Developing transferable skills through embedding reflection in the science curriculum

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Abstract

A longstanding challenge for educators in Higher Education is the need to prepare students for their career journey after graduation. While theoretical foundations are needed, students should be able to apply knowledge in new contexts and be able to demonstrate and evidence life- and employability-skills valuable to employers. Many degrees provide students with the opportunity to develop transferable skills, for instance through giving presentations and working in teams. Nevertheless, students are not always able to reflect on their skills development, and on the connection between theory, practice and their learning. Authentic assessments can create links between theory and practice preparing students for the workplace. However, it is common to see the product of a particular activity being assessed, and not the process through which the product was produced. This may encourage students to value the end product over skills development, and therefore not appreciate how their University experiences prepare them for the workplace. Science students can struggle with self-reflection, and therefore may find it difficult to articulate and evidence skills during job applications. We present different ways to foster self-reflection when transferable skills are embedded and assessed in the curriculum. However, we claim that the process of reflection should be taught and supported and new ways of assessing students are needed to help them develop their ability to self-reflect.

Introduction

A longstanding challenge for educators, when teaching undergraduate and postgraduate students, is the need to prepare students for their career journey after their studies. There has been pressure on institutions to develop skills in their students outside of their subject of study (Bridgstock 2011, Blickley et al. 2013, Mello and Voelkel 2017). The need to develop a range of key competencies for university students to enhance their life- and employability-skills was introduced in the UK by the Dearing Report in 1997 (NCIHE 1997), and in Brazil by the National Curriculum Parameters in 2004 (Ministerio da Educacao e do Desporto 2004). Increasingly, due to the competitive job market, graduates are expected to possess the skills, knowledge, and the commercial awareness that allows them to contribute to an employer soon after starting employment. Various studies have attempted to identify the employers' desired skills required for graduate employment (Brown et al. 2005; Archer and Davison 2008; Stewart 2021) as there has been a shift from the need to demonstrate academic knowledge to be able to demonstrate and evidence life- and employability-skills, herein called transferable skills, when applying for jobs.

In the last decade or so, Universities have been evaluated by their ability to produce employable graduates (https://www.topuniversities.com/university-rankings/employability-rankings/2020) and students are not just considering universities' reputation but how they can prepare them for future employment (Conard and Conard 2000; Joseph, Mullen and Spake, 2012). In the UK, prospective students can also use the Graduate Outcomes Survey which captures the perspectives and current status of recent graduates (https://www.graduateoutcomes.ac.uk/) to look at future prospects. This change in student behaviour aligns with employers' views. Although they are generally satisfied with student academic ability, standards and the value of their degree qualifications, many still report that students are often not *workplace ready* and find it difficult to transition to a workplace environment (Andrews and Higson 2008, Succi and Canovi 2020, Hurrell 2016).

Therefore, students are looking for universities that offer opportunities for placements, the ability to network with employers and provide effective advice on careers.

Another important factor to be considered is that undergraduate bioscience students go on to a wide variety of careers. The majority of students studying science, technology, engineering and maths (STEM) subjects will not get a job in academia. Landivar (2013) reported that, approximately 46% of life sciences undergraduates go on to careers in STEM or STEM-related roles in the USA. The JISC/AGCAS report (2021) shows that in the UK 9.7% of biology graduates work as a science professional, 22% as associate professionals and technicians, and 8.2% as education professionals. With so many students working in fields unrelated to science, universities should address the needs of all students, and not just of those who will embrace masters and PhD studies. When embedding activities to develop transferable skills into the curriculum, educators should emphasise their transferability; and help students to identify the skills, and understand what they learned during the activity, including successes and failures. Activities should include a component of reflection on skills development and ideally this component should be assessed to increase student engagement.

This article will discuss the transferable skills that employers are looking for, the reflective process needed to evaluate skills development, and the benefits of embedding and assessing skills development in the curriculum.

Transferable skills

There are various definitions of what a transferable skill is, though the definition used in this study is that of Knight and York (2004) as ‘a set of achievements, understandings and personal-attributes that make individuals more likely to gain employment and be successful in their chosen occupations’. Some transferrable skills may be further described as employability skills, in the sense that they are specific skills which help facilitate transition to employment or more effective performance in employment (Whalley 2009). Table 1 shows different groups of transferable skills and provides definitions of the individual skill or attribute. The table content was adapted from a wide variety of sources, including research articles, conference notes, and different universities' career-focused documents either publicly available or provided by request.

The literature shows that skills development requires critical self-reflection of the process (Billet 2011a, Billet 2011b), and that experiential learning (Kolb 1984, Bonwell and Eison 1991) can lead to greater student awareness and engagement, and so be more effective than the didactic teaching of such skills. Hill and collaborators (Hill, Overton and Thompson 2020) showed that science students reported ‘unfamiliarity of thinking beyond knowledge attainment in order to identify and reflect on skill-related experiences’. It should be made clear to the students how skills developed in the classroom may be applied to real world scenarios and future jobs. More importantly though, skills development activities should be highlighted to students and properly assessed using authentic assessments as many students do not fully recognise such opportunities. Students are often assessment driven (Dale and Lane 2007; Holmes 2018) and unless transferable skills are assessed, they are often seen as optional, extra or co-curricular activities.

Developing transferable skills through reflection

The approach of reflection as a learning tool in education is not new (Gibbs 1988, Schon 1991). Gibbs’ reflective cycle aims to foster learning from experiences. It covers six-stages and its framework allow students to learn and plan from their positive or negative experiences. The six stages are (a) **description** of the experience, (b) **feelings** and thoughts about the experience, (c) **evaluation** of the experience, both good and bad, (d) **analysis** to make sense of the situation, (e) **conclusion** about what you learned and what you could have done differently, and (f) **action plan** for how you would deal with similar situations in the future, or general changes you might find appropriate. Atkins and Murphy (1993) proposed a three-stage model of the reflective process where the outcome of reflection is learning: (a) awareness of uncomfortable feelings and thoughts, (b) critical analysis of feelings and knowledge, and (c) new perspective. Here, some of the stages previously reported by Gibbs (1988) were presented as skills needed in the reflection process: self-awareness, description, critical analysis, synthesis and evaluation. Both models aim to promote students’ reflection on their experiences and when applied to transferable skills development, it can foster students’ self-awareness. Although the use of reflective practice is common in clinical programmes helping the future professionals to become self-aware

about their role, behaviour and interactions within the workplace (Atkins and Murphy 1994, Smith and Roberts 2015), it is well known that science students can struggle with reflection (Taylor, Rogers and Veal 2009; Voelkel, Mello and Varga-Atkins 2018). Therefore, when proposing activities to help students to reflect on skills development, educators should be aware that not all students will have the skills needed for reflection, and that such skills need to be developed during education (Atkins and Murphy, 1993).

In the context of transferable skills, Pool and Sewell (2007) proposed a practical model of graduate employability. In this study, they describe that many students struggle with reflection of skills development during their Higher Education. This difficulty in reflecting can lead to them being often unable to articulate specific examples of how they can demonstrate competency in such skills at interview or in job applications. More than 10 years later, the need to improve students' reflective ability was also illustrated by Voelkel, Varga-Atkins and Mello (2018), where it was shown that students' willingness and ability to reflect on their learning process during their final year dissertation was patchy. This corroborates that reflection on skills development does not come naturally to students studying science, indicating that more training in the skills of reflection earlier on in their course is needed. Mello, Varga-Atkins and Edwards (2021) showed that a scaffolded reflective process is needed to support students during the reflective process. Students may benefit from having clear questions to prompt reflection when describing an activity leading to learn and skills development (Table 2).

Embedding skills development

One of the issues in the skills debate is developing methodologies to teach and assess skills effectively (Chadra 2006). Several approaches have been described for developing skills within the higher education curriculum ranging from standalone development to embedding skills within the subject context (Hodgkinson 1996; Chadra 2006; Harvey 2000; Baker and Henson 2010). It's important however to consider how skills will be developed across the undergraduate degree programme rather than at a year or module level (Drummond, Nixon and Wiltshire 1998).

Chadra (2006) describes using three different approaches across the curriculum to obtain the most benefits. The first approach they describe is *embedding*, where the emphasis is on promoting the development of technical 'know-how'. The second approach is *bolting on*, where skills are developed independently of the core subject knowledge and the third approach is *integrating* where skills are developed and taught within the core subject knowledge with similar emphasis placed on development of the skill and technical 'know-how'.

One positive of embedding skills into the curriculum is allowing students to develop a broad range of skills alongside the development of subject specific knowledge and it can also be easier to embed skills rather than integrate or bolt them on (Fieldhouse 1998; Chadra 2006). However, one danger of embedding skills is the visibility of skill development and students not recognising the skills that they are developing. Scott (2005) found that many bioscience students were unaware of skills training when it was embedded in modules and not formally delivered or included explicitly in module learning outcomes. Many students also find it difficult to articulate the full set of skills that they have acquired during their university education in job applications and interviews (Pool and Sewell 2007).

In order to equip students with the required transferable skills, universities will either incorporate skills-based learning outcomes into subject specific core modules or have formal skills modules alongside the academic curriculum (Harvey 2000; Baker and Henson 2010). Reflection is an important part of skills development as students need to be able to reflect upon skill development and later articulate their skills to employers. It is also important when developing skills that there are opportunities to practice skills with support, guidance and reflection (Drummond, Nixon and Wiltshire1998; Mello, Varga-Atkins and Edwards 2021).

Assessing skills development

As previously mentioned, we need to find ways of assessing skill development as most students are assessment driven and may not engage fully in the process without it. Using real-world scenarios also means that the assessment is authentic. When designing assessments, there needs to be careful planning, pedagogical reflection

and some experimentation to see what works and is feasible in practice. Many skills modules are delivered to whole cohorts and so class sizes can be large meaning the assessment also needs to be manageable. There also needs to be development of skills across the curriculum. In our experience, skills development in the early years of a degree tends to focus on communication and study skills, for example those skills and attributes shown under the communication and time management groups in Table 1. In the later years, there is a shift to developing advanced skills related to subject discipline, so for example those skills and attributes grouped into professional development and personal attributes in the same table.

From the skills and attributes shown in Table 1, some are more commonly assessed than others. For example, communicating to a lay audience can be assessed by a piece of lay writing and asking a non-expert to mark the work whereas other things such as time management (prioritisation, organisation, etc) are difficult to assess within a particular activity and so it may be more valuable to ask students to reflect on development of these types of attributes and evidence them in a portfolio. In addition, it is common to see the product of a particular activity, even if designed to foster skills development, being assessed and not the process through which the product was generated. However, the product is often assessed on academic knowledge or content, whilst the process, the skills development is not assessed. Therefore, students may not see the relevance of these skills (the process), or more generally, how their university experience prepares them for the workplace. Asking students to reflect on the process can be a way to bridge this gap, as discussed below.

Some other skills and attributes can be combined into single assessments. Group work is a good example how transferable skills can be encouraged in higher education (Candy 2000). So for example students could work together in small groups on a real-world problem and deliver an oral presentation, produce a collaborative written report or produce a conference style poster. But as just mentioned, group work assessments usually explore the by-product of the group work rather than the skills related to the activity. Aspects of peer evaluation can be built into the assessment to provide feedback to students on their group work by other group members (Davies 2009; Gibbs 2010; Mello and Voelkel 2017). While this approach helps to deal with mark fairness (Fellenz 2006), it also give the students the power to assess their peer skills and this practice has its own limitations. Aiming to address skills development, a suggestion would be to include a reflective process linked to the activity, where students would need to self-evaluate themselves before and after the group work through a skills audit, combined with a reflective exercise on skills development (Kensington-Miller et al. 2018).

Skills audits and portfolios are useful assessment methods as they allow students to audit their existing skills and identify gaps or areas of weakness that they need to focus on for future development. An important aspect of skills audits and portfolios is students being able to return to previous audits/evidences to be able to reflect on how they have improved and identify new areas for development. Studies show that while skills audits are a useful tool for self-evaluation of skills attributes (Beard 2007, Baker and Henson 2010), their combination with portfolios can foster reflection and personal development (Yan, Tai, Lim 2016; McKenna, Baxter and Hainey 2017). The use of portfolios is common in clinical training ensuring students meet the requirements for professional registration (Kjaer, Maagaard and Wied 2006). As previously mentioned, reflection does not come naturally to science students. Students will need support from academics, as the use of portfolio *per se* will not teach students how to reflect. In a recent publication we reported on an online reflection log (e-portfolio) which incorporated a skills audit consisting of 13 skills and attributes (Mello, Varga-Atkins and Edwards 2021) to assess students' skills development during a placement. The study emphasised the need for formative feedback supporting students' development of skills reflection, as the portfolio has emphasised students' initial difficulties with the reflection process. However, this can be overcome and students will engage with reflection, if they are properly supported both before (clear explanation of what a skill audit and portfolio entail and aim to achieve) and during the process. The use of skills audits combined with reflection and skills development evidence along the years of studies can help students to produce a portfolio to be used for future job applications and interviews, increasing their employment chances. We also argue that recording skills may serve as a launchpad for self-reflection and continuing professional development.

Commercial awareness is another skill/attribute which is in high demand by employers but is often seen as lacking in graduates (Nabi and Bagley 1999; Archer and Davison 2008). Young (2014) also notes the importance of all students having access to enterprise and entrepreneurship education. While there are dedicated courses to prepare those who start a business, Clarke, Cornes and Ferry (2020) argue that science degrees should aim to educate the students to add to an existing business. Rogers (2010, 2011) identified a number of teaching methods for teaching commercial awareness including encouraging students to access industry resources and

watching useful business programmes. Poon and Brownlow (2014) examined student perceptions on the incorporation of commercial awareness in real estate education. As part of this study, they developed a taxonomy of commercial awareness to aid student understanding and a list of skills and attributes important for the development of commercial awareness (Poon and Barlow 2014). In this study, students commented that the most important skills and attributes for commercial awareness development were 'critical thinking' and 'ability and willingness to update professional knowledge'. They also thought that the most useful way of developing commercial awareness was through work experience or placements. Other ways of developing commercial awareness include creating opportunities for students to apply their knowledge to real-life situations and to interact with employers and work on employer-based problems. Clarke and colleagues (2020) used problem based learning and self-reflective teaching methodologies to teach non-business students how to be more valuable to a business within their degree subject. By using problem based learning and self-reflective teaching methods the authors were able to obtain a high level of student satisfaction and cohesion between the business elements and science.

Concluding remarks and recommendation

When designing a particular curriculum, educators need to create opportunities for skills development. As with knowledge-based content, skills development should be introduced gradually, alongside the teaching of the reflective process. This will help students become aware of the skills they are developing and recognise the importance of being able to articulate them to future employers. Universities have introduced skills development activities alongside the academic curriculum. However, to succeed, it is important that students can reflect on the connection between theory, practice and their own learning and development. Based on the concepts of 'assessment driven' (Dale and Lane 2007) and 'constructive alignment' (Biggs 1996), activities which include skills development as learning outcome should be properly assessed. The use of self-evaluation and reflection of skills development can help educators with constructive alignment while engaging students with their learning. Therefore, we recommend wider use of reflection in science curriculum and importantly that the reflective process is explained to students and supported by academics. University careers and employability teams are ideally placed to help support the introduction of careers-based initiatives into skills modules and can help to provide current knowledge of the skills and attributes that are in demand by employers. Employers are a source of real-world scenarios that can help with the creation of new authentic assessments. Although some skills and attributes seem to be easier to assess, we need more innovative ways to assess others. We need to be aware of the large diversity of transferable skills and find ways to embed them in the curriculum. Therefore, when designing skills development and assessments in the curriculum it is important to involve relevant stakeholders, adding relevance to the degree subject to engage students (Rae 2007).

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Conflicts of interest

The authors declare no conflict of interest.

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Tables

Table 1. Transferable skills and attributes glossary

Transferable Skill Group	Attributes	Definition
Team work	**Ability to work with others**	Collaboratively working in diverse teams
	Networking	Developing lifelong connections that are important for your career and social life
	Global citizenship	Having global consciousness and cultural competency on a worldwide scale
Professional development	**Career Management**	Planning your career, and setting goals and objectives
	Commercial Awareness	Understanding what makes any organisation successful and its reason for existing as a business
	Work ethics/ professional conduct	Promptness, good time keeping, appropriate appearance and accepting responsibilities
Communication	**Presentation**	Presenting concepts using different methods of communication
	Team work	Being able to communicate with others
	Listening	Being able to accept other's view and act accordingly
	Negotiation	Analysing a particular situation and finding a compromise when necessary, keeping emotions in check Adapting communication skills to different audiences/settings
	Audience awareness	Being able to communicate with different audiences including scientific and lay audiences
Personal Attributes	**Problem solving/ initiative**	Identifying opportunities and being proactive in suggesting ideas/solutions
	Quick and proactive learner	Taking on new tasks and accepting new responsibilities
	Resilience	Having the determination to succeed despite challenges and disappointments
	Tolerance for stress	Adjusting and coping with new or pressured environments
	Adaptability/ flexibility	Working effectively in a changing environment
	Drive and self-motivation	Self-confidence, independence and maturity
	A high degree of self-reflection and acceptance of criticism	Learning from experiences and mistakes and improving based off them
	Creativity	Conceptualising and designing with imagination to generate new ideas
Time Management	**Prioritisation**	Being able to decide on the next step according to their needs/importance
	Organisation	Having the ability to organise, prepare, set a goal, coordinate, meet deadlines and deliver
	Independence	Becoming self-aware, taking initiative and knowing what you need to do
	Work-life balance	Working effectively while enjoying time outside work

Main sources of information: Kensington-Miller, Knewstubb, Longley and Gilbert (2018); Mello, Varga-Atkins, Edwards S (2021); MacCallum and Casey (2017); https://resources.depaul.edu/career-center/faculty-staff/Documents/TransferableSkillsBooklet_05.14.18.pdf; https://liverpool.joinhandshake.co.uk/articles/50; https://www.gla.ac.uk/schools/engineering/students/personaldevelopmentplanning/skillsaudit/

Table 2. Gibbs reflective cycle and questions to support each stage

Stages of Gibbs' reflective cycle	Questions
Description Feeling Evaluation Analysis Conclusion Action Plan	What happened? When and where did it happen? Who was present? What did you and the other people do? What was the outcome of the situation? Why were you there? What did you want to happen?

Adapted from https://www.ed.ac.uk/reflection/reflectors-toolkit/reflecting-on-experience/gibbs-reflective-cycle