Evaluation of an Inquiry-based laboratory approach

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Consider one or more of the following concepts in your prospective or existing approach or project summary:

- Embodied
- Experiential and participative
- Co-constructed
- Emergent
- Situated
- Engaged

Summary of an approach or project to enhance employability (1000 words):

Science investigates unknowns; it can be unpredictable and require higher level cognitive skills to be successful. Whether in research, industry or clinical settings, the vast majority of employment in the scientific field relies upon competency at complex problem solving and critical thinking. This is in line with the trend of top skills required across all disciplines, highlighting the transferrable benefit of these qualities (World economic forum, 2018). Here I will discuss and evaluate the approach of inquiry-based laboratory classes to enhance student employability, reporting on its application as group work, within a life sciences discipline at foundation year level.

An inquiry-based method introduces co-constructed, emergent learning through the design and implementation of a personal investigation (Domin, 1999; Martin-Hansen 2002). Case studies using inquiry-based approaches are often implemented within chemistry disciplines due to the analytical and quantitative nature of the work. These also tend to span a long

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time frame and involve more capable students (McDonnell, 2007; Sandi-Urena, 2012; Fakayode, 2014). However, the principles and selected elements can be applied to a wider variety of disciplines and scaled up to larger cohorts, retaining the benefits observed (Cummins, 2004; Bugarcic, 2012).

These benefits have been compared to the traditional scripted laboratory whereby using a deductive approach, predetermined outcomes known to the student are verified. Whilst there is the advantage of scripted laboratories facilitating students to achieve advanced practical skills and quality results in a short period of time, there can be a tendency for students to overlook an understanding of the process and application of knowledge (Szalay, 2016). As a non-contextual example; '*A baker adds the recipe-dictated quantity of baking soda and is complemented on the delicious cake produced. However, without understanding the role and impact of the ingredient or procedure, the baker would fail to improve upon a cake that has not risen, nor could they apply the use of certain steps or ingredients to other recipes'.*

The scripted style remains the predominant approach used today despite the fact that this has long been the most heavily criticised method (Hodson, 1996; Domin, 1999). It is worth noting that often accompanying pre- or post-laboratory exercises and report writing can often allow the chance for reflection and evaluation in learning; however these would arguably only be enhanced from an original inquiry approach.

Scripted laboratory classes are generally designed to robustly "succeed" and emphasis is placed on the results. However, by introducing co-construction with the student, they could enhance regulatory metacognitive skills through practise of declarative, procedural and conditional knowledge with activities such as planning, monitoring and evaluating (Sandi-Urena, 2012). Arguably, scripted laboratories miss the opportunity to challenge student's higher levels of learning that could be achieved through inquiry-based approaches. Whilst practical and technical skills develop in a dynamic, technological era; the underlying planning, organisation and problem solving abilities remain vital employability attributes applied to any scientific context.

Here, an inquiry-based approach was introduced for a 3 laboratory class series at foundation year level with around 70 students. In open-inquiry style, students formulated, designed and developed a mini-project to investigate. They were given permission to be creative and allowing freedom to select an area of interest. The personal ownership and control over selecting the investigation engaged and empowered students, increasing curiosity, effort and immersion in the work. This was evidenced by feedback that 56/58 students agreed that they "liked having the freedom to select our own topic".

It is important to note that although this is a student-centred approach; guidance and support from tutors throughout remains vital to ensure correct focus and to continue to challenge the students. Whilst the students take the lead, there should always be an opportunity for feedback, and during the progression of work tutors can nurture and stimulate additional ideas. 37/58 students "strongly agreed" that "Having to design my own experiments made me engage with the content more" with 15/58 "agree", 5/58 "neutral" and only 1/58 "disagree", therefore it is paramount to maintain a suitable balance of facilitation over decision making. Furthermore, as reported by Deters (2005), in many cases students required additional affirmation of their thoughts and ideas, before gaining the confidence to proceed.

An open structure of an inquiry laboratory also allows reflection and assimilation (Kolb, 2014). Performing all planning and execution steps facilitates a greater ability to apply critical thinking to resolve issues. Whereas the traditional lab set-up can cut short the experiential learning cycle by not providing the opportunity to evaluate and adapt for improvement through experimentation. Student's recognised this with only 1/58 students disagreeing that "Performing research with unknown results enhanced my critical thinking and problem solving skills".

With some investigations testing unknown outcomes or allowing the possibility for multiple outcomes, a level of emergent learning and authentic assessment is introduced (Szalay, 2016). It is thought that through the discovery of new information there is a level of personalisation acquired that creates more meaningful and better retained knowledge (Sandi-Urena, 2012). However, depending on the scale and level of the work (Hodson, 1996) also argues that: *"You cannot discover something that you are conceptually unprepared for.*

You don't know where to look, how to look, or how to recognize it when you have found it". It is therefore important that there is sufficient time and support to analyse and reflect, along with a suitable background provided from taught classes and supporting materials.

Overall, there were 47/58 students who agreed that "I feel that I learnt more from running our own project compared to following prescribed protocols" with 5/58 neutral and 5/58 disagree. Although interestingly, only 39/58 agreed to "preference of running our own project compared to following prescribed protocols" with a higher 14/58 neutral and the same 5/58 disagree. This suggests a self-acknowledged benefit to the approach, but with some challenges. Whilst there is a role for scripted laboratories, there are striking advantages demonstrated by an inquiry-based approach. Combined with literature case studies and the added credence of associated pedagogical background, this is a viable approach deserving additional consideration in module design.

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