Picture boards as demonstrator aids for pre-practical briefings

Leanne A. Blount* and Richard A.R. Blackburn

Department of Chemistry, University of Leicester, University Road, Leicester, LE1 7RH, United Kingdom

*Corresponding author: lb400@leicester.ac.uk

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Abstract

Picture boards as a visual support aid for in-lab demonstrator briefings were deployed for a single experiment in both the first and second year undergraduate practical classes. The boards are easy to create and provide an alternative, more accessible and 'presentation friendly' perspective of the laboratory manual associated with an experiment. The use of the boards during instructor briefings helped generate confidence and familiarity with the experiments to be performed and this type of demonstrator briefing was preferred to the traditional, more verbal style being used in other experiments. Utilization of the picture boards was also proven to help the students to process the pre-experimental and instructional information associated with the laboratory manual and practical operations.

Introduction

Practical laboratory work is an integral part of any undergraduate degree program, it is desired by employers and further study providers and is a key accreditation parameter by professional bodies such as the Royal Society of Chemistry (Royal Society of Chemistry, 2017) and American Chemical Society (Committee on Professional Training, American Chemical Society, 2015). The student experience in undergraduate laboratories (Johnstone & Wham, 1982; Reid & Shah, 2007; Dekorver & Towns, 2015; Galloway & Lowery Bretz, 2015; Galloway, Malakpa & Lowery Bretz, 2015) and how to improve upon the way that these practical sessions are delivered (Dechsri, Jones & Heikkinen, 2002; Robinson, 2009; Blackburn, Villa-Marcos & Williams, 2019) has been widely investigated for decades.

One of the earliest discoveries with regards to laboratory teaching is the amount of information that needs to be processed by the students' working memories, in such a short space of time, by both the experiment itself and the laboratory environment (Johnstone & Wham, 1982). This intense cognitive demand often leads to a so-called 'unstable overload state', where students forgo systematic and intelligent working strategies in favour of more comfortable actions (such as busying themselves with random activities) where the quality of learning is likely to be poor (Johnstone & Wham, 1982). These so-called comfortable actions can result in a disconnect between the laboratory tasks and the concepts behind them (Dekorver & Towns, 2015), leading to the aims of the practical sessions (as discussed by Reid & Shah, 2007) being left unfulfilled. One solution would be to reduce the amount of information needed to be processed by the students. An example of this approach might include giving students, separately to the operational procedure, a clear statement of the point of the experiment

(Johnstone & Wham, 1982) and the skills they will need or learn to meet the intended learning outcomes of the classes. This is helpful since it is important that the students not only believe that the experiments they are undertaking are worthwhile, (Johnstone, 1997) but also that there is value in the skills they are developing.

One common strategy that has been widely accepted to help disseminate information and support learning is the use of visual aids, (Shabiralyani *et al.*, 2015) the principles of which can be crudely related back to man's first rudimentary sketches ('Visual aids in chemical education', 1930). By utilizing the simple and concise nature of diagrams, pictures and drawings, it is possible to prioritize the vital information entering the working memory. In fact, given this is how the brain processes information, replacement of text with pictures can accelerate cognition. These visual images can be described as conceptual pegs, as information is known to be more readily recalled if associated with imagery (Dechsri, Jones & Heikkinen, 2002). An example of an area of the undergraduate laboratory experience that provides a great degree of information overload is traditional laboratory manuals, which mainly consist of text-based instructions and relevant theoretical background. In 1997, Dechsri *et al.* found that incorporating illustrative diagrams into the manual aided in increasing students' performance in all domains of the laboratory (Dechsri, Jones & Heikkinen, 2002), which further supports the argument that visual aids improve student learning. However, Dechsri *et al.* then go on to mention that even illustrated, text-based information still has the potential to overload students (Dechsri, Jones & Heikkinen, 2002). From this, it is necessary to develop tools that incorporate more visual stimulus than information-overloaded passages of text.

Wei *et al.* provide excellent insight into what undergraduates expect from interactions in their practical class, stressing that students perceive the pre-lab interaction with instructors as "most-important" (Wei *et al.*, 2018). It is generally accepted that some form of pre-laboratory exercise can help students prepare for laboratory practical classes (Agustian & Seery, 2017; Chaytor, Al Mughalaq & Butler, 2017). This often serves as a way of contextualizing or refreshing the information presented in the laboratory manual. Some of these pre-laboratory exercises feature the use of videos (Schmidt-McCormack *et al.*, 2017; Ardisara & Fung, 2018; Stieff *et al.*, 2018) to help the digestion of information, or simulations (Climent-Bellido *et al.*, 2009) as visual preparative aids. In our mind, the pre-laboratory experience includes the in-lab demonstrator briefing too. This provides the important direct interaction with students, and another opportunity to decrease the cognitive demand of laboratory experiments. Briefings, broken into smaller more manageable chunks throughout the day, provides a valuable opportunity to present the instructional information through a different facet of the prism. This communication reports the development and implementation of illustrative picture boards into pre-laboratory demonstrator briefings to do just this.

Instructional Context

The picture boards were the creation of one teaching assistant (LAB) and deployed for the first-year experiment (171) and second year experiment (273) that they oversee. The remaining experiments (c.a. 21 in first year, 23 in second year) led by other demonstrators did not involve the use of picture boards. Experiment 171, "Investigation of a phase equilibrium", involves the students measuring the equilibrium concentrations of iodine in organic and aqueous phases for different total amounts of iodine, allowing the determination of the distribution equilibrium constant, leading to the calculation of the standard Gibbs energy for the transfer of iodine from the aqueous to the organic layer. Experiment 273, "Acid catalysis of the reaction of iodine with hydrogen peroxide", aims to use the reaction between potassium iodide and hydrogen peroxide to help students understand the role of catalysts, to know how to calculate rate constants and activation energies of reactions and to understand the relationship between temperature and reaction rate. For all experiments the teaching assistant typically gives an initial verbal briefing at the start of the session, including a short commentary on the relevance of the experiment, a summary of the experiment or tips for efficient time management and any important safety information. Each experiment is performed by 70-80 students (6-10 per week approximately) and is assessed as a combination of the student's pre-lab test (theory, procedure and safety), the write-up (results, discussion, conclusion) and a performance mark for their practical aptitude.

Design and Implementation

From a demonstrator's perspective, it was not uncommon for students to show a lack of motivation, engagement and interest during the initial (and any subsequent) verbal briefing for their experiment. It was clear that a large proportion of the students were more interested in completing the experiment as fast as possible and obtaining a good grade, rather than processing what skills they are learning in the laboratory and, more significantly, contextualizing the theory behind it. This observation has also been reported by DeKorver & Towns (2015), who found that 77% of students have the goal to finish the experiment as quickly as possible. Others in the field have also commented on a lack of student motivation and confidence, which is not surprising when one considers the main emotions and feelings of undergraduate students in the laboratory: nervous, confused, intimidated, worried, unmotivated and lacking excitement (Galloway & Lowery Bretz, 2015; Galloway, Malakpa & Lowery Bretz, 2015). During the previous year's demonstrations, it was obvious that many students had failed to make the link between operation and theory and were also struggling with recall of the laboratory manual or the initial demonstrator briefing. Students were often disengaged during these briefings and felt "*burdened with even more information*" and were finding it "*hard to link the manual, briefing and experiment together"*. Further comments about "*difficulty remembering the briefing content*" and it being "*unexciting*" reaffirmed our concerns with what was being supplied for their preparation. Hence there was a clear need to develop something that the demonstrator can use to improve student confidence, increase the ease of processing the experimental information and retain the students' attention during laboratory briefings.

To this end, the key information for the selected experiments was extracted from the laboratory manual and displayed as single words or phrases and images or diagrams, hand drawn on coloured card, (ensuring that any colour combinations would be discernible to colour blind students) and pinned to corkboards. Corkboards were used to allow for constant modification throughout the semester. It was also important that the visual aid was portable, as they need to be taken in and out of the shared undergraduate laboratory for every practical session, and modifiable, so that any changes or adaptations were easy to make. Other considerations include the need for durability, as they are used weekly throughout the semester, and the laboratory environment: for example, it is not always practical to have large displays or electronic screens.

To determine what elements of the experiment to include, the key aspects were extracted from the laboratory manual, including important chemical mechanisms, mathematical and chemical equations in addition to safety key words. Any parts of the experiment that the students usually find complex were also included in the form of hints, tips and reminders. Due to the importance of teaching with emotional intelligence (Mortiboys, 2011), it was felt that using handmade or hand-drawn diagrams was important to show the students that the demonstrator cares and is willing to put in the effort to support their learning. Bright coloured card and markers were used to ensure that the boards were visually appealing so that the students' attention was attracted and retained during the briefing.

The boards were displayed in an easily visible position before the students entered the laboratory, with the demonstrator standing next to the picture boards ready to deliver the briefing. The demonstrator is then able to refer to specific

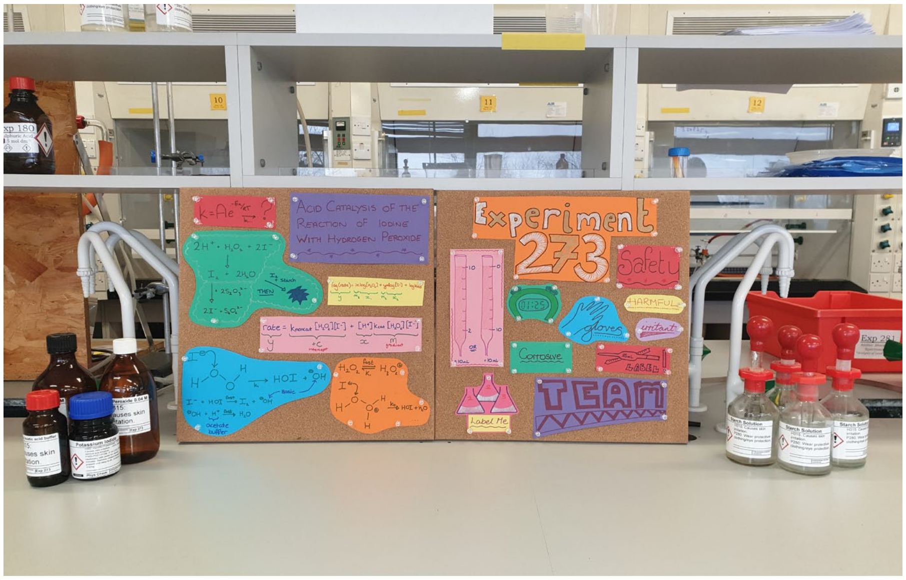

Figure 1 An example display of picture boards for a second year physical chemistry experiment

diagrams and images to emphasize the most important aspects of the experiment. Once the briefing is complete, the boards are left in clear view of the students, so that they can easily refer to them at any point in the experiment in order to increase their retention of the briefing's information.

For physical chemistry experiments, the significant mathematical equations can be displayed on the boards and used to subsequently discuss the physical chemistry calculations that are needed for the associated write up, at the end of the practical session. An example picture board display used for one of the two selected experiments is shown in figure 1. The picture board briefings would last the same time as the traditional verbal briefings (10 minutes approximately).

Evaluations

The picture boards integrated seamlessly into the demonstrator briefings for the two selected experiments and were well received by the students. From the instructor's point of view, the students were more attentive, asked better questions and retained their focus during this initial briefing for the experiment. When asked about the boards, 55% of the respondents strongly agreed and 43% agreed (a total of 98% agreement) that they found the use of picture boards beneficial to their practical tuition.

To evaluate further the effectiveness of the picture boards, the students were asked a series of additional Likert questions *via* a survey at the end of their practical sessions that utilized picture boards. The students were each given an anonymized questionnaire post experiment and asked to state (select) whether they strongly agreed, agreed, disagreed or strongly disagreed with the statement presented about the use of picture boards during the practical session. Of the 75 first year students that completed the practical session in which picture boards were used, 69 completed the survey. For the second-year students, of the 78 students that completed the practical session, 74 completed the survey. The data for each year group was consistent and hence it seemed acceptable for them to be combined and represented in a single 143 student sample size, the results of which are communicated in table 1.

Pleasingly the data collected during this targeted survey was overwhelmingly positive towards using picture boards during the demonstrator's briefings and throughout practical sessions. Most students (90%) preferred briefings that utilized visual aids over those traditional briefings that did not use a bespoke visual aid (such as a

	% Strongly Disagree	% Disagree	%Agree	%Strongly Agree
I prefer visual demonstrator briefings over those that use no visual aids	3	7	35	55
I prefer demonstrator briefings using picture boards over other briefings I have experienced	1	1	49	47
I feel more confident and prepared for the experiment after a briefing using picture boards	0	3	69	27
Picture boards during the demonstrator briefing make it easier to process the information	0	1	53	48
The use of picture boards helped me to visualise the experiment	1	15	55	29
The use of picture boards helped to retain my attention during the demonstrator briefing	0	9	57	34
The use of picture boards made the briefing more interesting	0	3	54	43
Picture boards are useful to refer to throughout the experiment	0	14	54	31
Overall, I found the use of picture boards in the demonstrator briefing beneficial	0	2	43	55

Table 1 Likert data for the positive student reception and usefulness as a tool to help students share research and connect to their department's research

picture board) during the demonstrator's presentation. For context, the other briefings would be verbal discussion, demonstrator guided highlight and annotation of the laboratory manual with tertiary information or operative tips and sample set-up of glassware.

When asked specifically about the use of picture boards for the visual presentation, 98% of the students surveyed stated that they preferred experiment briefings where the demonstrator used a picture board as a visual aid over all other briefing types they have experienced for the other experiments. Several students commented that the use of picture boards was *"different"* and *"creative"* and one student noted that this experiment *"was the only one that used a board, which was good".* It was noticeable during sessions that the use of picture boards was also successful in causing the students to feel more confident and prepared for their practical work after the briefing, with a 96% happy factor (strongly agree or agree) being returned when surveyed. Student comments reflected that the boards *"helps [them] feel more confident with the experiment"* because the visual aids allow them to have *"more independence as [they are] not having to constantly question the demonstrator"*.

The data collected also helps to validate another main aim of the picture boards, which was to make the briefings more engaging and the experiment information easier to process. Impressively, 142 students out of the 143 respondents agreed or strongly agreed that the experimental information was easier to process due to the use of picture boards, most likely due to it being less daunting to work through than a large block of text. This is supported by the student responses, with students commenting that it was *"really helpful seeing the key information not in a block of text like in the manual"* and that the boards were *"very useful"* because they *"often find too much information in the lab manual but the board summarized it neatly".* From this we can perhaps suggest that this approach has enabled better contextualization and led to a reduction in cognition when preparing for the session's experiment.

During these briefings we also made sure that thorough verbal delivery of information was consistently contextualized and backed-up with reference to the visuals mounted on the board. An 84% of the students reported that the boards helped to visualize the experiment and 91% of the respondents agreed or strongly agreed that the picture boards helped to retain their attention during the briefing. A majority of 97% agreed that the briefings were more interesting with the inclusion of picture boards. For this, students reflected that the briefing with picture boards was *"visually engaging"* and made them feel it was *"an interesting experiment",* with one student highlighting that they *"enjoyed the presentation at the start of the experiment".* Finally, an added benefit of the boards is clearly their longevity to the session, enabling better retention of the briefings information and the reassurance of being able to review back to the key demonstrator points. An 86% majority of students agreed or strongly agreed that the picture boards were useful to refer to throughout the experiment, highlighting that the picture boards are not limited to initial experimental briefings and have a use throughout the session.

Conclusion

As a result of using picture boards in a demonstrator's laboratory briefings or instruction, students are more confident, better contextualized and appear more engaged from the start of the briefing until the end of the practical session. Fewer questions about the procedure or other key aspects discussed in the initial briefing were asked throughout the practical component, indicating not only a greater retention of the briefing material, but also in the students' confidence in their own practical ability. The majority of students preferred this style of highly visual demonstrator briefings and reported that the success of the picture boards toward information retention, experiment visualization and information processing.

Notes and Acknowledgements

Larger image copies of each of the experiment's picture boards are provided as PDFs in the supporting information.

The methods used to evaluate the student perceptions and performance data was carried out in accordance with the University of Leicester's Code of Practice for Research Ethics.

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References

Agustian, H.Y. & Seery, M.K. (2017) *'Reasserting the role of pre-laboratory activities in chemistry education: a proposed framework for their design'*, Chemistry Education Research and Practice. Royal Society of Chemistry, 18(4), pp. 518–532. DOI: 10.1039/c7rp00140a.

Ardisara, A. & Fung, F. M. (2018) *'Integrating 360° Videos in an Undergraduate Chemistry Laboratory Course'*, Journal of Chemical Education. American Chemical Society, 95(10), pp. 1881–1884. DOI: 10.1021/acs.jchemed.8b00143.

Blackburn, R.A.R., Villa-Marcos, B. &Williams, D.P. (2019) *'Preparing Students for Practical Sessions Using Laboratory Simulation Software'*, Journal of Chemical Education. American Chemical Society, 96(1), pp. 153–158. DOI: 10.1021/acs.jchemed.8b00549.

Chaytor, J.L., Al Mughalaq, M. & Butler, H. (2017) *'Development and Use of Online*

Prelaboratory Activities in Organic Chemistry to Improve Students' Laboratory Experience', Journal of Chemical Education, 94(7), pp. 859–866. DOI: 10.1021/acs.jchemed.6b00850.

Climent-Bellido, M.S. et al. (2009) *'Learning in Chemistry with Virtual Laboratories',* Journal of Chemical Education, 80(3), p. 346. DOI: 10.1021/ed080p346.

Committee on Professional Training. Undergraduate Professional Education in Chemistry: ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs; American Chemical Society: Washington, DC, 2015. https://www.acs.org/content/dam/acsorg/about/g (no date). Available at: www.acs.org/cpt (Accessed: 11 April 2019).

Dechsri, P., Jones, L.L. & Heikkinen, H.W. (2002) *'Effect of a labratory manual design incorporating visual information-processing aids on student learning and attitudes'*, Journal of Research in Science Teaching, 34(9), pp. 891–904. DOI: 10.1002/(sici)1098-2736(199711)34:9<891::aid-tea4>3.3.co;2-9.

Dekorver, B.K. & Towns, M.H. (2015) *'General Chemistry Students' Goals for Chemistry Laboratory Coursework'*, Journal of Chemical Education, 92, pp. 2031–2037. DOI: 10.1021/acs.jchemed.5b00463.

Galloway, K.R. & Lowery Bretz, S. (2015) *'Measuring Meaningful Learning in the Undergraduate Chemistry Laboratory: A National, Cross-Sectional Study'*, Journal of Chemical Education, 92, pp. 2006–2018. DOI: 10.1021/acs.jchemed.5b00538.

Galloway, K.R., Malakpa, Z. & Lowery Bretz, S. (2015) *'Investigating Affective Experiences in the Undergraduate Chemistry Laboratory: Students' Perceptions of Control and Responsibility'*, Journal of Chemical Education, 93, pp. 227–238. DOI: 10.1021/acs.jchemed.5b00737.

Johnstone, A.H. & Wham, A.J.B. (1982) *'The demands of practical work'*, Education in Chemistry, 19, pp. 71–73. DOI: 10.1037/10855-002.

Johnstone, A.H. (1997) *'Chemistry Teaching - Science or Alchemy? 1996 Brasted Lecture',* Journal of Chemical Education, 74(3), p. 262. doi: 10.1021/ed074p262.

Mortiboys, A. (2011) *Teaching with Emotional Intelligence : A Step-By-step Guide for Higher and Further Education Professionals*. 2nd edn. Florence: Routledge.

Reid, N. & Shah, I. (2007) *'The role of laboratory work in university chemistry'*, Chemistry Education Research and Practice, 8(2), pp. 172–185. doi: 10.1039/B5RP90026C.

Robinson, W.R. (2009) *'A View of the Science Education Research Literature: Visual Aids in Laboratory Manuals Improve Comprehension',* Journal of Chemical Education, 75(3), p. 282. doi: 10.1021/ed075p282.

Royal Society of Chemistry (2017) *Accreditation of Degree Programmes.* Available at: http://www.rsc.org/images/Accreditation criteria 2017- update july 17_tcm18-151306.pdf (Accessed: 8 April 2019).

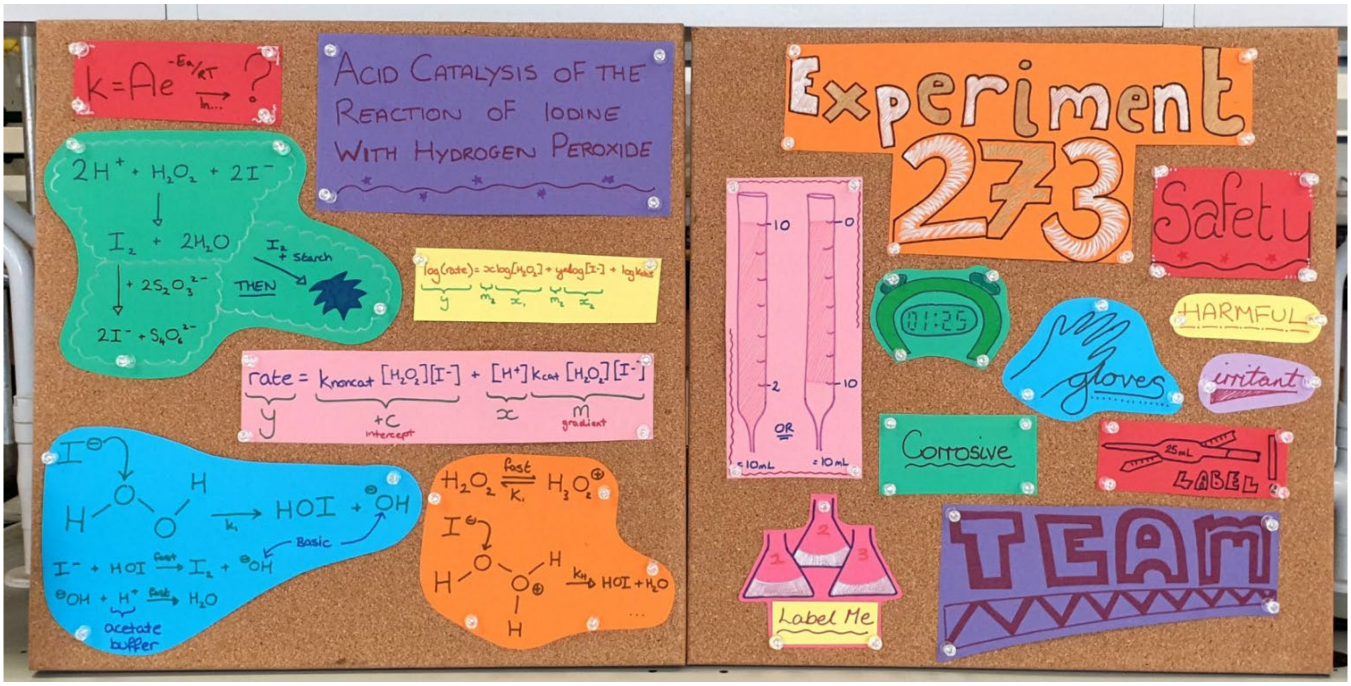
Schmidt-McCormack, J.A., Muniz, M.N., Keuter, E.C. Shaw, S.K. & Cole, R.S. (2017) *'Design and implementation of instructional videos for upper-division undergraduate laboratory courses'*, Chemistry Education Research and Practice, 18(4), pp. 749–762. DOI: 10.1039/c7rp00078b.

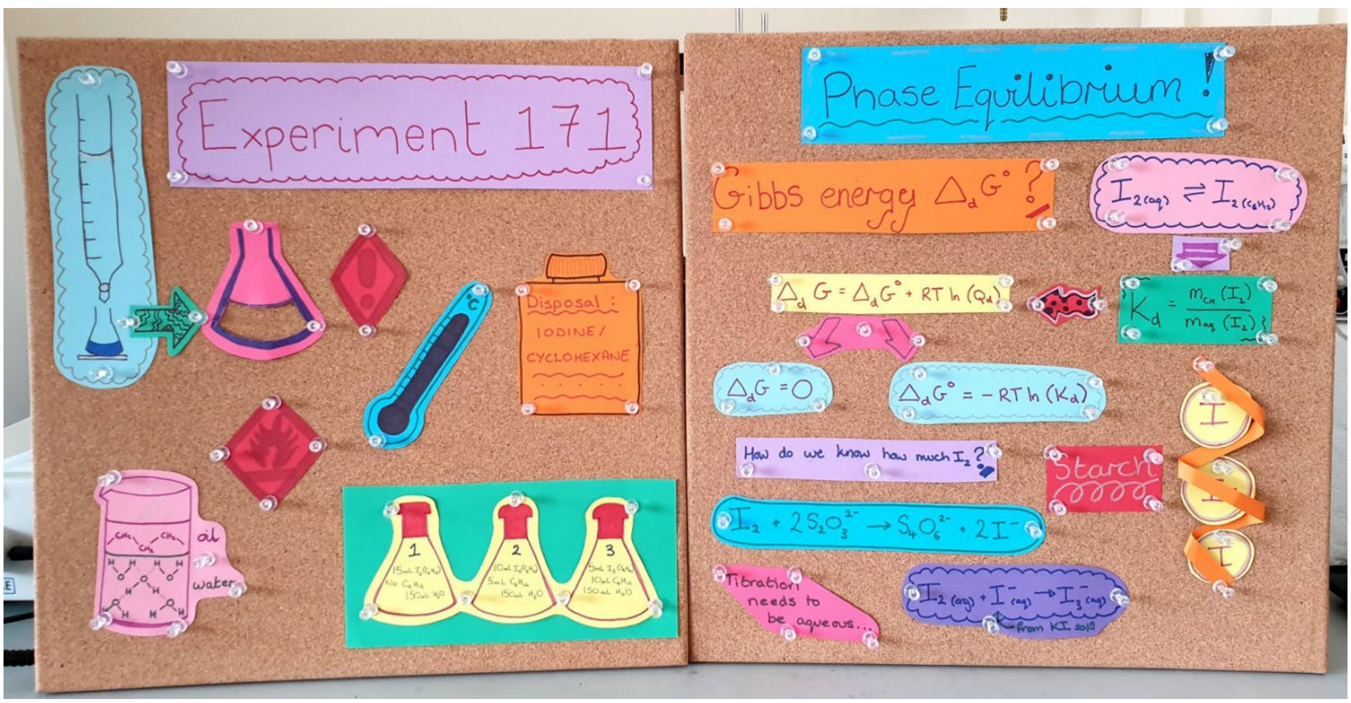
Shabiralyani, G., Hasan, K.S., Hamad, N. & Iqbal, N. (2015) *'Impact of Visual Aids in Enhancing the Learning Process Case'*, Journal of Education and Practice, 6(19), pp. 226–234. Available at: www.iiste.org.

Stieff, M., Werner, S.M., Fink, B. & Meador, D. (2018) *'Online Prelaboratory Videos Improve Student Performance in the General Chemistry Laboratory',* Journal of Chemical Education, 95(8), pp. 1260–1266. Doi: 10.1021/acs.jchemed.8b00109.

‘Visual aids in chemical education’ (1930) Journal of Chemical Education, 7(4), p. 828. doi: 10.1021/ed007p828.
Wei, J. et al. (2018) ‘Developing an understanding of undergraduate student interactions in chemistry laboratories’, Chemistry Education Research and Practice. Royal Society of Chemistry, 19(4), pp. 1186–1198. doi: 10.1039/c8rp00104a.

Supplementary Materials





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