithstanding a powerful extrinsic motivation to succeed, Chinese students have to cope with the emotional impact of living in a different culture and using a language that, being stress-based rather than tonal, is some distance from their own. Berry and Williams (2004) found that Chinese students in a boarding school exhibited considerable anxieties about expressing themselves in English, and understanding spoken English in their lessons, as well as the social aspects of the language and culture, finding it difficult to comprehend the customs of a small community, and handle peer pressure from their English and Chinese classmates. This anxiousness, for some, caused them to withdraw and speak very little.

Krashen (1982), furthering work by Dulay and Burt (1977), discusses the role of the affective filter in language acquisition, whereby the filter prevents input for language development, and is activated by poor motivation, low self-confidence, poor self-image and high anxiety.

### 6.1 Multimedia resource and affective considerations

The DLM builds confidence, as students feel they have rehearsed the procedure. This related particularly to the video components which helps to visualise the steps, so lessening the anxiety of tackling previously unfamiliar practical procedures (O'Sullivan, 2014).

## 7. Cognitive considerations

A consideration that has merited significant research is the particular learning style of the individual. Norenzayan and Nisbett (2000) argue this arises from a cognitive difference between eastern and western learners, whilst Erhman et al. (2003) contend that it is more appropriate to discuss individual differences, rather than culture or continent. Atkinson (1999) suggests a middle-ground view of culture developing as a dialectical process that occurs between individuals and contexts, which affirms the influence of culture on cognition, without allowing this to become an immutable monolithic construct. In the debate on the reflexivity of Chinese students and their ability to adapt to new cognitive demands, it might be useful to be mindful of Hall's idea that, although we may perceive patterns of behaviour as innate, these have been acquired: 'Everything man is and does is modified by learning and is therefore malleable. But once learned, these behaviour patterns, these habitual responses, these ways of interacting gradually sink below the surface of the mind and, like the commander of a submerged submarine fleet, control from the depths.' ..... 'What makes it doubly hard to differentiate the innate from the acquired is the fact that, as people grow up, everyone around them shares the same patterns.' (Hall, 1976, p.42)

Chinese learners have been seen as rote learners, and criticised for this (e.g. Bradley and Bradley, 1984; Samuelowicz, 1987). Biggs (1994) contests this, maintaining that high performance in international tests indicate an ability to learn deeply and rather than indulging in rote learning - considered a superficial method with a negative correlation to attainment (Ramsden et al., 1989) - Chinese learners engage in repetitive learning. Work by Dahlin and Watkins (2000) highlighted a contrasting understanding of repetition between German and Hong Kong Chinese secondary school learners, and found the latter had a clear idea that repetition allows the learner to discover new meaning and to have a deeper impression of the material, as well as being much clearer about the 'attentive effort' (p.76) required in repetition. Marton et al. (2005) found Chinese University students portrayed memorisation as understanding (p.311), and, earlier work highlighted a firm belief amongst 20 Chinese and Hong Kong Chinese teachers of English that repetition grants a deeper understanding (Marton et al., 1996). Gardner, as early as 1989, talked of the difference between American and Chinese teachers' approaches to the order of learning to draw, with the latter emphasising skill development through repetition of a limited number of objects, prior to drawing novel subjects, which the children were able to do very competently; the American method emphasised discovery and exploration, rather than an accomplished product. Rao (2006) also found that Chinese learners preferred to review material multiple times, viewing this as an effective method for language learning.

A study examining repetitive and novel language use by Barton et al. (2005) found a reduction of 10% in attainment of English as an Additional Language (EAL) students studying undergraduate mathematics in New Zealand, which they attributed to language deficiencies. Their study indicated there are particular challenges once courses require students to 'reproduce the logical trains of thought adapted to new situations' (p.722) in the third-year of their studies. Prior to this year of study, the language used was 'repetitive, confirmatory, and predictable...similar to those [examples] that students will be required to repeat' (ibid). Interestingly, those surveyed were unaware they were underperforming in the subject, which the authors attribute to early success in mathematics and the confidence this brings.

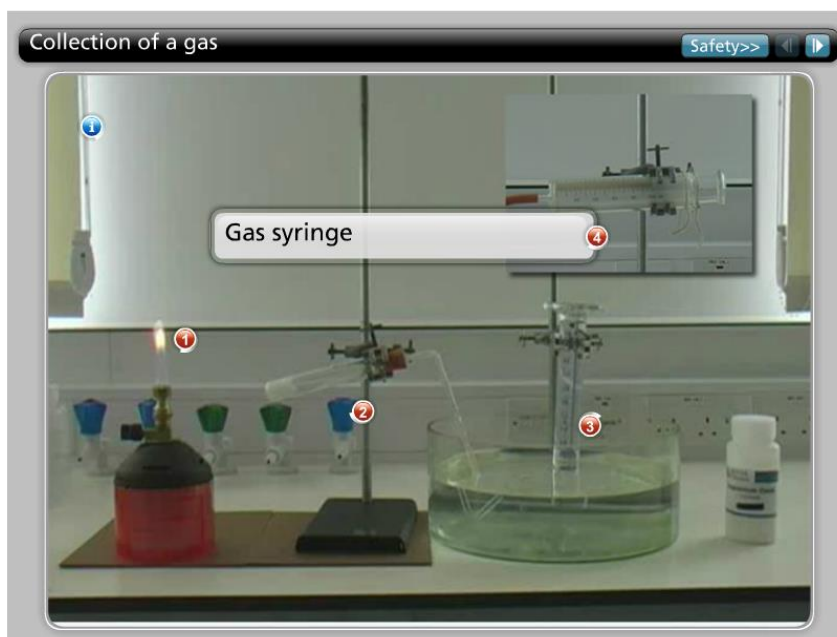
## **7.1 The multimedia resource and cognitive considerations**

### **7.1.1 Achieving mental readiness**

The 'A' Level Chemistry LabSkills software is designed to allow the user to become familiar with the practical task, equipment and safety considerations prior to undertaking the actual procedure in the laboratory. In this way, it has cognitive benefits, allowing the user to achieve mental readiness, and to engage with the chemistry without the concerns of physical manipulation, or the time pressures of achieving a practical outcome within the lesson allocation. The idea is to build 'funds of knowledge' (Meyer, 2000), subsequently reducing the cognitive load of the actual practical lesson, as students are drawing on their, albeit recently acquired, prior knowledge, and gaps in past practical work in China are addressed through virtual experiences.

### **7.1.2 Multi-modal learning**

The software design allows the student to receive multi-modal information, as there are visual representations accompanied by text.



**Figure 1:** *Proximal positioning of text and picture*

In addition, interaction is promoted by the use of a moving circle around each salient point, to encourage the user to click that area on the page, and relevant information is located directly next to the item in question (e.g. gas syringe as in Figure 1). By presenting context-embedded information, EAL students have a greater opportunity to understand the presented material, and work by Dixon (1995), using a dynamic instructional environment to teach mathematics, showed that all students improved their learning compared to traditional class-based teaching, and those with limited English performed no worse than their English proficient peers.

### **7.1.3 'Chunking' of information to allow for easy repetition**

The practical chemistry software also provides videos of key techniques, breaking each stage into its constituent parts, and showing a typical example of the technique in use. There are written descriptions under each video that highlight the salient point(s). Again, visual and written information is located together and allows the user to select (by directing their attention) the most favoured learning preference. As the information is in bite-size chunks, it is easy to review particular steps, removing the tedium of having to scroll through the entire sequence to find the relevant section. Critically, the design allows users to repeat each section multiple times, allowing Chinese learners to develop a mental model for the practical work, including the important, but often missed, details.

### **7.1.4 Pertinent and timely feedback**

The simulations provided draw out key learning points, for example, the importance of releasing the pressure during solvent extraction.

In this way the resource, in line with carefully designed simulations 'can accelerate the learning process by ensuring that learners face certain situations' (Guralnick and Levy, 2009, p.10) and the help and check functions provide 'appropriate...feedback to the learner, while real-life experiences often can pass by without the learner taking away the key points' (ibid) (figure 2).

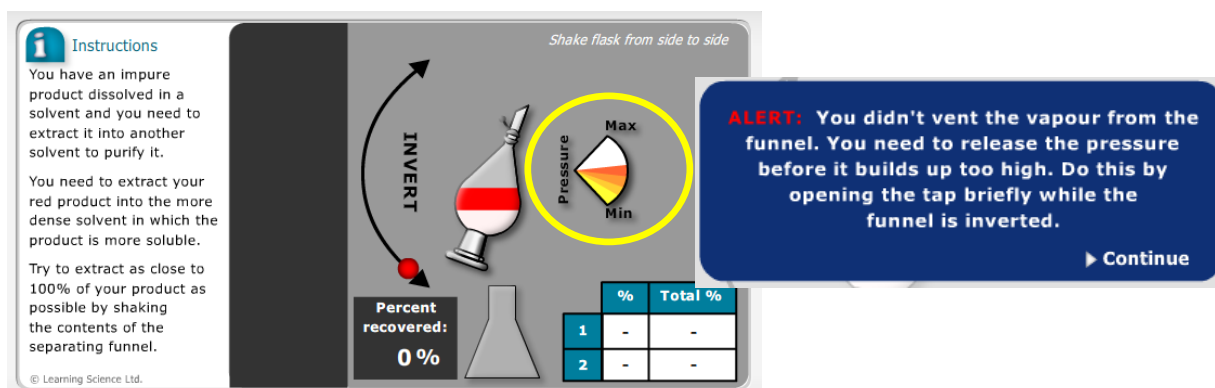


Figure 2: Simulation feedback draws attention to key learning points

### 7.1.5 Purpose-based vocabulary

Another useful feature is the separate equipment and reagent glossary. By separating these, the user makes important distinctions in their mental constructions of these items, seeing their purposes as different. The separation makes the resource less clumsy to use and less daunting, as each glossary is smaller and information is readily found.

### 7.1.6 Context-based mathematics

The students are provided the opportunity to practise relevant calculations for each experiment, where applicable. This is a useful tool for teachers to support all students in building links between the mathematical manipulation and the chemical concepts behind the experiment.

### 7.1.7 Skill development

Finally, the software offers instruction and insight into particular skills and then illustrates these with common examples. In this way, it allows the student to generalise the skill to a variety of practical work encountered in class, and may, therefore, avoid a prescriptive approach to the practical work that can arise as a consequence of non-native English speakers following practical manuals to the letter, lacking the ability to adapt to new situations or alternative procedures (Jacobson, 1986), although a longer study is needed to determine this.

## 8. Linguistic considerations

Due to the technical vocabulary demanded in the study of Chemistry, all students have a 'language load' (Meyer, 2000, p.232) and Wellington and Osborne (2001) argue that 'science teachers are (among other things) language teachers' (p.6). Whilst Kimbrough and Cooper (2008) contend this provides 'a more level playing field' (p.120) for EAL students, Arden-Close (1993) highlighted four problems specific to the teaching of Chemistry to non-native English speakers: finding concrete analogies for invisible entities that are familiar to a foreign culture; the use of 'synonyms' in explaining words; using scientific vocabulary which has alternative meanings in everyday life, and the problem of finding a common range of reference (p.260).

Notwithstanding the difficulties that teachers face, Chinese learners report an anxiety to speak publically based on a feeling of inadequacy in terms of language ability (Jackson, 2002); whilst Robinson (2005) found that EAL students 'remained silent not because they didn't know the answers, but because they couldn't frame the answers in the same kind of analytical and scientific framework in which the question had been posed.' (p.437)

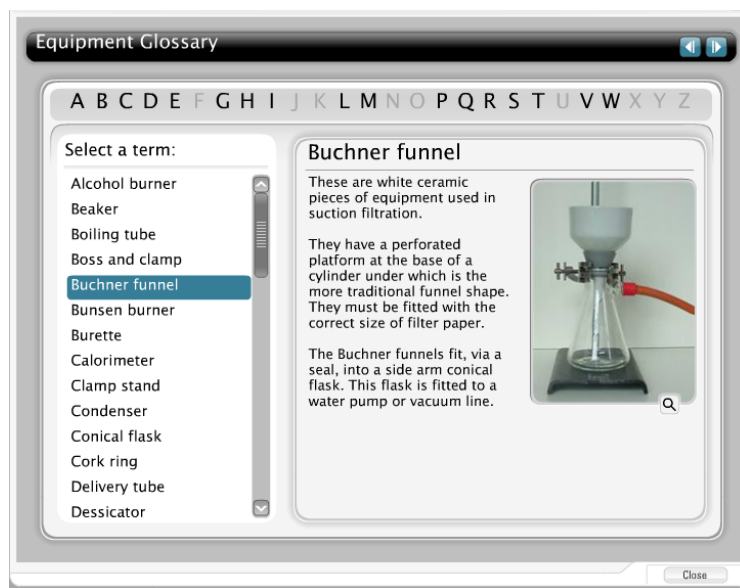
This reticence is also found in practical work - researching an undergraduate Physics laboratory, Jacobson (1986) found that non-native English speakers communicated less with their supervisors when sorting equipment problems, resulting in a considerable delay in their resolution, and were quieter when working with native speakers.



## 8.1 Chemistry LabSkills' linguistic considerations

### 8.1.1 Rehearsing and exploring relevant language

The Ofsted report *Managing support for the attainment of students from minority ethnic groups* (2001) identifies, among other factors, two key ways in which EAL students can develop their English successfully, namely by performing activities that enable 'students to rehearse and explore the language' they need; and a focus on the 'language necessary to complete the task' (p.27). The resource allows students to perform these two aspects through the virtual 'rehearsals' and through the provision of an equipment and reagent glossary. Additionally, in line with DfES (2002) guidance on teaching Science to EAL students, the software provides 'instructions and information in ways that combine visual presentation and short text' (p.23) (figure 3).



**Figure 3:** A parallel focus on the vocabulary required is provided through specialist glossaries.

### 8.1.2 Additional time for comprehension tasks

The software, by virtue of it being accessible on the VLE and out of the classroom, allows students autonomy over the time they spend on the different sections, benefitting EAL students, who often need more time to comprehend written text (Calderón, 2009).

### 8.1.3 Context-based vocabulary

NALDIC (National Association for Language Development in the Curriculum) gives clear guidance in its 'Subject specific information – Science and EAL' (2011) on the importance of the following in supporting the development of subject specific language for EAL students:

- Vocabulary development
- The use of the mother tongue
- The use of visuals
- The use of DART (Directed Activities Related to Text)

The software promotes vocabulary development through the use of glossaries. Additionally, it provides the context of the use of that vocabulary through the simulations and the videos, promoting both learning and understanding of the language used, in line with findings by Rusanganwa (2013) working with Physics undergraduates learning technical vocabulary.

### 8.1.4 Reducing extraneous processing

The resource seems well designed to reduce extraneous processing (Mayer, 2005), as the connections between text and graphics are easier to make, by virtue of these being closely aligned on the page and split into bite size chunks, with short passages of text, which should support the language learning of EAL students (Calderón, 2009).

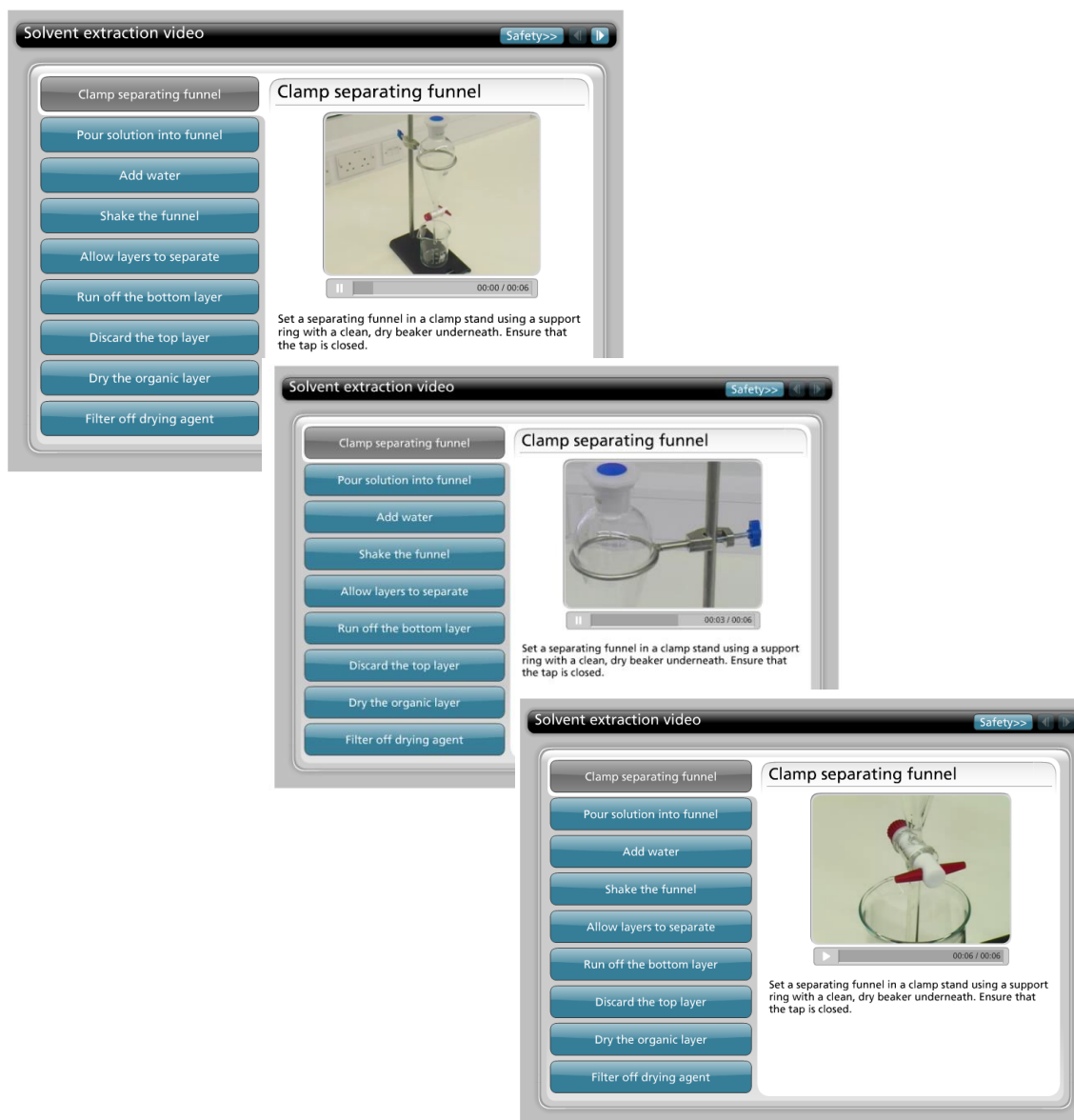


Figure 4: Small sections of text are located close to the visual representation.

### 8.1.5 Visualising text

Interestingly, work by Plass et al. (1998) looked at the role of multimedia in promoting language learning for comprehension, which was contrasted with low-level rote learning of vocabulary, and found that using visual cues helped both 'visualizers' and 'verbalizers', (p.34), suggesting that the use of multimedia in language acquisition is beneficial, no matter the particular learning preference of the student (figure 4).

### 8.1.6 Pronunciation issues

The software chosen for the analysis of usefulness in this context does not offer an optional voice-over of the written text which would prove a useful feature to allow all students to make multi-sensory connections (Carrier, 2012). This is of particular benefit to EAL students, as it would model the pronunciation of words, seen as a key aspect of language acquisition by Nation (2001), as well as reduce their anxiety over pronunciation mistakes when speaking to peers and teachers (Berry and Williams, 2004). The DfES (2002) guidance also recommends the use of a pronunciation guide for vocabulary lists, along the lines of a dictionary, which might be an easier alternative to a voice-over for the glossaries, but is, perhaps, unwieldy for the main content of the resource. In addition, A Level Chemistry LabSkills provides no translation or use of mother tongue languages other than English, and, again, this might be a worthwhile addition for EAL students (NALDIC, 2011).

### 9. Use of the software other than for chemistry lessons

There is strong encouragement from NALDIC (2011), Ofsted (2001) and Kimbrough and Cooper (2008) for subject teachers to work closely with their EAL departments in the development of SoW and teaching episodes, and in the sharing of resources to allow EAL teachers to use subject specific contexts in EAL lessons, so students encounter the subject outside of designated Chemistry curriculum time. As the VLE version of this software can be accessed anywhere within a school site, it potentially provides an opportunity for the collaboration between departments as recommended.

### 10. Conclusion

The A Level chemistry LabSkills software was written to promote practical skills for English speaking students. However a number of the incorporated elements are shown to be of value in aiding, alongside complementary formative assessment tools, learning for students of Chinese origin studying in the UK schools' system. Many of the pedagogical considerations apply to UK students as much as Chinese EAL students; the addressing of gaps in practical knowledge, awareness of hazards, promoting self-directed study and examination preparation. The cognitive and linguistic considerations of the resource in chunking information, giving timely feedback, having glossaries that separate reagents from equipment suggest that the pre-laboratory preparation for Chinese students is very supportive. Where such software could be improved is in the area of pronunciation. Any software designed to target EAL students would be encouraged to employ a voice-over function. However, collaboration with the school's English as an Additional Language (EAL) Department may provide an avenue for overcoming specific difficulties with the text sections.

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