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# Science students develop multiple employability literacies from large, early-year courses without employability modules

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## Abstract

Concerns have been raised about the employability of Science graduates, however undergraduate Science curricula rarely focus on building employability. Our goal is to harness existing Science-focused curricula to improve Science graduate employability. In this study we asked whether students could identify learning of employability literacies from their experiences in undergraduate Science courses that do not explicitly teach employability literacies. To address these questions, we employed a short reflective activity in three large first year courses; these courses focused on scientific content and processes, and did not include employability modules. We asked students to choose an employability literacy from a menu and describe how components of the course prompted them to develop this literacy. Students chose a wide variety of literacies and linked their development to multiple aspects of their course experience. They also consistently indicated they had achieved multiple literacies from their course. Course coordinators highlighted the strength-based quality of the reflections, which differed from the usual course evaluation comments given by students. Coordinators who used the reflection activity in the first year were eager to continue in subsequent semesters and years. This mechanism gives students and staff the opportunity to understand the wide and varied opportunities for employability skill development that already exist in undergraduate Science courses. The approach does not require course teaching amendments or student skill-building instruction. This study shows that students can achieve multiple employability literacies from early-year courses, and raises new possibilities around how we can boost students' understanding and development of their employability.

**Keywords**
employability; science; graduates; first-year; large-scale course; higher education; reflection; curriculum

## Introduction

### STEM graduate employment

In multiple developed countries, governments focus on the need for Science Technology Engineering and Mathematics (STEM) capable workers as a mechanism to future-proof the country (Panizzon et al., 2015). Historically, graduate employment reports show, however, that across disciplines, Science graduates are frequently slow to find work post-graduation (Norton & Cakitaki, 2016; Rayner & Papakonstantinou, 2016), and STEM graduates are still less likely to be in full time employment than graduates from most other programs (Quality Indicators for Learning and Teaching (QILT), 2022, Table 7). Despite this, STEM employers have difficulty finding appropriate graduates (Smith and White, 2019). There are many factors that might contribute to this, but one is the apparent lack of STEM graduates' employability skillsets (or the inability of STEM graduates to describe their skillsets to employers) (McGunagle & Zizka, 2020).

To address these concerns around graduate preparedness, the Australian government encourages universities to deliver 'job-ready' graduates to the market (Department of Education, Skills and Employment, 2021). This can be difficult to accomplish – in part because it is unclear which jobs our graduates will gain. Science graduates pursue a diverse set of careers that transcend the 'typical' science career in the laboratory or field. Indeed, in Australia (the context for this study), a surprisingly small proportion of university STEM graduates (only 23% at of 2020) are employed in 'professional, scientific, and technical services' (Office of the Chief Scientist, 2016; 2020). A significant proportion of STEM graduates are employed in education and training (10%), public administration and safety (9%), and manufacturing (8%), as well as a myriad of other roles (Office of the Chief Scientist, 2020). This diversity of employment demonstrates that science graduates are valuable employees, who should be encouraged and enabled to work in non-traditional areas, transgress expected boundaries, and navigate a branching career (Alberts, 2008; Fuhrmann et al., 2011; Rowland et al., 2020). As such, we need to develop science curricula that help students understand who they are, what they can offer an employer, and how to articulate these attributes. In short, we need curricula that help Science students develop their employability.

## Developing employability in Science students

In this article we report on an employability development curriculum initiative that is highly-transferable, simple to implement, and easy to integrate into existing curricula. We use this initiative to examine whether, and how, students are developing employability literacies from their Science curricula. As a pedagogical foundation, we use Yorke's (2006) conception of employability - 'a set of achievements - skills, understandings and personal attributes that make graduates more likely to gain employment, and be successful in their chosen occupations, which in turn benefit themselves, the workforce, the community and the economy'. This definition gives us scope to develop students holistically and help them build a broad set of attributes that STEM and Science employers value (Deloitte Access Economics, 2014; McInnis et al., 2000).

There are many ways to develop students' employability through the curriculum. These include Work-Integrated Learning (WIL) (Johnson, 2019; Jackson & Rowe, 2022), the inclusion of interdisciplinary offerings, stand-alone employability modules (Scott &Willison, 2021), and formal extra-curricular career guidance with employability-related skill development (Callier et al., 2014). While these approaches are effective vehicles for employability development, they can be difficult to implement sustainably due to resource requirements and a lack of available space in curricula.

Thus, we are interested in whether students can develop significant employability capabilities from Science programs that do not contain these specialised pedagogies. In all Science curricula, students navigate a flexible program structure (with an ill-defined career pathway), a demanding course load, challenging content, diverse learning environments, collaborative laboratory and field work, and a consistent requirement to produce high-quality assessable work. It is possible that these activities develop students' capabilities in group work, problem solving, project management, critical thinking, self-assessment, and resilience. We propose it is quite possible that Science students do have the skills that employers seek. Perhaps all they lack is the capacity to demonstrate critical, reflexive appraisal of their abilities (National Association of Colleges and Employers (NACE), 2017).

Helping students understand and articulate their developing employability is a complex task, as we are asking students to look critically at themselves and describe who they are becoming during their education. Complexity should not, however, inhibit an attempt to graduate students who are better equipped to enter and benefit the workforce.

## A reflection-based approach to understanding employability development

In this study we use student reflection to understand students' developing employability (Pegg et al., 2012). While the goal of this study is to gather data on the student experience, it is possible that the reflective activity will also help students learn. In using a reflective approach, we draw on the pedagogical philosophy of Dewey (1933), who considers that 'reflective activity' is key to helping students uncover connections between different parts of an experience. This exactly mirrors the request we make of students in our pedagogy – they are asked to link parts of their coursework to their development of an employability literacy.

We also draw on Boud, Keogh, and Walker's (1985) conception of reflection as the 'response of the learner to experience' (p. 18). They point out that experience 'consists of the total response of a person to a situation or event: what he or she thinks, feels, does and concludes at the time and immediately thereafter' (p. 18). When we consider how a course experience can contribute to learning, this approach gives us licence to consider all course components – and students' responses to them – as legitimate stimuli for reflection. Consistent with this idea, our pedagogical approach encourages students to reflect on any aspect of their course experience, and their responses to that experience, when they discuss their employability development.

## The University of Queensland Faculty of Science Employability Framework

The Faculty of Science at The University of Queensland (UQ) directly enrols over 9,000 and teaches over 14,000 students annually. The Faculty is one of six at UQ, a large (>53,000 students), comprehensive, research-focused university. As students studying Science come from across UQ, their skills, interests, and goals are extraordinarily diverse.

Our goal is to help all students increase their employability, and their awareness of their developing employability literacies. We have adopted the Faculty of Science Employability Framework (The Employability Framework) (Figure 1) to guide our work.

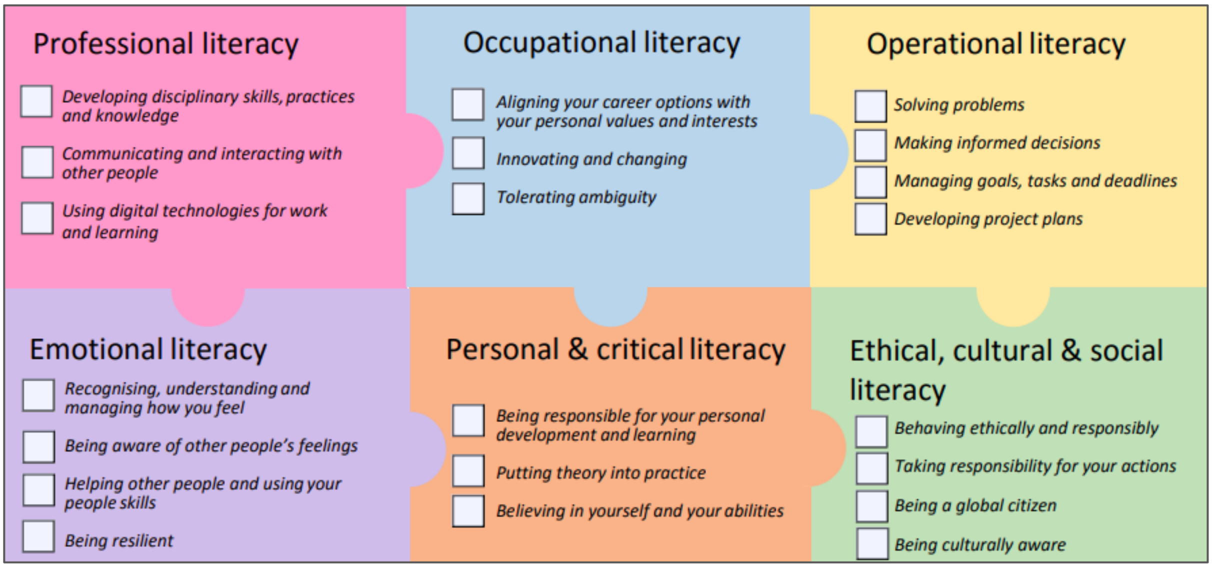


***Figure 1: The Employability Framework***

Adapted from Bennett's (2018) 'Literacies for Life' framework for employability thinking. It describes the 21 Literacies used in this study. Note, we use a capital 'L' when referring to Literacies from this Framework.

Restructuring curricula to focus on the development of employability literacies would require organisational change on a large scale, which is often met with negative reactions (Kotter, 1995; Lawrence et al., 2014; Maitlis & Sonenshein, 2010) and implementation difficulties (Maurer, 2010; Yorke & Knight, 2006). Similarly, including employability modules in courses would likely be difficult for academics, potentially inconsistent, and unpopular amongst students. This practice dilutes the discipline-specific material taught in courses and may lead to decontextualised (and thus poor) learning of employability literacies (Bilican et al., 2015).

Bennett (2018) argues that 'employability thinking' can be achieved in the absence of formal employability training or work-related modules in courses. Thus, instead of asking our staff to include bespoke employability modules in courses, we have developed a reflective approach that uses the Employability Framework *without requiring any other, or additional, teaching of employability in the curriculum*. This reflection activity has now been embedded in over 60 courses within the Faculty.

In this paper we report on the first implementation of the reflection activity in three large, generalist, first-year courses during Semester 1, 2019. In this reflection activity we ask students to identify course components (termed 'Situations') in which they believe they developed one or more Employability Framework Literacies (which we term a 'Learning'). We provide evidence to demonstrate that our approach enables students to identify their developing employability within a curriculum that is discipline-focused and devoid of specific employability-related training. It also enables us, as educators, to see the employability learning achieved by the students and the curriculum elements that students identify as central to their development.

We ask the following research questions:

RQ1: In a curriculum that does not have any explicit employability teaching, do students identify course components as 'Situations' that engender their employability Literacy development? If so, which components do they identify?

RQ2: Which Literacies do students identify as Learnings from their Science-focused courses?

RQ3: Are individual students able to develop multiple employability Literacies from their Science-focused courses?

RQ4: As a cohort, what course components (Situations) and employability Literacy development (Learnings) do the students frequently associate?

RQ5: How do students develop Literacies from their Science-focused courses?

## Methods

### Courses

Three courses, or units of study, were included in this study: BIOL1030 – Global Challenges in Biology; SCIE1000 – Theory and Practice in Science; SCIE1100 – Advanced Theory and Practice in Science. Each is a 2-unit offering for first-year students (one eighth of a full-time annual BSc enrolment). The course curricula are shown in Appendix 1, Items 1-3.

### Participants

A total of 925 students were recruited for the study (BIOL1030 n=179, SCIE1000 n=665, SCIE1100 n=81) in Semester 1, 2019. The activity reported here included these participants over one semester.

Students completed the reflection as an assessment item (for 1% of the total course assessment). Over 90% of students in each course completed a reflection. Around 92% of participants gave informed consent for the research team to include their reflections in the study. Thus, study results are derived from the reflections of around 80% of students in each course.

## Ethics approval

This project was conducted under Human Research Ethics Approval #SR00162 from our university.

## Build and trial of the Employability Reflection Tool (ERT)

The UQ ePortfolio system was used to build an interactive portal ('The Employability Reflection Tool' or ERT) that allowed students to submit their reflections.

Students' ERT use was supported with an online document (see Appendix 1, Item 4) explained the Employability Framework (Figure 1), the benefits of reflection, and how to use the ePortfolio. The document included a model reflection, but it did not give students course-related prompts (i.e., a list of course activities; a model reflection topic related to university study). Hence, it did not lead the students to reflect on specific components of their course.

Before launch to classes, the ERT and the support documentation were trialled with a small group of students and staff. Their feedback allowed refinement of the tool and documents.

## Student use of the ERT

During Week 13 of semester, students were given access to the ERT and invited to complete the reflection during class time or as homework.

The ERT asks students to identify a primary Literacy they learned in their course (using the Employability Framework), and then reflect on how they developed this Literacy using the Situation Effect Action Learning (SEAL) process (Reid et al., 2021). SEAL asks students to reflect on:

- A Situation (a course-related experience) that prompted them to develop their chosen Literacy.
- The Effect this situation had on them (i.e., how they responded to this experience).
- The Action they took to deal with the situation and the effect.
- What they Learned and how they developed from this experience (i.e., the primary employability Literacy they developed during their actions).

After students completed this part of the reflection, they were prompted to select any additional Literacies they felt they developed (optional Literacy selections) using checkboxes. They did not write a reflection on these optional selections.

## Processing responses before analysis

Responses from the consenting cohort in each course were retrieved from the ERT in an Excel spreadsheet. Each response was deidentified and assigned a pseudonym with a course code and student number (e.g., SCIE1000S001), converted into a Word document, and imported into *NVivo* as a case file for textual analysis. Responses from the same course were analysed together to build course-specific frameworks for 'Situations' (i.e., course components cited by students).

## Qualitative (inductive coding) data analysis

The ERT outputs were analysed using an inductive/deductive coding approach and were visualised using an *R Shiny* tool we built as part of the project. Coding of reflections was completed, using *NVivo* software, as follows and as shown in Figure 2.

Step 1: For each course (BIOL1030, SCIE1000 and SCIE1100) we inductively built a Situation Framework. Students' 'Situation' responses were built into a structure of general nodes (e.g., assessment) with more specific sub-nodes (e.g., field and laboratory reports; mid-semester exam). After building this structure we clarified the node and sub-node names by comparing the inductively-built framework with the published curriculum for each course. The Course Situation Frameworks (one for each course) do not necessarily contain all elements of the published curriculum for each course. Instead, they contain all the elements of the course curriculum ('Situations') that students found useful for employability learning.

Step 2: For each course, we set up a Learning-Situation Linkage Framework structure with one parent node for each Learning (each Employability Framework Literacy from Figure 1). The Course Situation Framework was embedded as a set of child nodes under each parent Learning node (see examples in Tables 1 and 2). No additional coding was done at this stage – each Learning (Literacy) was assigned the same Course Situation Framework structure.

Step 3: In this stage, we linked Situations to Learnings, using the students' reflections. Two researchers independently used a deductive approach, to code the students' holistic reflections into the Situation Frameworks of the corresponding student-selected Learning (Literacy) node. This process allowed us to link a defined set of course components ('Situations') to each selected Literacy (and vice versa).

Step 4: A comparison of the deductively coded files using the 'coding comparison query' function in *NVivo,* yielded an interrater reliability across all three courses with Kappa > 0.987 ('perfect agreement') (McHugh, 2012). This validates the coding framework and results (Appendix 1, Item 5).

Step 5: NVivo's 'matrix coding query' was used to calculate the number of associations students made between the selected primary Literacies and course components ('Situations') (for example Using digital technologies for work and learning and the Situation 'python coding'). The calculated outputs from NVivo were uploaded to Galaxy Australia and visualised using the package heatmap with ggplot (e.g., Results Figure 8).

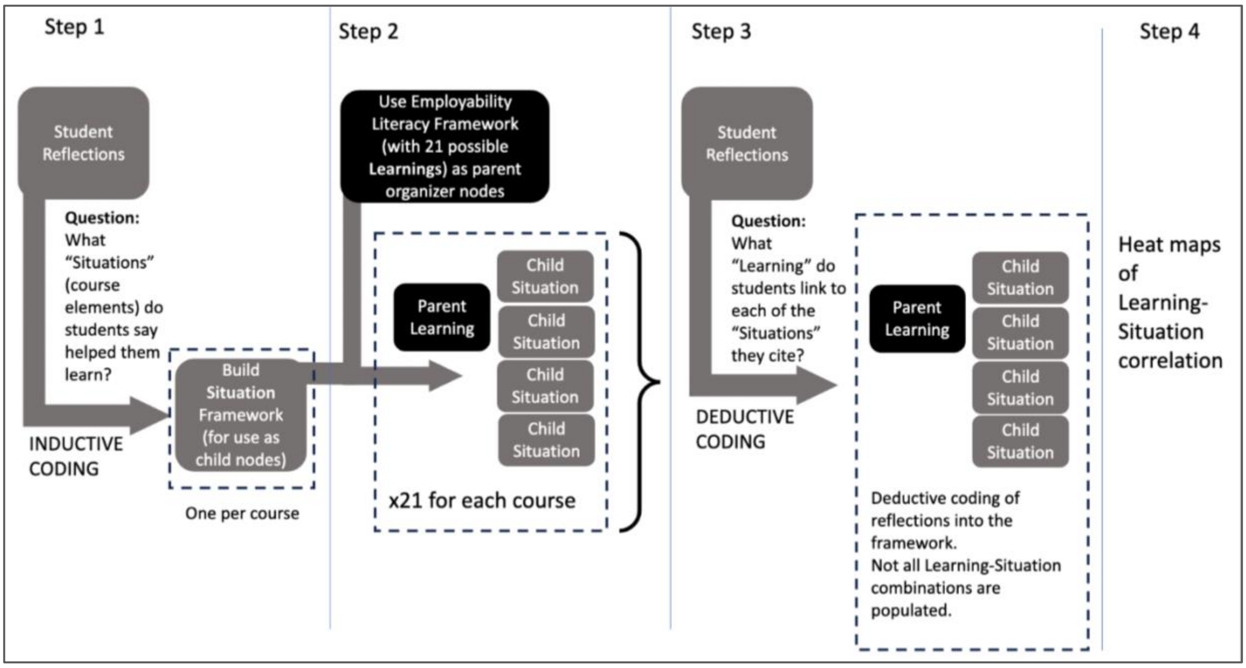


***Figure 2: Coding Steps for Analysis of Student Reflections.***

Step 1 shows creation of the Situation Framework. Steps 2 and 3 show creation of the Learning-Situation Linkage Framework.

***Table 1: BIOL1030 Learning-Situation Linkage Framework Using the Literacy 'Solving Problems' as an example Learning***

| **Learning** | **Situation Framework presented for each Learning (Literacy)** | |
|---|---|---|
| | Parent nodes | Child nodes |
| Solving Problems | Assessment | • General assessment<br>• Field and laboratory reports<br>• Mid-semester exam<br>• Post-workshop activities<br>• Pre-laboratory quizzes |
| | Field trip | • General field trip<br>• Group work<br>• Technical skills |
| | General course | |
| | Lectures | • General lectures<br>• Guest lectures |
| | Other | |
| | Practicals | • General practicals<br>• Group work<br>• Laboratory activities |
| | Workshops | • General workshops<br>• Group work<br>• Workshop activities |

***Table 2: SCIE1100/SCIE1000 Learning-Situation Linkage Framework Using the Literacy 'Solving Problems' as an example Learning***

| **Learning** | **Situation Framework presented for each Literacy** | |
|---|---|---|
| | Parent nodes | Child nodes |
| Solving Problems | Assessment | • Assignments<br>    • Communication<br>    • Python coding<br>• Fortnightly reflections*<br>• General assessment<br>• Mid-semester exam<br>• Philosophy essay |
| | Contact | |
| | Course-wide groupwork | |
| | General course | |
| | Other | |
| | Lectures | • Lecture content<br>• Lecture discussions |
| | Tutorials | • Communication tasks<br>• Pre-work<br>• Python coding<br>• Discussions<br>• Worksheets |

* SCIE1100 only

Although students had the opportunity to select 'optional Literacies' after their reflection, we did not code against these; they are reported only in the Literacy selection counts (Results Figures 3—5).

During the holistic deductive coding of students' responses, the researchers noticed many students used the reflection to discuss additional Literacies alongside their selected primary and optional Literacies; we term these 'described Literacies'. The method of identifying described Literacies is shown in Results Figure 6. We consider the described Literacies to be evidence of students' deep reflective practice, but we have not attempted to formally link them to Situations in the reflections – to do so risks over-interpretation of the students' responses. The described Literacies are only shown in Results Figure 7 and are not included in the dataset used to generate other plots.

### Statistical analysis

A Chi-Square Goodness of Fit Test was used to determine if the frequency of primary Literacy selection is purposeful, or random. The null hypothesis is that 'there is a uniform distribution of Literacy selection in a course' (which we equate with students choosing literacies at random). The lower the p-value, the farther the frequencies of primary Literacy selection deviate from the null hypothesis. A p-value of $<0.05$ is statistically significant.

A Fisher's Exact Test was used to determine if there were differences in the primary Literacies selected, depending on the course. A Fisher's Exact Test was chosen, instead of a Chi-Squared Test of Homogeneity, as several Literacies did not satisfy the sample size requirements for Chi-Squared, and the group sizes were unequal. The null hypothesis is 'the primary Literacy selection is not dependent on the course' (so the distribution of primary Literacy selection looks the same for each course). The lower the p-value, the more significant the association between the course and primary Literacy selection (i.e., more deviation from the null hypothesis). A p-value of $<0.05$ is statistically significant.

## Results

### Students can identify course activities as situations that develop their employability literacies

To determine whether (and which) course components were identified by students as 'Situations' that engendered their Literacy development (RQ1) we examined the 'Situation' data provided by students in each course. We did not provide students with a list of course activities for their reflections; hence, their responses identified components they articulated as learning opportunities.

Tables 1 and 2 show the Learning-Situation Linkage Frameworks for each course, with one of the Literacies 'Solving Problems' used as an example and the inductively-derived Situation Framework in the right-hand column. Students cited a variety of course components as their learning prompts. For all three courses, the Situation Frameworks are fully reflective of the designed curriculum. This indicates that all elements of the courses are identified as a learning Situation for at least one student.

The 'Other' node encompasses situations where the student did not reflect on a course component specifically, but instead described a personal or non-course experience that impacted how they interacted with the course in general, or with specific course component(s). Many students noted multiple situations as contributors to their Learning (Literacy development).

### Students indicate they learn multiple Literacies from their Science-focused courses

We next asked which Literacies the cohort of students selected as Learnings from their Science-focused courses (RQ2) and whether individual students developed multiple Literacies from their Science-focused courses (RQ3).

Figures 3—5 show the primary Literacies selected by students at the beginning of their SEAL reflections and the optional Literacies they selected at the end of their reflections. It appears from these graphs that students are purposefully selecting Literacies in a course-dependent pattern. To investigate this proposition, two statistical tests were employed:

(1) A Chi-Squared Goodness of Fit Test to determine if primary Literacy selection within each course was purposeful, or random;
(2) A Fischer's Exact Test to determine if the differences in primary Literacy selection were course dependent (i.e., different between courses).

For the Chi-Square Goodness of Fit Test, the null hypothesis is that 'there is a uniform distribution of Literacy selection in a course' (i.e., students choose literacies at random). The test result was statistically significant ($p<0.05$) for all three courses (Appendix 1, Item 6A); thus, the null hypothesis is rejected, and the primary Literacy selection is non-random. This supports our idea that students were experiencing meaningful employability development and purposefully selecting Literacies that reflect their learning.

For the Fisher's Exact Test the null hypothesis is 'the primary Literacy selection is not dependent on the course' (i.e., distribution of primary Literacy selection looks the same for each course). Pairwise comparisons of BIOL1030 to SCIE1000, and BIOL1030 to SCIE1100, yield statistically significant differences in proportions between the primary Literacies selected in each course as assessed by Fisher's Exact Test, $p < 0.001$ (Appendix 1, Item 6B). The null hypothesis (that primary selection is not dependent on the course) is rejected for both pairings.

When comparing SCIE1000 and SCIE1100 there was no statistically significant difference in proportions between the primary Literacies selected as assessed by Fisher's Exact Test, $p = 0.530$ (Appendix 1, Item 6B). The lack of statistically significant difference in selected Literacy proportions between SCIE1000 and SCIE1100 can be explained by the knowledge that a) the two courses have very similar curricula; and b) most activities are delivered in tandem to the cohorts. Thus, it is reasonable to expect that these curricula will engender very similar Literacy selection.

Collectively, these results suggest students are considering their course components ('Situations') as they reflect on the Literacies they have developed. It also suggests that different curricula can develop different Literacies for the student participants.

The Literacies most frequently selected by BIOL1030 students (Figure 3) included Communicating and interacting with other people, Solving problems, Putting theory into practice, and Aligning your career options with your personal values and interests. The most-frequently-selected Literacies were similar between SCIE1000 and SCIE1100 (Figures 4 and 5). These Literacies included Solving problems, Using digital technologies for work and learning, Communicating and interacting with other people, and Managing goals, tasks and deadlines.

Students frequently chose Developing disciplinary skills, practices and knowledge for all three courses, but qualitative analysis of their reflections indicated some were interpreting the Literacy as 'developing self-discipline', rather than our intended interpretation of 'developing skills in a particular field of study (or discipline)'. Thus, we include an additional Literacy in Figures 3—5, Discipline (self), to reflect this.

Students selected Literacies from the Ethical, Cultural & Social and the Occupational categories far more frequently in BIOL1030 than in SCIE1000/1100. This is expected, since BIOL1030 is an elective course about human-environment interactions. Students report (in course evaluation data not included here) that they find the course relevant to their life philosophy or goals.

Students in SCIE1000/1100 were relatively unlikely to select Ethical, Cultural & Social and Occupational Literacies. This is expected, as SCIE1000/1100 a compulsory course in the BSc degree, and many students report (in course evaluation data not included here) that they do not understand its relevance to their career or study goals.

Many students described developing other Literacies from the Employability Framework in addition to their primary (and optional) Literacy selections. These described Literacies reflect the 'thinking out loud' that students were doing as they considered how and why they had learned the primary and optional Literacies they selected. An example is shown in Figure 6 and the total counts for described Literacies are shown in Figure 7. We have not added these described Literacy counts into the data used to produce figures in this paper that reflect students' primary and optional Literacy selections.

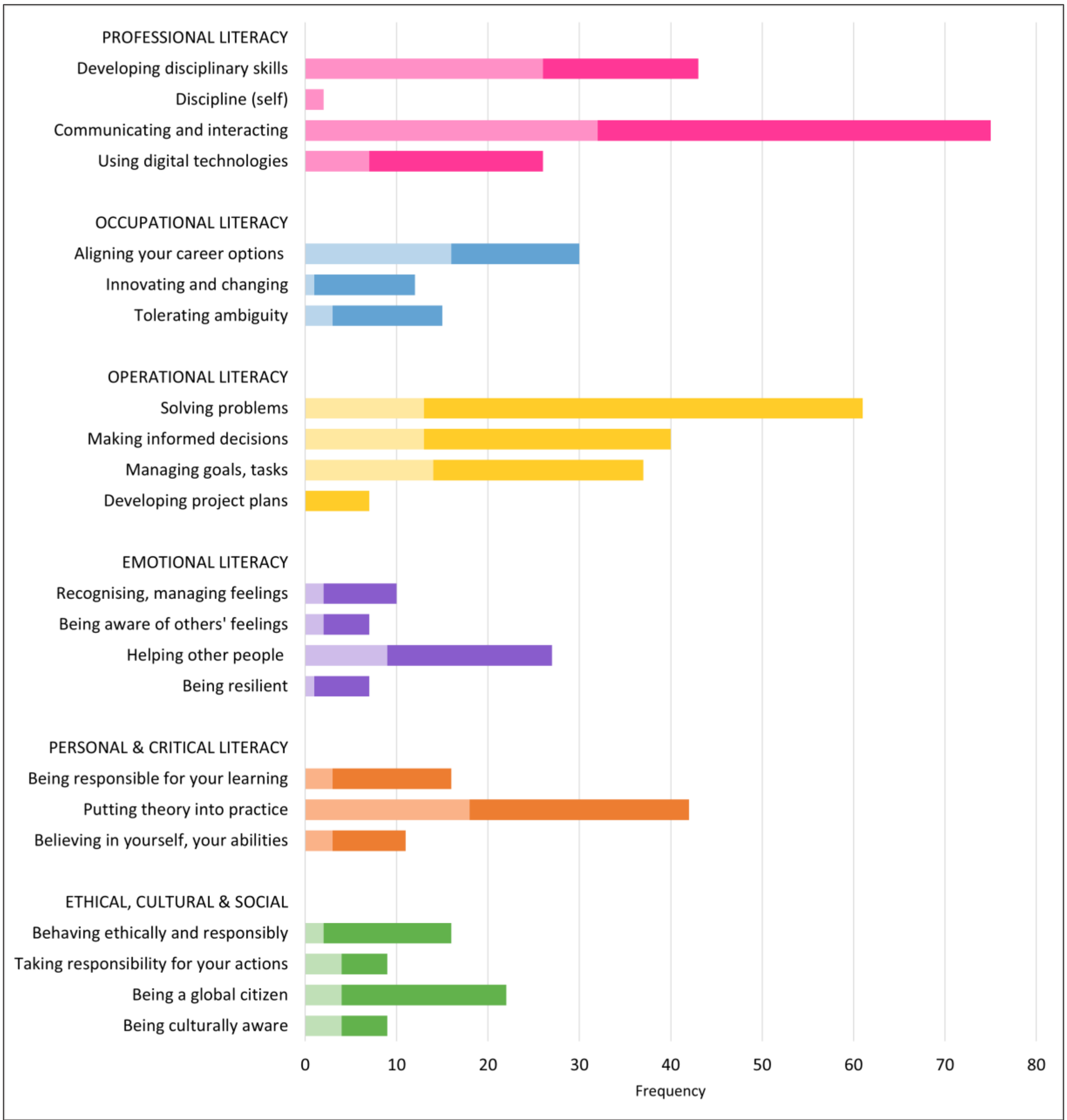


***Figure 3: Literacy Selection by BIOL1030 Students (n=179).***

Light colours indicate primary selected Literacies, while dark colours indicate subsequent (optional) Literacy selections. Colours align with the categories in the Employability Framework (Figure 1) from which students selected their Literacies. Frequency data reflect the sums of the selections coded against each Learning in the Learning-Situation Linkage Framework.

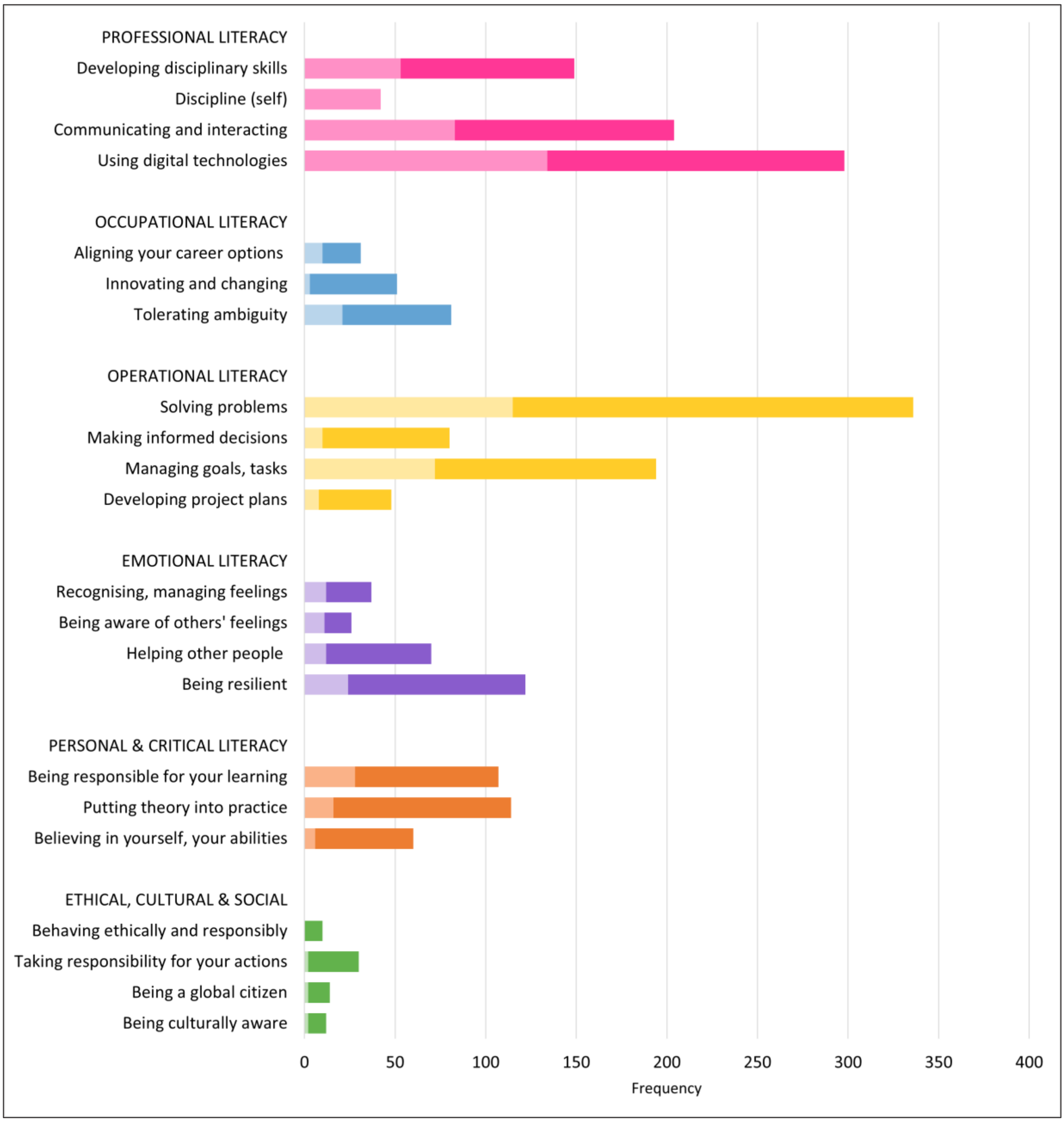


***Figure 4: Literacy Selection by SCIE1000 Students (n=665)***
Data presented as per Figure 3.

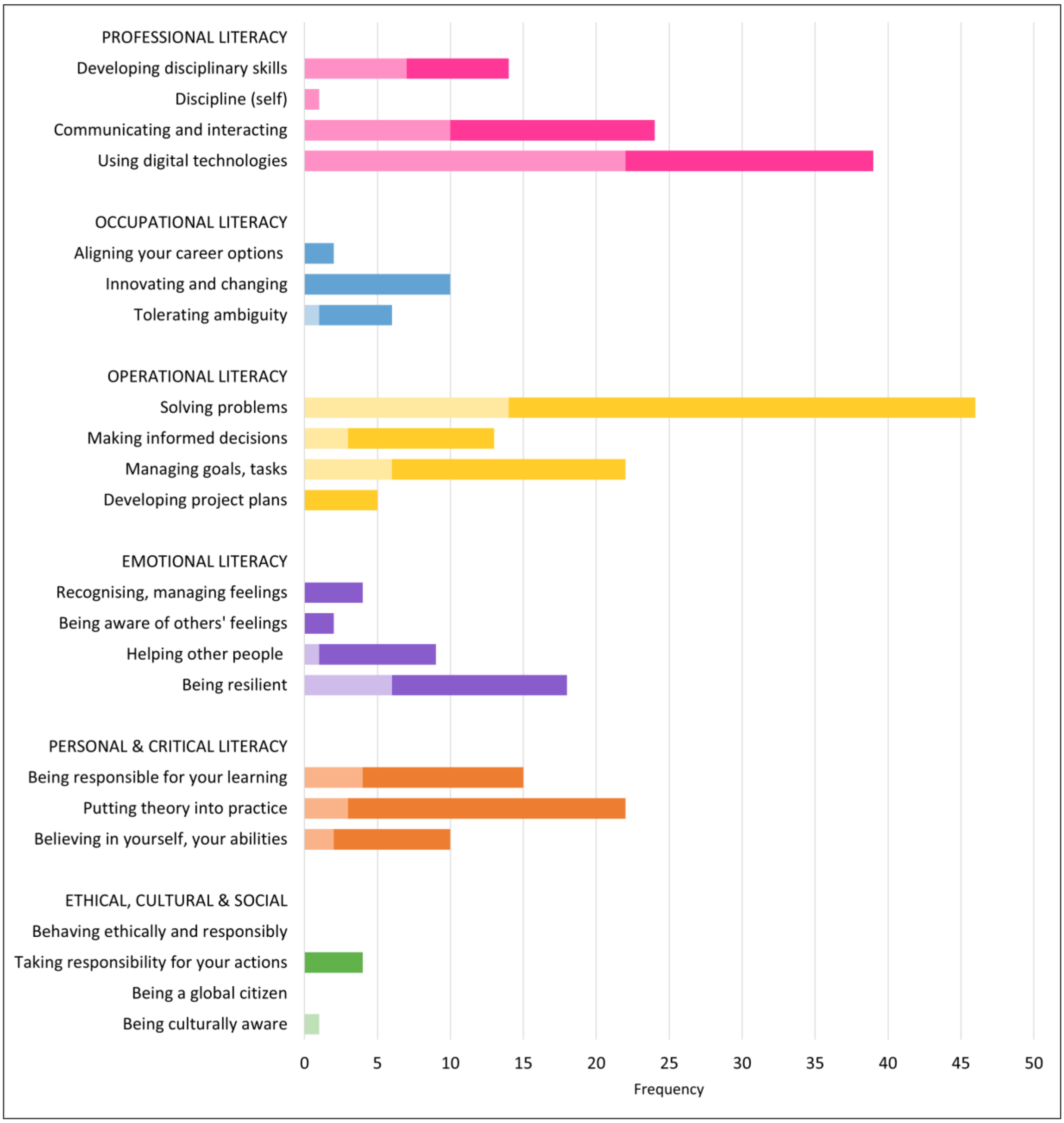


***Figure 5: Literacy Selection by SCIE1100 Students (n=81)***
Data presented as per Figure 3.

| Course Code/Participant Number | SCIE1000S228 |
| --- | --- |
| **Primary Selected Literacy** | **Using digital technologies for work and learning** |
| **Situation** | Throughout the course we have had to use technology for our work. A large section within SCIE1000 is working with Python, a common coding language. Additionally, if a lecture was missed then I was able to use the UQ site to catch up as all of the lectures and the annotated booklet was uploaded there. |
| **Effect** | Python has allowed me to gain a good basis of understanding on common coding languages which are used extensively in the STEM field. It will allow me to continue developing my problem-solving skills as coding forces the user to think of creative ways of producing an output. |
| **Action** | In addition, when problems arose in the python code it required full attention and meticulous scanning of the code to locate the error. Consequently, my ability to stay on task has improved. Additionally, I also benefited from asking my peers about certain errors and having a new set of eyes on the task. |
| **Learning** | I learned interpersonal skills by collaborating with others to solve a common goal. I also learnt resilience by setting my mind on a difficult task. |
| **Optional Literacies** | • *Communicating and interacting with other people*<br>• *Tolerating ambiguity*<br>• *Solving problems*<br>• *Being resilient*<br>• *Putting theory into practice* |

In the situation section, this student identifies three unique situations (red), related to their primary selected literacy (pink).

In the remaining text, the student focuses on the python situation, linking it to an additional three literacies. The student specifically identifies the literacy name, or skillset, they learned. These are described literacies.

Solving problems (blue).

Communicating and interacting with other people (green).

Being resilient (purple).

When re-presented with the Employability Framework, the student is able to select all three described literacies, and two additional optional literacies.

***Figure 6: A SCIE1000 Student's Reflection, Used as an Example to Demonstrate Primary, Described and Optional Literacy Selection, and Coding***

Explanations of Literacy selection are shown in the grey boxes.

Across all three courses, students articulated an average of 2.27 unique situations that prompted their development of their primary selected Literacy (an average of 2.32, 2.19 and 2.31 situations for BIOL1030, SCIE1000 and SCIE1100 respectively).

In all three courses, students identify and articulate a broad range and number of employability Literacies, informed by their experiences with a wide variety of course components (on and off campus). Statistical analysis supports the notion that students are considering the course components when selecting their primary Literacy, and that their Literacy selection is non-random.

Not all students clearly articulate and describe their literacy development, but a significant number do use the reflection as an opportunity to elaborate on their learning (beyond the Literacies they formally state they learned using the selection options in the tool). More than one third (n=254) of SCIE1000 student reflections described additional Literacy development (Figure 7). In SCIE1100, 17% (n=14) of students described additional literacies, and 2% (n=4) of BIOL1030 students described additional Literacies. The presence of described Literacies suggests the reflection process allows students to 'think aloud', identify, and connect additional Literacies to their articulated course experience, which may inform their selection of optional Literacies.

Together, these results strongly suggest that existing curricula offer fertile grounds for developing student employability, and that it is not necessary to embed specialised employability modules into courses.

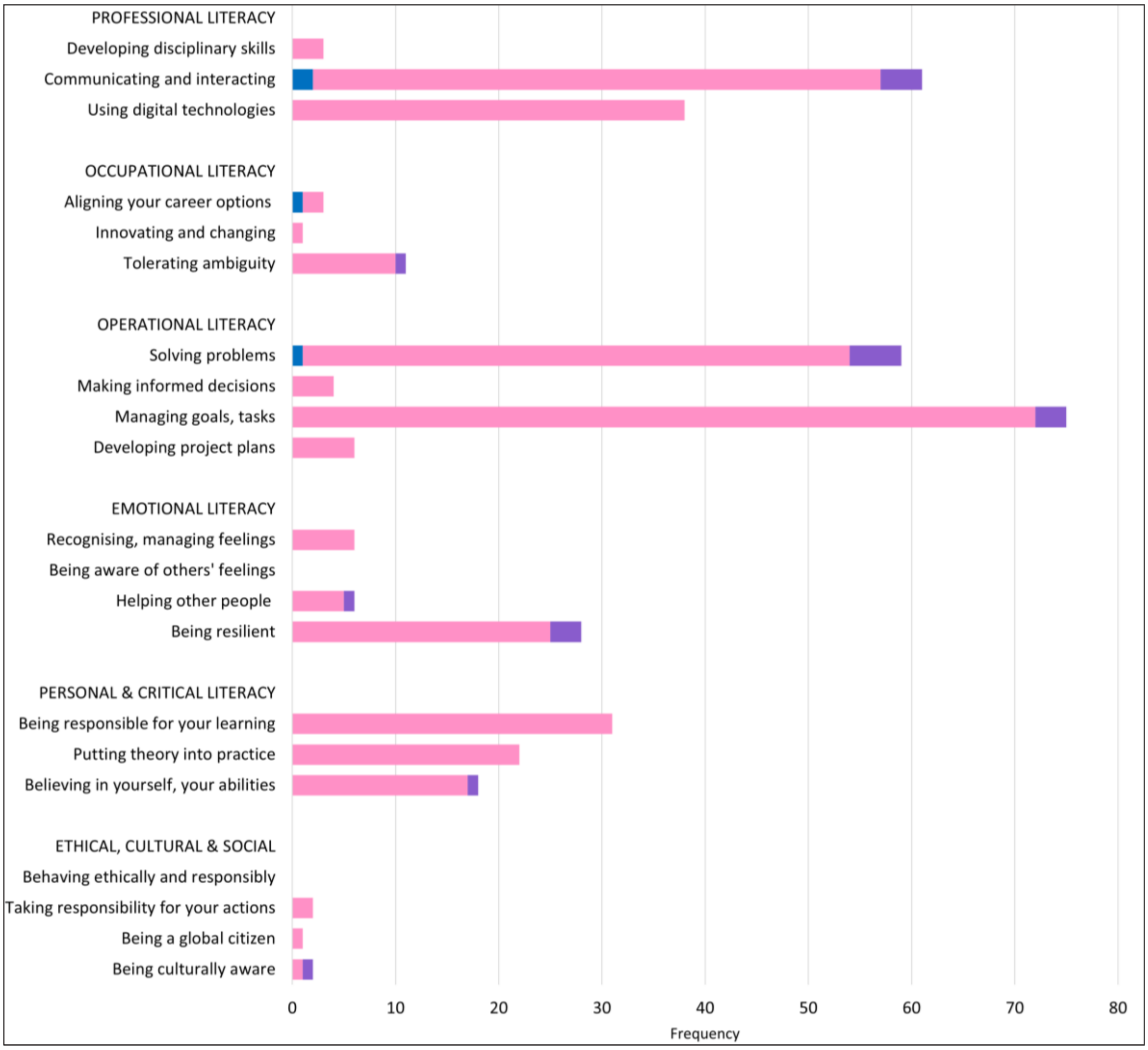


***Figure 7: Total Numbers of Described Literacies Articulated by Students***
BIOL1030 Students (n=4; 4 description instances, blue bars), SCIE1000 (n = 254; 354 description instances, pink bars), and SCIE1100 (n= 14; 19 description instances, purple bars).

### Heat mapping shows correlations between course activities (Situations) and Literacy development

We next asked ‘As a cohort, what course components (Situations) and Literacy development (Learnings) do the students frequently associate?’ (RQ4). The data allow us to map associations between course situations and the primary selection Literacies that students said they developed as a result. The associations are shown in heatmaps (Figures 8—10).

The data indicate that, in the students’ opinions, particular course components (‘Situations’) are more frequently associated with learning of particular Literacies. For example, groupwork situations in BIOL1030 are strongly linked with the Literacy Communicating and interacting with other people (Figure 8). As another example, many SCIE1000 and SCIE1100 students associate their learning around Using digital technologies for work and learning with computer programming (Python), the tutorials where they practiced programming, and the programming assignment. Thus, Figures 9 and 10 show a strong association between these Situations and the Literacy. Interestingly, programming and group work were also commonly described by students as difficult and challenging.

Other Situations (such as practicals/laboratories and lectures) link to a range of Literacies; while some Situations (such as examinations) are infrequently cited as driving Literacy development. All the course components listed (Tables 1 and 2) informed some Literacy development (because they were all nominated as ‘Situations’ in the students’ reflections). However, not all Literacies were linked to a Situation in a course (e.g., Developing project plans was not cited in BIOL1030 and Behaving ethically and responsibly was not cited in SCIE1000). This indicates that, according to students, there are some Literacies that are not obviously developed during some courses.

The data give a sense of which Situations develop which Literacies, while highlighting the value of a variety of course experiences for students. They also reinforce the idea that different course curricula foster development of different Literacy sets.

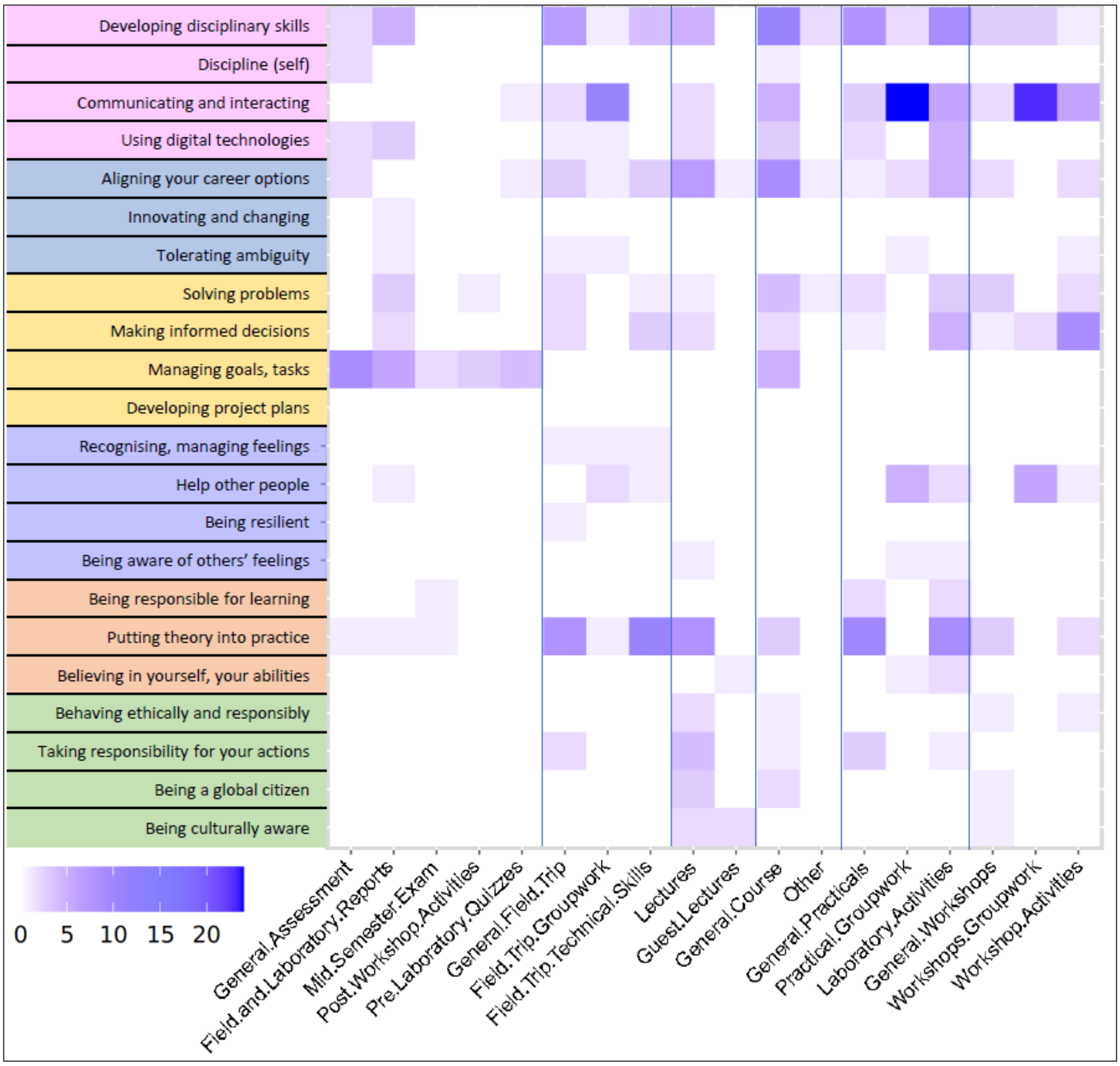


***Figure 8: Frequency of Situation Mentions (415) Against Primary Selected Literacies for BIOL1030 Students (n = 179 students)***

In this figure, the students' nominated Situations (X axis) are mapped against the associated Literacies they chose (light bars from Figures 2—4) (Y axis). Frequencies of Situation mentions are shown in a graduated colour scale, where white indicates 0 and dark purple indicates the data set maximum. Literacies are presented as per the Employability Framework (Figure 1).

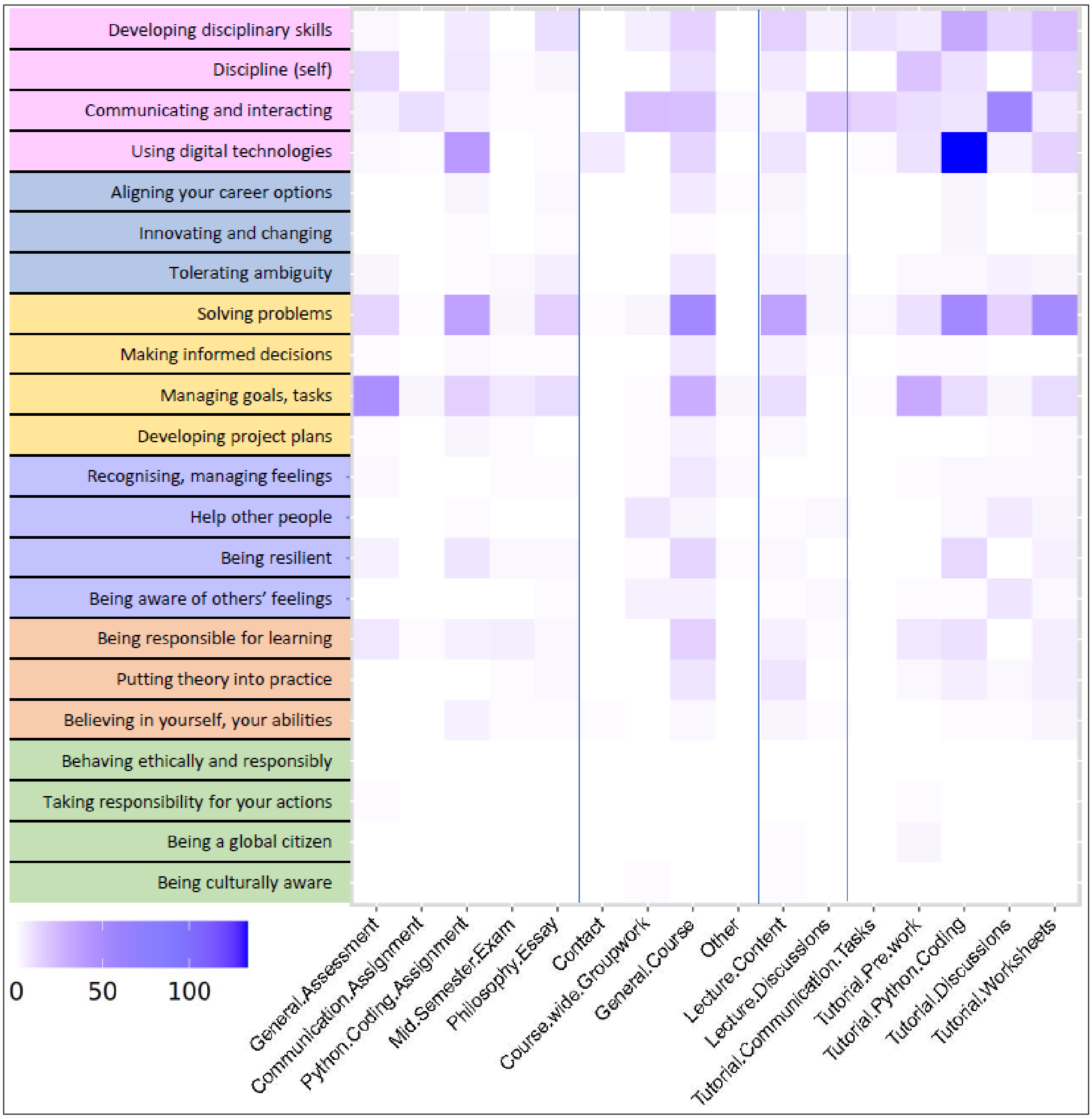


***Figure 9: Frequency of Situation Mentions (1456) Against Primary Selected Literacies for SCIE1000 Students (n = 665 students)***

Data presented as per Figure 8.

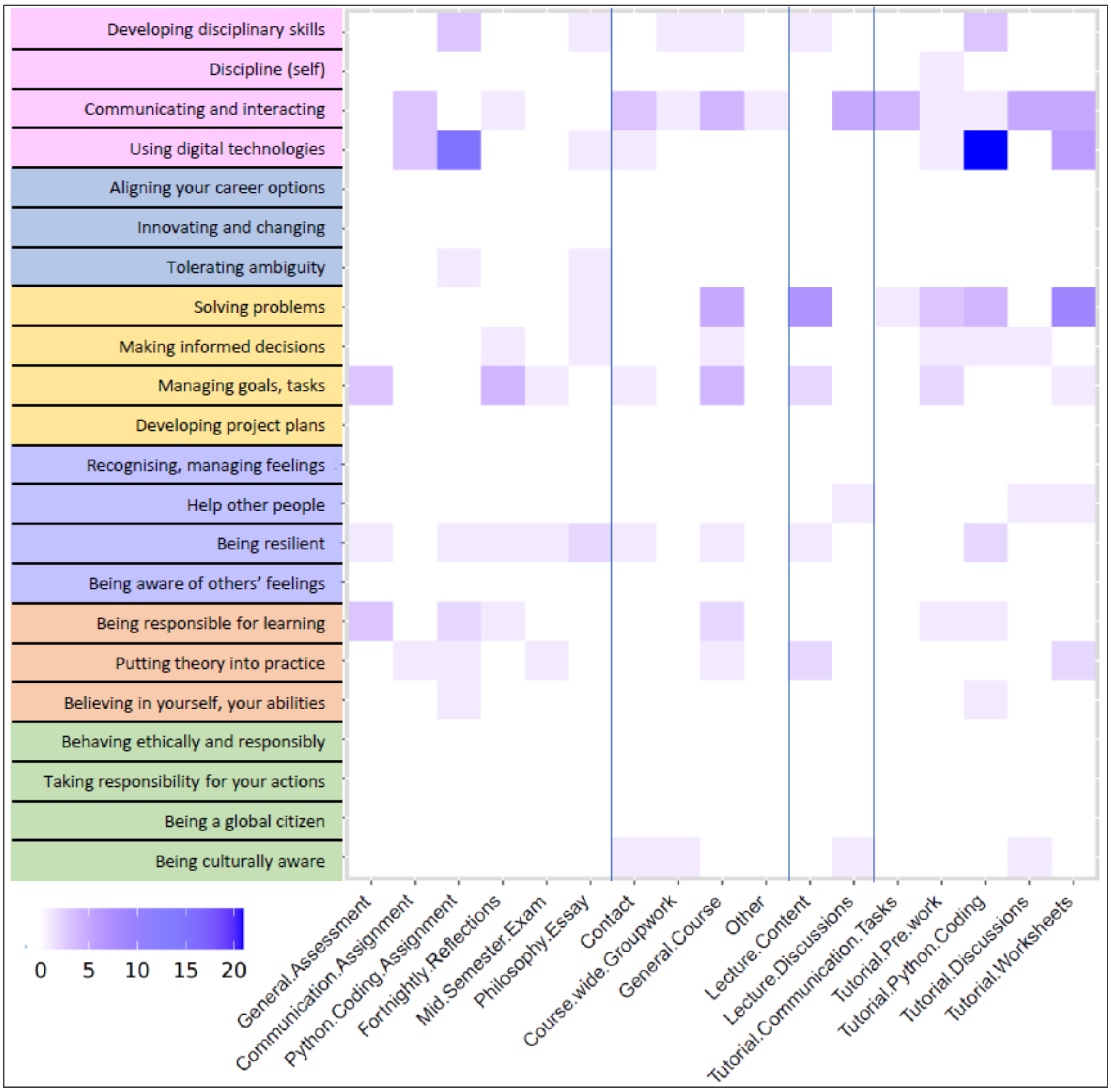


***Figure 10: Frequency of Situation Mentions (187) Against Primary Selected Literacies for SCIE1100 Students (n = 81 students)***

Data presented as per Figure 8.

## Students' reflections indicate they associate Literacy development with both the taught and lived curriculum

We next asked 'How do students develop Literacies from their Science-focused courses?' (RQ5).

Our initial expectation of the data was that students would identify particular Literacies that they had developed most frequently through associated Situations in the courses. While this was apparent (Figures 8—10), the reflections also revealed that Literacy development was complex, multi-layered, and not only dependent on the taught curriculum.

Students appeared to develop employability Literacies during the courses through three distinct means: (i) through learning course content that was designed and delivered to develop specific Literacies; (ii) through pedagogical approaches that required students to practice particular behaviours; and (iii) through the individual student's struggle (and engagement) with the course components.

## Literacy development through learning content

Most associations between course components and employability Literacies were expected and aligned with the intended learning outcomes of the course. For example, many BIOL1030 students reflected on their development of skills, practices and knowledge related to biology:

> *The experimental part of this course is of great help to me in developing academic skills, practice [sic] and knowledge. In the experiment, we learned to use instruments, how to use more scientific methods for research, and how to prove the conclusion through data. This helped me learn a lot of academic skills that I must master […] and deepen my understanding through practice. (BIOL1030S061, Developing disciplinary skills, practice and knowledge).*

BIOL1030 students also developed a range of Literacies (particularly ethical, cultural, and social literacies) through the course focus on global environmental issues.

> *The lecture content and workshops made me aware of things happening all over the world and how everybody is impacting on everyone else including animals, plants and other organisms. Discussions about global warming and decreasing biodiversity also taught me […] the world has to work together to save itself. (BIOL1030S051, Being a global citizen).*

In BIOL1030, students were given opportunities in lectures, workshops, practicals and field trip exercises to discuss and apply theory in real-world conservation contexts. These experiences prompted students to reflect on the impacts of their own actions, and their future careers.

> *This course focuses on real world problems and threats our climate and environment faces, and I believe that this subject gives an insight into the field of conservation and the impacts we have on nature. It prompts me to want to go out and use my knowledge for the greater good. (BIOL1030S147, Aligning your career options with your personal values and interests).*

> *During in class exercises, we had the opportunity to learn about many concepts, theories, and practices that relate to the biological field. This was especially true for the practicals. It was extremely educating being able to put these theories into practice and actually go out into the field and collect samples and species as true professional scientists do. (BIOL1030S116, Putting theory into practice).*

Workshop discussions were commonly mentioned. Students found it ‘interesting to see other people's opinion and justification using biological concepts as to why a policy was a good idea or bad idea.’ (BIOL1030S125, Making informed decisions). Having ‘to brainstorm ideas and solutions and make decisions on what the consequences would be based on the situation’ was a new experience, particularly ‘thinking of solutions to current problems that exist in [their] local area.’ This ‘developed [the student’s] problem-solving skills and decision-making skills.’ (BIOL1030S015, Making informed decisions).

Mathematical problem-solving and computer programming were foci of the SCIE1000/1100 course content; consistent with this intent, many students reflected on how they developed their problem-solving and digital technologies skills in these courses:

> *There have been many situations that have led to the development of my problem-solving ability. Specifically, the weekly tutorial sheets have stimulated this growth. These sheets present new and previously unseen problems to be solved in a time efficient manner, using previously learnt skills. (SCIE1100S035, Solving problems).*

> *I learned how to use python which is useful for writing scripts and plotting scientific data. Python helped me understand how mathematical models are used in real world situations. (SCIE1000S065, Using digital technologies for work and learning).*

Resilience was commonly linked to Python-related activities in both the tutorials and assignment, with many students learning programming for the first time.

*SCIE1000 challenged me. The tutorials and python questions have taught me to be resilient, as it has sometimes taken me lots of time and attempts to complete problems, yet my resilience in trying has paid off. The challenges have allowed me to understand that it doesn't matter how hard I have to try to do something, if I am resilient I can do it and grow as a person. (SCIE1000S202, Being resilient).*

Communicating science effectively to different audiences (using visual, written, and spoken genres) is a central theme of SCIE1000/1100. Students reflected on their Communicating and interacting with other people learnings through specific communication tasks in the tutorials, course-wide group work (including discussions in lectures and tutorials) and communicating their reasoning in Python coding tasks and assessments.

*A major focus for SCIE1000 was communication skills. In the back of our lecture book, there was an entire section dedicated to good science communication. We were required [in …] tutorials to discuss our communication with each other. We had a philosophy essay and a python communication assignment. Both required us to think about the audience and communicate in an appropriate manner. In the past I would have just said what came to mind, with no real consideration for the audience. I would also struggle to articulate myself. I found myself stumbling over words, struggling to find the correct words, and I'd regularly lose track of what I was trying to communicate. (SCIE1000S600, Communicating and interacting with other people).*

These expected, student-articulated associations between Literacies and course components indicate the students understand how to use the ERT to make sense of their learning experiences. This lends validity to our results.

### Literacy development through pedagogical approaches

Many students reflected on learnings that were tied to pedagogy, rather than to the course content. For example, mandatory group work prompted reflections around Communicating and interacting with other people:

*During tutorials in this course we were required to work together with a small group of peers to understand and work through a set of problems. To do this efficiently, we were required to communicate effectively and interact with people who we may not have met before. (SCIE1000S009, Communicating and interacting).*

The workload of the courses, and the requirement to self-teach also appeared to help students develop employability. Reflections commonly mentioned keeping up with learning activities (especially assessment). This sentiment was expressed commonly in the nodes Managing goals, tasks and deadlines, and Self-discipline.

*The work assigned to this course - the lecture notes, the pre-work, the assignments - forced me to become proficient at managing deadlines as well as setting smaller goals [...]. A new experience was the format of university learning - coming to lectures where there were 500 students and not having individual attention by a lecturer. This forced me to become more self-reliant and to work more on figuring out problems by myself. Over time I also became more familiar with how university worked and what routines would best allow me to get work done as efficiently as possible. (SCIE1000S002, Managing goals, tasks and deadlines).*

### Literacy development through student struggle (and engagement) with course content

Challenges in learning unfamiliar course content for assessment tasks were cited as situations that enabled Literacy development. These reflections were more common among SCIE1000/1100 students.

*One thing that helped me become more resilient is the philosophy assessment, as I didn't understand the content and I wasn't sure how to write the essay. But by continuing to read about the topic I eventually got it all done. (SCIE1100S032, Being resilient).*

*Doing the python and communication assignment. When I initially viewed the tasks, I was intimidated and didn't believe that I could do it. But what I had learned in the tutorials was a great foundation for the assignment and I was easily able to complete it. This situation taught me that I should believe that I can complete tasks using my own abilities and shouldn't be intimidated just because something looks hard. (SCIE1000S378, Believing in yourself and your abilities).*

Across all three courses, students selected a range of Literacies, not just the Literacies that were included in (or implied by) the formal course learning outcomes. The students reflected from a strengths perspective on how they developed their employability from course experiences. It was clear that these foundational, first-year courses catalysed significant development of student capabilities. The reflective process and the Employability Framework work as useful tools to help students articulate their employability learning, even though they have not been explicitly taught about employability or the Literacies they are building through their studies.

### Teaching staff reactions to the use of the Employability Reflection Tool (ERT)

As noted earlier, it is difficult to introduce and maintain bespoke employability modules in courses, so we examined whether this reflective activity was sustainable.

In the first implementation of this activity, we began with the three courses described here. The teaching staff found the implementation to be low-impost. They reported that their curricula remained essentially unchanged, and they believed their students were benefitting from the exercise. The reflection became embedded in all three courses and it is still offered in all of them four years later. In the four years the reflection has run (2019—2022), it has been deployed in almost 100 course offerings and has served over 7000 students. It is rare for the reflection activity to be removed from a course once it is included.

Course coordinators report enjoying reading the strengths-based, positive reflections. Year-on-year implementation of the reflection gives staff a picture of one aspect of their students' development. It also provides some feedback on how course components are useful to students (this information may not be readily apparent to staff in the absence of the reflections). Staff cite their participation in the project as an indicator of their teaching prowess in appraisal and award applications. Staff recommend the activity to each other and provide written testimonials we use to encourage other staff to include the ERT in their course. The ERT has disseminated and become widely embedded across the Faculty of Science on its own merits.

## Discussion and implications for practice

This research asks whether students can develop employability literacies from large, early-year Science courses that do not contain explicit employability teaching. Our work was spurred by the difficulty we encounter around embedding, and sustaining, employability modules in our courses – a difficulty we know is encountered by colleagues in other universities as well. Our approach was to include a simple, short reflective activity in undergraduate courses. We asked students to choose an employability Literacy from a list, identify a component of the course that helped them develop that Literacy, and explain how the two were linked. We examined the Literacy development that students reported and mapped the course Situations they articulated as prompts for their Literacy development.

Clearly, students can and do develop employability from Science courses without employability modules, and the reflective approach used in this study helps them articulate this learning. Across the three pilot courses presented, 925 students gave informed consent for use to analyse their submitted reflections. Overall, most of these students were able to engage with the tool and reflect in a positive, strengths-based, and meaningful way. Only 26 students submitted reflections that were deemed underdeveloped. Some of these students appeared to have language barriers hindering their engagement; others chose not to genuinely attempt the ERT, only providing a cursory reflection to gain the course credit. Only one student submitted a reflection that indicated they felt the activity was a negative experience.

We are heartened by this level of constructive participation in the activity. Our first indication of the value of the activity emerged during the pre-launch trial we conducted with students. After using the ERT, the students admitted to us they had intended to 'game' the exercise but had decided to truly engage as they wrote their reflections. Gaming reflections has been reported previously (Birden & Usherwood, 2013) and there will always be a proportion of students who choose not to engage authentically with a reflection activity. We believe, however, that most students did complete the reflection appropriately. Perhaps this is because we did not specifically grade the contents of their reflections (and hence they were not trying to fulfil set criteria). It may also be because we made it clear the reflection was for them to articulate their abilities, and not for us as assessors.

Our analysis of the reflections shows that students can link their participation in Science-focused course Situations to their development of employability Literacies. Students showed us the diversity of course components that contribute to Literacy development, and conversely, the variety of Literacies that can be developed from course components. We were struck by the plethora of learnings the cohorts could ascribe to the 'same' course component – this speaks to the vast difference between the planned curricula shown in Appendix 1, and the multiple lived curricula experienced by the students (Aoki, 1993).

We frequently observed students mentioning several Literacies in one reflection, when they reflected on their primary selected Literacy. The description of multiple literacies in the reflections suggests that students often develop several Literacies simultaneously through participating in course components. This idea is supported by the large numbers of optional literacies selected post-reflection by the students. We believe that this work opens new possibilities for demonstrating (and helping students realise) the value of Science training as a vehicle to develop the skills, attributes, and knowledge that build a graduate's employability.

This reflection tool is simple to implement, sustainable, and popular with teaching staff. The staff who used the tool in this pilot believed the reflection added value to the course for their students. The reflections allow teaching staff to identify curriculum components that help students develop employability literacies – for most of the staff this was the first time they had encountered this type of strengths-based, constructive feedback on their curricula and pedagogy.

The tool also allows curriculum designers to identify curricula (in individual courses or suites of linked courses) that do not develop particular employability Literacies for students. Our results, indicate, for example, that SCIE1000/1100 foster very little development of Ethical, Social, and Cultural Literacies. Program-wide, iterative use of this reflective tool could be used to map Literacy learning and drive curriculum modifications to craft more rounded graduates.

Importantly, students consistently reported developing Literacies from areas of the curriculum that they found difficult, challenging, uncomfortable, and confusing. Confusion can be beneficial for learning (D'Mello et al., 2014), but it is rare to have students cite it positively in our university course evaluations. In SCIE1000, for example, many students reflected on their struggles with Python coding. Despite their frustrations, students selected Being resilient and Solving problems, as Literacies they learned through the challenge. They also detailed parts of the curriculum that helped them:

> *I had never encountered computer programming before. It was very hard to persevere when I didn't understand the python content, and this had a significant effect on me and my views towards the course. I asked for assistance from tutors and my peers and gradually became more*

*confident in my abilities. I also worked through the prework to improve my skills throughout the semester. I learnt that stress is temporary and there are multiple avenues for a solution. (SCIE1000S103, Solving problems).*

In some cases, critical course evaluation data can create pressure to 'dumb down' (Haggis, 2006) a course. The reflections, however, provide an opportunity for staff to understand areas of productive curricular challenge and make changes that help students learn (as opposed to simply making a course more palatable in the short term).

## Implications for future practice

Yorke and Harvey (2005, p. 53) describe employability as 'a slow growing crop', and Claxton (1998) points out the need for 'slow learning' as students build their understanding, practice, and self-awareness around employability. Yorke and Harvey (2005) also describe how complex learning (such as developing employability) requires 'repetition of broadly similar, yet progressive, learning experience if it is to be fully successful'. In their opinions, employability learning 'is not well served by [...] incorporating in the program a separate module on skills development', and indeed, such compartmentalisation of employability learning devalues it.

The results from this study show that students can develop employability Literacies from their experience of a Science-focused curriculum – a curriculum which does not include a specific employability skills module. This knowledge, combined with encouragement from Yorke and Harvey (2005), gives us a platform to consider how we can further enhance students' awareness of their employability learning from Science-focused curricula through reflection.

The use of reflection to develop employability understanding is not novel - popular models of employability development - USEM (Knight &Yorke, 2003), CareerEDGE (Dacre Pool & Sewell, 2007), and SOAR (Kumar, 2009) - all incorporate reflection. What is novel in our work is the universality of the ERT approach. Because the reflection activity follows a generic structure, the ERT is easy to clone between courses. Because the students specify what they have learned, and how they learned it, it is also contextualised, personal, agile, and repeatable.

We anticipate that students who choose to truly engage with the ERT can use the tool to understand and map their learning, while also developing their capacity to articulate their abilities. Now that we have evidence that students can develop employability Literacies from Science-focused curricula, we look forward to enhancing that learning through repeated, structured reflection.

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## Appendix 1

Supplementary Material:

Carpenter, L. J., Hubbard, S., Basinski, N. S., & Rowland, S. L. (2023). Supplementary Material. The University of Queensland, Data Collection. https://doi.org/10.48610/4b955f3