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Chemistry Students' Perceptions of 'Active Learning'

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Abstract

Whilst active learning strategies have been gaining increasing attention over recent years, the traditional lecture has remained commonplace in higher education teaching. However, the Covid-19 pandemic has provided stimulus for educators to re-examine the most effective way to teach their subject with spotlight on active learning strategies. This article explores chemistry students' understanding of the term 'active learning'; the main features and how this relates to the learning that occurs in lectures. It also encourages contemplation about post-pandemic teaching and learning – should we remove lectures completely or is further consideration required?

Introduction

Active learning is defined as '*any instructional method that engages students in the learning process'* [Prince, 2004]. This is in direct contrast with instructor-focussed didactic teaching experienced in traditional lectures, which are deemed to promote mainly passive learning, [Revell & Wainwright, 2009], and have been widely discredited as being effective for student learning [Bligh, 2000]. Michael [2006] has identified five key principles of active learning (Table 1).

Key Principles of active learning [Michael, 2006]	Code
'Learning involves the active construction of meaning by the learner'	***Constructivism***
'Learning facts and learning to do something are two different processes'	***Problem Solving***
'Some things that are learned are specific to the domain or context in which they are learned, whereas other things are more readily transferred to other domains'	***Knowledge Transfer***
'Individuals are more likely to learn more when they learn with others than when they learn alone.'	***Collaborative***
'Meaningful learning is facilitated by articulating explanations, whether to one's self, peers or teachers.'	***Explanation Articulation***

Table 1: Key principles of active learning

There is growing evidence that active learning strategies lead to enhanced learning in the physical sciences [Freeman, 2014; Partenan, 2018; Prince, 2004; Ruiz-Primo, 2011]. A plethora of activities can be used to promote active learning in chemistry classes. These may involve in-lecture activities such as worked problems [Crippen and Brooks, 2009], in-class polling activities [Christianson, 2017], whole class discussions [Orvis and Orvis, 2005], or complete classroom flipping [Seery, 2015]. The latter may employ a range of specific instructional techniques such as problem-based learning [e.g. Belt et al. 2002; Wang, 2003], process oriented guided inquiry learning [e.g. Moon et al. 2017] or team-based learning [Capel et al., 2021].

The Covid-19 pandemic has stimulated educators to scrutinise educational strategies, [Ewing, 2021; George-Williams, 2021] and the sector now looks towards promotion of more active learning strategies. However, in order for these to be effective, educators need 'buy-in' from students, which involves understanding of active learning alongside it's benefits and objectives. The aim of this research study is to determine chemistry students' perceptions of the term 'active learning'. The data presented in this article, although collected pre-pandemic, give important insight into chemistry student perceptions; their understanding of the term 'active learning' and the learning they perceive to take place in lectures.

Methodology

Research Question: *What do 3rd year chemistry students understand by the term 'active learning'?*

Ethical approval for this project was obtained through the School of Social Science and Public Policy Student Projects Ethics Committee at Keele University. The data used in this article was collected as part of a wider questionnaire (relating to the use of Team Based Learning in chemistry teaching) using open ended questions, deployed to 3rd year chemistry students (N=63) in a timetabled face to face session in September 2017. The students were studying a specific module (CHE30042) as part of either a 3 year BSc or 4 year MChem programme at Keele (N=40) or 3+1 BSc articulated degree programme between Nanjing Xiaozhuang University, China and Keele (N = 20). Answers to the question '*Please indicate what you understand by the term active learning*' were analysed via thematic analysis by the author, according to a method reported by Bree and Gallagher [2016], and checked by a 3rd party to ensure credibility.

Results and Analysis

Perceptions of Active Learning

Following thematic analysis of responses to the question asking students to explain what they understood by the term active learning, four themes were emergent (see Figure 1). In-class active learning '*requires prior knowledge*' and '*being prepared',* which provides the scaffolding upon which knowledge is constructed. '*Solving problems'* and '*engaging with learnt content and applying it in some way*' have also been highlighted as important points in active learning, demonstrating how higher levels of Bloom's taxonomy can be accessed through active learning strategies. '*Learning as part of a group'* and '*actively participating in discussion/debate with peers*' highlight the emphasis on a collaborative learning experience, where '*one can learn from another*'.
Implicitly, learning actively involves being engaged with learning or '*learning where you participate'*. The three themes previously discussed: *preparation*; *collaboration* and *application*, all contribute to engagement. As part of the theme of engagement, there was a strong emphasis on student responsibility and effort. Students must '*choose to learn*' to take part in active learning and it '*requires more individual effort*'.

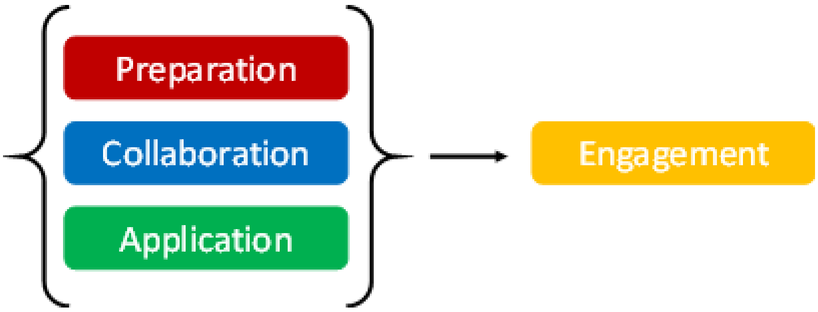

Figure 1: Themes emerging from the research question: *What do 3rd year chemistry students understand by the term 'active learning'?*

The themes that have emerged broadly map onto some of Michael's five principles of active learning [Michael, 2006] (Table 2). Michael's principle of active learning that does not appear in these results is *Knowledge Transfer*. This is a particularly important aspect of a chemistry curriculum where knowledge and concepts taught in one module are applied in a later module. However, students can be prone to thinking about knowledge in terms of the discrete content of a module, rather than how they might apply it elsewhere. For students on the MChem programme at Keele, there is a synoptic module where links and knowledge transfer is explicit, however students on that degree programme participating in this research project would not yet have studied it.

Key principles of active learning	Themes
Constructivism	Preparation
Problem Solving	Application
Knowledge Transfer	N/A
Collaborative Learning	Collaboration
Explanation Articulation	

Table 2: Alignment of Key principles of active learning [Michael, 2006] to themes emerging from the research question: *What do 3rd year chemistry students understand by the term 'active learning'?*

Perceptions of Lectures

As part of the themes that emerged was the widespread perception that active learning was the '*opposite of lectures*' (despite the specific question not mentioning lectures). Table 3 provides examples of responses relating to each of the themes discussed above, comparing these to lectures.

It is apparent from these responses that, in general, students see lectures as a method for content transmission, where they are '*talked at'* and are '*passively listening'*. Indeed Andrews [2011, p394] defines active learning as when '*an instructor stops lecturing and students work on a question or task designed to help them understand a concept*'.

Theme	*Student Quotes*
Preparation	*'Active learning is learning the topic yourself,…rather than being taught it all in lectures'* *'… so as opposed to sitting there listening to lectures, you would go and study in advance on your own'*
Collaboration	*'When you directly engage in the process via debate, asking questions and discussion. This is different from passive learning such as just listening to a lecture'* *'Learning via working through problem solving with each other, instead of just being talked at in a lecture'* *'Discussion, doing questions etc. opposite of lectures'*
Application	'Participating in discussion/problem solving *as oppose to listening to information and trying to memorise'* *'Applying your knowledge as you have been taught rather than being spoken at'*
Engagement	*'Actively participating in activities rather than passively listening to a lecture'* *'the involvement of a student. Passive learning could be from listening to a lecture. Active learning is where the student is involved by practice'*

Table 3: Student quotes relating lectures to each of the themes identified in students' understanding of active learning.

It is interesting to reflect upon students' perceptions of lectures. The majority of the chemistry teaching staff at Keele (and elsewhere) build interactivity (and hence active learning strategies) into their lectures, for example through worked problems, student discussion or electronic voting devices. However, students do not perceive active learning to take place in lectures. It is possible that students are less willing to participate in activities designed to enhance active learning in a class that is labelled as a 'lecture'. It is also worth considering that some students need more time to assimilate information before they are able to complete problems:
'Going to lecture and being told on the spot 'do the question', I can never do it'
It is possible that any active learning strategies that take place during lectures should expect students to operate at the lower end of Bloom's taxonomy to allow students time to construct appropriate scaffolding before moving on to higher level application.

Despite the perception that active learning does not take place in lectures alongside evidence showing active learning strategies are more effective, there is substantial literature evidence that students want to retain lectures [e.g. Marmah, 2014; Yeung and O'Malley; 2014]. Students may struggle to adapt to a fully active learning model and want the familiarity of lectures [Haidet, 2004] or may worry they are not covering all the material [Qualters, 2001]. These are important considerations for planning teaching in post-pandemic HE.

Conclusion and Implications

The data obtained is this investigation indicate that 3rd year chemistry students at Keele have a coherent understanding of what active learning involves. However, they have not identified the ability to link between topics as a key aspect of active learning and this may be the result of modular degree programmes. What is not clear is whether this understanding has been gained through exposure to various active learning techniques throughout their degree programmes, and whether students at lower levels of their degrees share the same understanding of the term. This warrants further investigation.

It is also apparent that they do not believe that active learning occurs in lectures, but it is not clear what they are identifying as a 'lecture'. The upheaval of the pandemic gives good cause not to return to the didactic instructor-focused lecture. However, it is likely that a large number of university educators have not been lecturing in this manner for many years prior to the pandemic. It is perfectly possible to include a range of active learning strategies within a lecture setting, which has focus on both content delivery and student-centred learning techniques. A balanced curriculum that appeals to a wide range of student preferences and learning styles may include a combination of flipped classroom strategies alongside lectures. This is the time to focus on active learning strategies, not necessarily by removal of the lecture, but by reframing what a lecture is. As part of this, it may be necessary to attach a different name (e.g. '*Interactive lecture'* or '*Content delivery seminar/workshop*') to avoid the synonymous association of the term 'lecture' and 'passive learning' held by students.

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