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A rubric approach to assessing information literacy competency in tertiary curricula

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A rubric approach to assessing information literacy competency in tertiary curricula

Abstract

Systematic analysis of undergraduate curriculum design and assessment is required to ensure real world experiences are embedded in a degree structure for a high level of information literacy (IL) attainment. IL competencies and skills are critical for successful graduate outcomes. We developed a framework using a constructive alignment approach to develop the Student Attributes for Information Literacy (SAIL) and accompanying rubric with outcomes that categorize depth of application over degree progression. The rubric was used to audit IL in core units of a multidisciplinary Bachelor of Environmental Science degree before and after a cycle of curriculum design. SAIL's rubric provides educators with a practical and repeatable approach to identifying IL development in units of learning. The SAIL rubric found that IL, for most core units, was taught, practiced, and assessed at the foundational level. At the advanced level, however, students had limited opportunities for literacy training, practice, and assessment in a digital context until the end of the degree. The framework and rubric identified gaps and opportunities in IL attainment, and thus warrants further application. Making sure these gaps are addressed, with opportunities identified for learning throughout a progressive program, will ensure resilient and adaptable graduates in a digital dominant workforce.

Practitioner Notes

1. Formally developing information literacy (IL) in a disciplinary context is essential to enhancing self-directed learning, and may be best achieved by aligning within the sequence of curriculum content.
2. Using the framework of Student Attributes for Information Literacy (SAIL) the level of information literacy as it was taught, practised and assessed in core units in an applied science degree was mapped, before and after a degree review.
3. The rubric approach to mapping IL attribute achievement a degree highlighted where the critical student competency in information literacy is now lacking at the advanced levels of the program since curriculum change.
4. The digital skills necessary to support information literacy in a disrupted digital world need to be placed throughput the whole the curriculum, and not only focussed early in a degree programme as is often reported.
5. The explicit consideration of IL within the progressive curriculum translates to the graduate outcomes with knowledge of the discipline that allows students to be adaptable to the future digital dominant work environment

Keywords

graduate attributes, STEM, curriculum mapping; course learning outcomes; SOLO taxonomy

Introduction

Information competencies are essential for learning; enabling a student to assess, evaluate and engage with information for effective learning outcomes. In the 21st century, information literacy and digital competency must be intimately entwined within curricula. To be information literate in the current digital world, students need to be able to scrutinise, assimilate and integrate digital information from various sources for contextual learning purposes, going beyond simply searching for, and identifying, digital information (Demirbag & Bahcivan, 2021; Ng, 2012; Tang & Chaw, 2016).

Information literacy (IL) is defined as “the set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning” (ACRL, 2015, p.8). Therefore, digital literacy, as the possession of the technical skills together with the abilities needed to use digital devices, embodies information literacy. Based on well-established frameworks of digital literacy competencies, Silber-Varod, Eshet-Alkalai, and Geri (2019), examined seven skills for digital literacy, or which critically evaluating, selecting, processing information and constructing new knowledge, directly impacts on collaboration and communication. Further, communicating information to multiple audiences is a central outcome of the tertiary learning setting: with the assimilation of selected information into the personal knowledge base to learn, create new knowledge, solve problems and make decisions. The latter application becomes an integral strategy of independent learning and lifelong scholarship (McGuiness, 2006). Fundamentally, students are required to demonstrate the skills of interpreting digital text and representing ideas in digital media to effectively communicate with others (Frazel, 2010). Adequate development of digital literacy for learning enables a deep understanding of the digital environment, enabling co-creation of content and intuitive adaptation of information into new contexts (van Laar et al., 2020).

To future-proof the workforce, today’s students continually need to acquire new skills as new technologies emerge (Dondi et al., 2021). Within the dominant foundational skills of cognitive and digital proficiencies, seeking relevant information through critical thinking, synthesising messages through communication, and digital fluency through digital learning and literacy are all embedded as outcomes of information literacy. It is therefore imperative that systematic development and integration of IL competencies, within the evolving digital context, are addressed as a vital skill set in undergraduate curricula in higher education. Unfortunately, students often struggle to consolidate IL competencies, resulting in ineffective learning strategies for life-long practice (Biggs & Tang, 2011; Bruce 2008). Although IL is traditionally gained rather passively via libraries or other central facilities in a university, a holistic approach argues that active IL instruction placed within the disciplines can be more effective (Grafstein, 2011; McGuinness 2007; Moore 2005). Intervention in IL development, by embedding IL through the degree, can profoundly improve students’ research and writing outcomes (Ladbrook & Probert 2011; Secker & Coonan, 2011).

In STEM (Science, Technology, Engineering and Maths) disciplines, epistemic cognition, and digital literacy have been found to positively relate to learning outcomes (Greene et al., 2014) and strongly underpin students' information organising skills (Demirbag & Bahcivan, 2022). In environmental science curricula, as an example, students require a grounding in interdisciplinary knowledge and skills to tackle complex environmental problems that address conservation, sustainable solutions and rehabilitation of both managed and natural ecosystems. Environmental scholarship is problem-driven, and both context and transferable information literacy skills are critical to the transdisciplinary nature of environmental research and development (Scholz & Tietje, 2002). Hence, developing IL in a disciplinary context is essential to student development of self-directed learning but is often left to chance rather than formally built into learning programs (Feekery, 2013).

Educational systems have been transformed by integrating discipline information and technological skills, (Griffin et al., 2012), although the absence of well-founded guidance for development of generic competency capabilities makes integration and assessment of these difficult (Chan et al, 2017). There is a further lack in pedagogical expertise of academic practitioners to make curriculum decisions informed by learning research attuned directed at the development of generic capabilities (Salmon, 2019). In response to the changing global higher education and learning environment, there is a shift from information literacy (IL) to information fluency to include multiple literacies, including digital literacy. In 2015, the Association of College and Research Libraries issued a pioneering document: "Framework for Information Literacy for Higher Education" (ACRL, 2015). The re-focus on threshold concepts rather than standards provided a beneficial perspective for assessing information literacy (Bauder & Rod, 2016). However, the framework does not provide a mechanism to embed the competency thresholds within a contextual curriculum progression.

Generally, integration of IL often occurs within specific instruction modules to address discipline-specific information acquisition (eg. Knapp & Brower, 2014; Maybee, Doan, & Flierl, 2016), but few studies exist assessing the efficacy of this approach, especially for STEM disciplines (Bakermans & Plotke, 2018; Mays 2016). Bakermans & Plotke's, 2018, study was unique in that it blended both STEM and Humanities content with information literacy instruction at the first-year level of a course, and showed improvement in perceived learning by students. Integrating information literacy into multidisciplinary courses, and units of learning with evolving experiences is likely to be the most productive pathway for successful graduate outcomes (Bakermans & Plotke, 2018). To achieve this, a mechanism by which a student can develop from information consumer to an active developer and distributor of new knowledge is the desired outcome for a transparent and progressive learning pathway (Bauder & Rod, 2016). Therefore, evaluation of a curriculum addressing competency in discipline specific information literacy is desirable so that educators can identify gaps and opportunities in how IL is taught, practiced and assessed.

Curriculum review cycles, common across tertiary institutions, provide valuable opportunities for educators to examine the sequence of IL development in a degree structure and its alignment with student learning outcomes to ensure IL is embedded in the discipline learning (ACRL, 2015;

Secker 2011), rather than gained by standalone measures offered by centralised facilities (Hulett et al., 2013). Curriculum mapping provides an informative part of course reviews across disciplines that can provide a mechanism for reflection by educators on unit-level contribution to course delivery on IL. This needs to be undertaken in a clear, consistent and transparent way (Al-Eyd et al., 2018).

To address the gap to achieve the desired information literacy threshold outcomes at degree level, and provide a process to embed information literacy into units of learning across evolving learning experiences; in this work we propose and evaluate a framework for assessment of Student Attributes for Information Literacy (SAIL) in a Bachelor of Environmental Science Degree at the University of New England (UNE), Australia. This approach enables the assessment of student capability in IL from year one through to the final year of an applied multidisciplinary science degree, a process previously lacking in the literature.

The objective of this work was to develop a framework that educators can use as a transparent, practical and repeatable approach to identifying progressive IL development at the unit (subject) learning level. We evaluate the framework by reviewing information literacy in a digital context as it is taught, practised and assessed (through curriculum mapping) across a review cycle of the in the Bachelor of Environmental Science (BEnvSc) degree at a regional university, in Australia. We assessed the level of IL instruction, competency development and assessment strategies used. The analysis describes and reflects on the influence of revising the curriculum structure to address course review recommendations, one of which was to ensure the degree was preparing environmental science students to deal with complex multidisciplinary problems in an increasingly disrupted digital world. In this study we compared the recent core degree structure as developed from the review recommendations with the earlier, 2015 iteration. The paper presents the steps in the process whereby we:

- Develop a framework of Student Attributes for Information Literacy (SAIL) attainment.
- Apply the SAIL framework to the current and earlier degree core units, to identify the level of attainment in IL provided
- Assess the level of IL instruction, competency development and assessment strategies used.
- Determine the gaps and opportunities for the current core degree structure, based on framework of SAIL findings.
- Provide recommendations how the SAIL framework may be used as an audit tool for other multidisciplinary degrees.

Context and Background

The University of New England (UNE), Australia is a mixed-mode tertiary research and teaching institution based in regional New South Wales (NSW) offering a blended learning experience to enable an equitable education experience for a range of different student cohorts to learn on- and off-campus. The UNE Bachelor of Environmental Science (BEnvSc) degree had its first student cohort intake in 1999. Since that time, the university teaching and learning has developed rapidly

to engage with the online environment and provide students with online learning platforms that allow them to learn asynchronously and independently of a physical setting - “anywhere and anytime”. The on-campus blended learning practise is supported by an online learning management system (LMS) for administrative and forum-based communications. The majority of learning for these students is synchronous and presented face to face with structured weekly and class paced learning activities. Conversely, the off-campus student cohort, although having the equivalent online LMS for administrative and forum-based communications, complete many activities asynchronously at a more flexible pace (Burns et al., 2021). For many environmental science units, the off-campus students gain the requisite contextual practical and laboratory skills by attending the regionally located campus to engage in field and laboratory-based intensive schools. However, for both learning modes the instructional design and assessment strategies have not necessarily kept pace with the online developments. This is particularly the case since the onset of the COVID-19 pandemic in 2020, with the rapid initiation of online learning environments for large student cohorts (Burns et al., 2021). Frequently, student assessment can be summative (e.g., exam-based) or use only basic online resources (e.g., quizzes), developed from traditional learning practices, that do not necessarily integrate and develop higher order thinking or meaningful competencies in information literacy in a digital and technologically expanding setting.

Typically, UNE on-campus and off-campus students have contrasting background knowledge and educational experiences and therefore different expectations of their transition to a university learning environment (Rovai, 2002). The on-campus teaching is synchronous with material delivered face-to-face and aligned to student learning. The current student profile in the BEnvSc 2020 (census before COVID lockdown 2020), shows a dominance of off-campus domestic enrolments age 25-29, with gender parity. The majority of students enrol as mature age entry or previous tertiary level entry. Over the decade to 2020, an increasing proportion of students are enrolled as off-campus with 89% (n = 137) in 2020. There has been consistent gender parity from 2018, with greater proportion of female enrolments in 2020 (59%). A shifting demographic was age distribution of the commencing and continuing student cohort in off-campus students, regardless of gender, with increasing representation of 25 - 39 year age bracket form 2012-2022. In contrast, the on-campus continuing and commencing student cohort were predominately in the 18 to 24 year age bracket, but contributed less than 25% of student enrolments).

Degree Structure and Review

The three year BEnvSc degree, aims to provide students with a systematic and sound scientific understanding of regional, national and global environmental issues and their management. The degree is designed to provide a flexible and personal learning journey, with students gaining generic and specialist skills to be job-ready in a range of career pathways including environmental protection, conservation, land, wildlife and water management, and further postgraduate study. Fundamental knowledge and well-developed field and practical skills are gained in core units of the degree with four majors (conservation ecology, envirobusiness, natural resources

management, remediation and restoration) enabling specialisation, or a generalist program of knowledge. Industry engagement and experiential opportunities enable students to operate as competent professionals in a wide range of different environmental science careers.

The BEnvSc degree was reviewed in 2015, and as part of that review the curriculum, graduate attributes and assessment tasks were examined. A key outcome of the review was to ensure the degree prepared environmental science students to solve complex environmental problems in a digital information world. The current degree program, offered since 2017, was developed on the recommendations of the review. The degree level graduate attribute on information literacy is described as follows (UNE student Handbook, 2021). "*Students will be taught how to access the literature (especially on-line resources), how to evaluate the robustness of literature sources (discrimination skills) and how to critique available information. Students will then practise these skills through the generation of reports and oral presentations in relation to environmental science"*

The degree program is composed of 14 core units, with 50% of these in 1st year (Table 1). Prior to degree changes in 2017, pre-empted by a 2015 course review, there was a more even distribution of core units across 3 years, but a smaller range of elective options in the final year of the degree (Table 1). Prior to the degree changes, the degree comprised two streams, a general environmental science stream, and a management major. A significant outcome of the degree review was the introduction of four majors along with a generalist program to allow students greater flexibility and specific streams of specialisation as recommended by the review. In this study we compared the recent core degree structure as developed from the review recommendations with the earlier, 2015 iteration.

The degree review process was progressed through the establishment of a multi-disciplinary course team who were responsible for the redevelopment of degree level learning outcomes and graduate attribute descriptions for compliance with Australian Quality Framework (AQF) requirements (Table 2). Of the five degree learning outcomes in the revised degree structure, those with strongest emphasis on information literacy and allied communication competencies are CLO 3; *gathering, synthesising and critically evaluating information from a range of sources*; and CLO 4 *effective communicators of environmental science* (Table 2). A significant feature of the redevelopment of LOs entailed a shift whereby graduate attributes were no longer assigned to individual assessment tasks within units of study, but were articulated only at the degree level. Hence, unit descriptions no longer included the contribution to a graduate attribute, as was the case in the pre-2017 degree. The structure of the revised degree, including the core units, prescribed and elective units were aligned with the revised course learning outcomes.

Table 1.

Core units in the Bachelor of Environmental Science degree, before and after curriculum revision. Bold – pre and post 2017 curriculum change; Italics–pre-2017, removed form core; *New to core with 2017 curriculum change.

100 level	200 level	300 level
Biology I	**Plant Diversity**	**Environmental Impact Assessment**
Biology II	**Ecology - Populations to Ecosystems**	**Introduction to GIS and Spatial Thinking**
Quantitative Skills with Applications	*Ecological Methods*	*Remote Sensing and Surveying*
Chemistry 1	*Vertebrate Zoology*	
Sustaining Our Rural Environment I	Aquatic Ecology* 2017	
Introduction to Statistical Modelling	Soil Science *2017	
Ecology: Concepts and Applications*2017		
Our Blue Planet*2017		

Table 2.

Bachelor of Environmental Science degree course learning outcomes (CLO), with direct quotes and selective text highlighting information literacy (italics) 2017-2021.

	Description
CLO 1	demonstrate a coherent understanding of environmental science by *articulating* the scientific basis for environmental science and *explaining* why current scientific knowledge is both contestable and testable by further inquiry; and *explaining* the role and relevance
CLO 2	exhibit depth and breadth of scientific knowledge of Environmental Science …
CLO 3	critically analyse and solve scientific problems by *gathering, synthesising and critically evaluating information from a range of sources*; designing and planning an investigation...
CLO 4	be *effective communicators of environmental science* by communicating scientific results, information or arguments, to a range of audiences, for a range of purposes, and using both written and oral delivery modes…
CLO 5	be accountable for their own learning and scientific work by being independent and self-directed learners …

Method

Developing a framework of Student Attributes for Information Literacy (SAIL)

In order to help students become expert knowledge brokers, the SAIL model builds from foundation-level skills based on acquisition of knowledge to the development of meta-cognitive skills. Using the knowledge practices from the ACRL framework (2015) in conjunction with key standards of the Australian and New Zealand Information Literacy Framework (Bundy, 2004), we developed the Student Attributes for Information Literacy (SAIL) Framework. The cognitive constructive perspective is appropriate development of expert thinking through a progressive development of learning, such as from information capture to application in novel situations (Geerthuis et al, 2022). The cognitive constructive perspective further maintains that learning is purposeful and active whereby the learner is supported and encouraged to progress from learning of initial skills, to self-efficacy in goal setting (Baeten et al, 2010), and the finally mastery and flexibility in performance (Persky & Robinson, 2017). Within the cognitive constructive perspective, the learner's conceptions are recognised in the learning environment to ensure progression from foundational knowledge adequate to support higher level strategies in context. At each level student achievement is demonstrated by their ability to independently apply and integrate that knowledge using the SOLO taxonomy ('structure of observed learning outcomes", (Biggs & Collis 1989), which describe levels of increasing complexity in students' understanding and application.

Application of the Rubric

The rubric, accompanying the framework of SAIL, demonstrates how IL levels can be embedded across a degree structure, so that subsequent learning levels are dependent on acquisition and application of information literacy capabilities in the preceding level. The rubric is intended to assist educators to identify the IL levels with the statement of student achievement, demonstrable competencies and assessment strategies for each level. The level descriptions are all essential attributes and can be embodied in multiple assessment tasks. With each level of IL there is increasing knowledge and skill proficiency attainment with the expectation that students will have capacity to deal with more complex scenarios in the curriculum.

We developed the Student Attributes for Information Literacy (SAIL) by adapting the knowledge practices from the ACRL framework (ACRIL, 2015) in conjunction with core standards of the Australian and New Zealand Information Literacy Framework (ANZILF; Bundy, 2004) (Figure 1). The principles of the ANZILF describe core standards, which underpin information literacy acquisition, understanding and application are:

(1) recognises the need for information and determines the nature and extent of information and source it effectively and efficiently

(2) critically evaluates the information and the information seeking process and manages the information collected or generated

(3) uses the information with understanding and acknowledges cultural, ethical, economic, legal, and social issues surrounding the use of information

(4) applies prior and new information to construct new concepts or create new understandings

Alone, the framework of Bundy (2004), and the ACRL (2015), cannot provide a template on which to categorise, *progressive* levels of attainment, and core standards 1-4, in essence are the outcomes of a degree completion. To achieve a more nuanced understanding of IL throughout a degree we implemented a constructive alignment approach to developing a rubric with incremental attainment of IL acquisition and application over a degree programme. A constructively aligned program benefits from the powerful effect of assessment on students' learning experiences by clearly evaluating their practice of intended learning outcomes (Biggs, 1996). The rubric identifies the progressive intended learning outcomes, demonstrable competencies and assessment strategies by which to measure attainment. The framework of SAIL was applied using a rubric as a constructive alignment tool to the UNE's Bachelor of Environmental Science degree to assess levels of IL across the core units in the pre and post 2017 versions.

Embedded within a constructive alignment approach the rubric melded with the SOLO taxonomy ('structure of observed learning outcomes', Biggs & Collis (1989), to describe levels of increasing complexity in students' understanding and application. Based on cognitive development theory, the SOLO taxonomy helps to map levels of understanding that can be built into intended learning outcomes and create assessment criteria or rubrics. SOLO taxonomy consists of five levels of information retrieval and understanding: Pre-structural: Uni-structural, Multi-structural, Relational, and Extended abstract. At a foundational level, we would aim for a progression from uni-structural to multi-structural understanding as a student's response focuses on several relevant aspects but are likely treated independently. At an advanced level of IL we aim for relational application and understanding of concepts whereby skills and knowledge are integrated to form a coherent whole, demonstrating connections between and across acquisition and application. At an Innovative and abstract level, in the latter parts of a degree progression, the learning outcomes strive that the integrated whole is now conceptualised at a higher level of abstraction, with demonstrated ability for linking information, and applying skills in novel situations.

The rubric, accompanying the framework of SAIL, showed how IL levels are embedded across a degree structure in the pre and post 2017 versions of the UNE degree so that subsequent learning levels are dependent on acquisition and application of information literacy capabilities in the preceding level. The rubric identifies the IL levels with the statement of student achievement, demonstrable competencies and assessment strategies for each level (Table 3). The level descriptions are all essential attributes and can be embodied in multiple assessment tasks. Therefore, no single assessment task has to achieve all aspects of the IL level. There are

two aspects to structural complexity in assessment: the amount of detail in the student's response (acquisition of material), and how well put together that detail is (the application response). The tenet of the open-ended SOLO progression is used here to elicit both acquisition and application of higher cognitive outcomes from students.

With each level of IL there is increasing knowledge and skill proficiency attainment with the expectation that students will have capacity to deal with more complex scenarios in the curriculum. Ideally a student should experience a sequence of levels in IL over several units building from year one through to the final year of their degree with foundational being the lowest level and innovation and abstract being the highest level of achievement in accordance with the framework of SAIL (Figure 1).

At the foundational level (1st year) – acquisition: Provides a progression from uni-structural to multi-structural student outcome within the SAIL framework by building on the ANZIL (core 1,2) at a foundation level, whereby [students] identify keywords, synonyms, and related terms for the information acquisition (Bundy, 2004 pg 27). Further foundational understanding includes understanding of ethics and acknowledgement of sources are the focus of student achievement (core 3). For this level the academic integrity skills for acknowledgement of sources is particularly emphasised, being also an institutional level requirement and incorporated into all units of learning. Within specific units, student performance of basic databases searches using different systems with appropriate source citation, in highly scaffolded assessment tasks is demonstrated (Table 3). Students also use multiple lines of evidence in the situational context in a moderately scaffolded assessment tasks (Table 3). Student achievement is shown by using sources that are relevant, current and of high quality with accurate citation (Table 3).

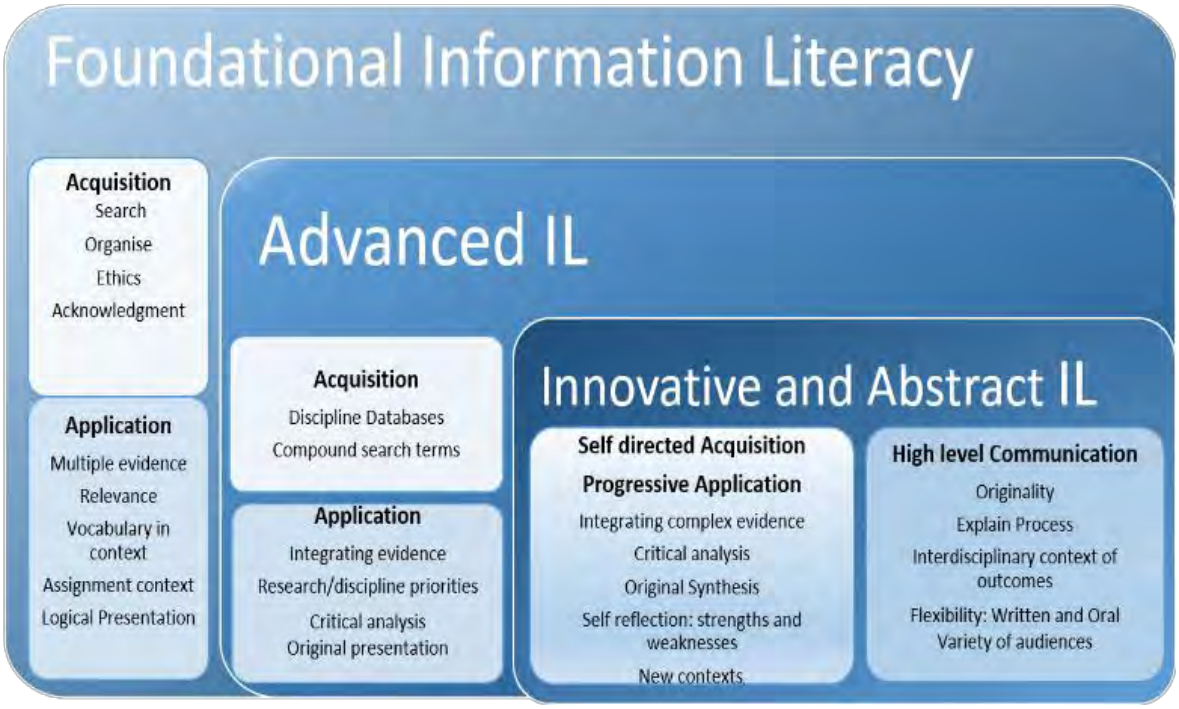
At advanced levels (typically in 2nd and 3rd year) (Figure 1, Table 3): The SAIL framework provided outcomes within a relational outcome building on the ANZIL (core standard 4) 'whereby a [student should] extend initial synthesis with some level of abstraction to construct new hypotheses' (Bundy 2004, pg 27). Students would be expected to demonstrate increasing IL competencies to acquire, integrate and evaluate multiple lines of evidence in context, in a loosely scaffolded assessment task. Information acquisition would involve students applying advanced skills to new databases and to organise and present acquired information in multiple formats. In addition, at the advanced level, students would be able to demonstrate reflection on quality of research effort and difficulties encountered. Assessment tasks would include multimodal presentation formats, critical appraisal, and reflective practice. High-level communication skills are integrated into assessment tasks at the advanced levels of IL to enable students to transition to the highest level - innovative and abstract IL.

The highest level – Innovative and Abstract: Provides outcomes at an extended and abstract level (expanding on core 4) and may be demonstrated by a capstone research or workplace experience in 3rd year, or through an honours (4th) year (Figure 1, Table 3), whereby students would be expected to display autonomy in IL acquisition. At this level, students should demonstrate ability to independently acquire, relevant and high quality literature, and apply the

sources to a non-scaffolded assessment task to address 'complex' research questions or highlight research priorities.

Figure 1.

Framework of Student Attributes for Information Literacy (SAIL) in a tertiary environmental science degree



Note. Foundational level (1st year); Advanced level (2nd -3rd year) and Innovative and Abstract (capstone experience or honours) (IL Information Literacy).

Table 3.

Rubric of Student Attributes for Information Literacy (SAIL) including for each stage: statement of student achievement, demonstrable competencies and assessment strategies. (Developed from Biggs & Collis, 1989; Bundy, 2004)

Level, (SOLO level equivalency) Description	Statement of student achievement	Demonstrable competencies	Assessment strategies
Foundational: Acquisition (Unistructural / Multistructural) Information acquisition skills and, understanding of ethics and acknowledgement of source	**Acquire a basic understanding** of information literacy and the specific skills required to acquire, organise and present information. **Able to identify** the ethical considerations when citing work, and acknowledge all sources, and **Acquire skills** to identify and evaluate relevant information for a highly scaffolded assessment task.	• Investigate an assigned topic • Perform basic database searches (Library searches, Google scholar) • Access a wide variety of sources • Recognise and avoid plagiarism	• Academic integrity quiz[#] • Wiki for group reference collection • Report writing [#] Institution requirement
Foundational: Application (Multistructural) Provide multiple lines of evidence in context	**Apply the understanding of information literacy** and the specific skills to new contexts. **Apply the identified** ethical considerations consistently when citing work, and acknowledge all sources in text, tables and figures. **Apply developed skills** to identify relevant information for a moderately scaffolded assessment task.	• Rely on primary sources • Demonstrate sources used are relevant, current, and of high quality • Establish the validity and importance of sources to context • Citation is accurate/ full bibliography	• Essay • Annotated literature review • Scientific report • Practical report
Advanced: Acquisition and Application (Relational) Acquire, integrate and evaluate multiple lines of evidence in context	**Acquire relevant and high quality literature and apply** to a loosely scaffolded assessment task to address research questions or highlight research priorities. **Able to integrate concepts**, and reflect and critically analyse research effort applied to assessment task. **Apply advanced skills** to new databases, organise, and present acquired information in multiple formats.	• Discipline-specific databases used • Reflect on quality of research effort and difficulties encountered • Demonstrate intellectual curiosity • Demonstrate critical thinking to separate information, misinformation and disinformation on a topic	• Critique of published material • Impact assessment report • Scientific reports with critical discussion • Extended practical report • Reflective journal/portfolio • Oral presentations
Innovative and Abstract: Application. (Extended Abstract) Autonomous information acquisition; Initiates research ideas; progressive level of information literacy applied to new contexts and situations through effective communication	**Acquire independently, relevant and high quality literature, and apply** to a non-scaffolded assessment task to address 'complex' research questions or highlight research priorities. **Able to reflect and critically analyse** research effort applied to assessment task, including strengths and limitations in research. **Highly developed skill development** with ability to communicate research outcomes; high level of synthesis; multiple formats.	• Self-directed research skills • Reflect on quality of research effort and difficulties encountered • Originality of project • Develop research proposals • Innovative presentation of research s	• Extended research project report (e.g. Capstone unit/ Workplace Integrated Learning report) • Oral presentation/Seminar • Research poster • Honours thesis /Postgraduate research

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Results

Degree Mapping of Information Literacy before and after Curriculum Change

Information literacy was mapped using the SAIL rubric (Table 3) across the three year progression (full-time equivalent) in the BEnvSci, before and after curriculum changes, and showed that after 1st year there were fewer opportunities incorporating IL development with the curriculum changes (Fig. 2). In year one of the degree, IL was addressed by 7 core units (mostly 100 level) in both degree structures. IL was taught, practised and assessed in the 7 core units at the foundational acquisition and application level. Although acquisition competencies were dominant, there was a 12% increase in application competencies in these core units after the degree curriculum changes at the 100 level. At 100 level there was an increase in assessment tasks via open book tests and quizzes (from 2 to 4 tasks) after the curriculum change compared with a decrease in invigilated exams and tests (from 10 to 8 tasks), which do not explicitly assess IL (Table 4). There was a slight decrease in highly scaffolded assessment tasks such as essays and scientific reports with curriculum change. The sole oral assessment task in the core units was removed at 100 level.

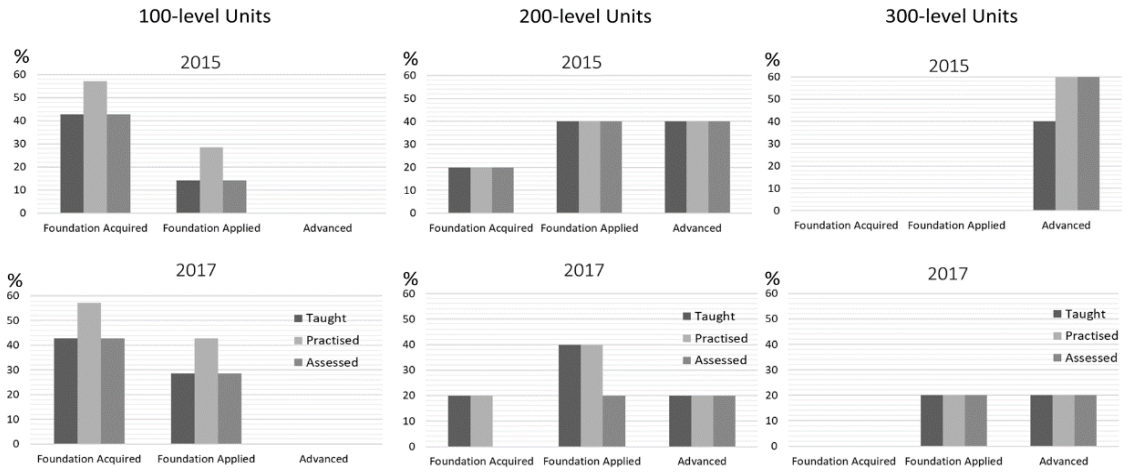
Information literacy in year 2 (200 level) of the degree was covered by 5 core units before curriculum changes but was reduced to 4 core units in the current degree version (Fig. 2). There was a clear decrease in foundational acquisition IL competencies in core units compared with 100 level, and acquisition competencies were no longer explicitly assessed at 200 level. The foundational level of IL remained the same in both iterations of the curriculum. There was a 20% decrease in advanced level IL embedded at 200 level after degree curriculum changes (Fig. 2). Changes in the assessment tasks within the core units showed a sharp decline in invigilated exams (from 6 to 3 tasks). One moderately scaffolded written task was removed whilst highly scaffolded written tasks remained. There was a 100% increase (from 2 to 4) in open book quizzes after curriculum change (Table 4).

In year 3 there was a decrease in the core units from 5 to 2 core units with curriculum change to offer students greater flexibility in degree content. In third year (300 level), before the curriculum was changed, 60% of the 5 core units practised and assessed IL at an advanced IL level. With the degree changes, there was a marked decline for all aspects (taught, practised or assessed) of advanced IL level development opportunities. Notably, in the current curriculum only 20% of core units include foundational application skills at 300 level (Fig. 2), although IL in locating, assessing and using online information in order to solve real world problems is expected. Changes in the assessment tasks after curriculum change show that the use of invigilated exams increased (0 to 2 tasks). The reduction in opportunities for moderately or loosely scaffolded written tasks is notable, including the only student-directed problem based learning assessment task (Table 4).

The dynamics of assessment activities has remained fairly static in core units (n=14) over the two degree structures, with a greater reliance on online quizzes in the current degree (increase of 50%) as the most noticeable change (Table 4). Summative assessment through end-of-unit invigilated exams remain common-place (n=13) but provide little opportunity for IL development or assessment (Table 4). Hence, students, on the whole, have fewer opportunities for advanced levels of IL learning, and there has been a notable reduction of innovative and abstract assessment activities in the core curriculum after curriculum change.

Figure 2.

Mapping of information literacy training, practice and assessment (TPA) using SAIL rubric



Note. Percentage of core units over a 3 year Bachelor of Environmental Science degree before (2015) and after (2017) curriculum change.

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Table 4.

Information literacy levels of assessment tasks in core units over a 3 year Bachelor of Environmental Science degree before (2015) and after (2017) curriculum change using SAIL rubric

	Exam/ tests (invigilated)	Tests/ quiz (open book)	Highly scaffolded essay/ practical report	Loosely scaffolded essay/report (lecturer defined topic)	Oral presentation Live or recorded powerpoint or video talk	Critical essay - student-autonomous	Problem-based learning – student directed topic
Level of information literacy	**No assessment of IL**	**F**	**F**	**A**	**A**	**I &A**	**I &A**
2015							
Yr 1	10	2	6	0	1	0	0
Yr 2	6	2	3	4	0	0	0
Yr 3	0	1	2	1	0	1	1
Total	**16**	**5**	**11**	**5**	**1**	**1**	**1**
2017							
Yr 1	8	4	5	3	0	0	0
Yr 2	3	4	3	3	0	0	0
Yr 3	2	1	2	1	0	0	0
Total	**13**	**9**	**10**	**7**	**0**	**0**	**0**

Note. F – Foundational, A – Advanced, I & A – Innovative and Abstract

Discussion

Embedding learning activities that allow students to practice and develop their information literacy skills in a digital environment requires placing the student in a real-world situation where they need to solve problems, and navigate a pathway to a satisfactory resolution (van Laar et al., 2020). Students increasingly need to be able to demonstrate their information literacy and digital dexterity to prospective employers (Mercer et al, 2020). Consequently, the digital skills necessary to support information literacy need to be systematically integrated in the whole curriculum (Wilkes, Goodwin & Gurney, 2015) and, in the context of dominant online learning environments imposed by current world events. The unique concentration of deep disciplinary diversity in an applied course such as Environmental Science provided a testable model for other diverse courses to foster the ability to creatively and collaboratively transform and apply knowledge and skills across multiple disciplinary contexts. The focus on one core graduate attribute of IL assists in assessing the development of critical thinking and the ability of students to discern the integrity of information from a vast array of information available to future knowledge workers (Barrie & Pizzica, 2019).

The SAIL framework supported by a rubric enabled the examination of the student experience of IL across core units in year one through to the final year of their degree in core units of the BEnvSc degree for two different programs, before and after a degree review. The mapping of assessment activities in core units showed that IL, although incorporated into units, was mostly at a foundational level regardless of year offered in degree. Particularly, opportunity for advanced IL development in core units was reduced with the modified degree structure as developed based on recommendations of the degree review. Likewise, the mapping of IL found that information literacy was taught, practised and assessed, comprehensively by first year units. There was a transition from foundational acquisition dominance at 100 level, to an increased focus on foundational application at 200 level in both degree structures. Advanced level IL attainment opportunities existed in only a select number of 300 level units in 3rd year with the curriculum change. Further, there were fewer opportunities in core units to undertake autonomous learning experiences with the curriculum change.

Advanced level information literacy opportunities were concentrated in a few core units. Increasing flexibility in choice of units in the revised curriculum further removed the opportunity to focus on information literacy competencies. Potential opportunities for advanced acquisition and application levels, however, could exist in elective units. As the IL learning outcomes in elective units were not

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assessed it is not possible to assure the attainment of the equivalent IL learning outcomes would be achieved, and in any case, there was no guarantee students would enrol in units that could provide this.

The major changes to 'open up' the Bachelor of Environmental Science in the 2017 curriculum stemmed from a review recommendation to build in options to both maintain a generalist training option, and offer specialisations in key areas integrated into the strengths of disciplines and employment pathways, while maintaining a range of flexibility within themes. Providing autonomy and flexibility in learning across topics, class availability, and online availability of course offerings (Derrick & Carr, 2003), are paramount for increasingly mature age market, at trend seen in the BEnvSc at our institution. Offering some breadth through listed electives within specialisations and a generalist option provided an opportunity to extend and expand upon core units to further develop in students not only work place skills but also the skills necessary to navigate and negotiate a volatile work future (Barrie & Pizzica, 2019).

Increased flexibility in the degree resulted in a significant increase in student enrolments, which achieved one of the goals of the degree review. Nevertheless, the decrease in core units at 3rd year resulted in a decrease in guaranteed information literacy in graduates at an advanced level. Particularly, opportunities for autonomous abstract and integrative assessment also decreased. Aside from review recommendations for the changed degree structure resulting in less core units at higher levels, staff resourcing, and time availability may also be contributing. Prior to the degree restructure, UNE altered the teaching calendar to a trimester system, which reduced the number of teaching weeks per period. Assessment of these high-level IL tasks requires time, which was reduced by the trimester system, creating a greater reliance on assessment tasks with a rapid turnaround time or those that could be marked automatically (such as on-line quizzes), which have limited IL development. To address IL for our students in the future, a range of prescribed units that fill the identified IL level gaps could be embedded in each major. Prescribed units (core within majors) need to complement existing core units, and at the same time define a clear progression to advanced levels of IL. Applying the SAIL framework rubric to units that sit outside the prescribed units would also identify where further opportunities in developing advanced competency in information literacy exist.

Frameworks such as the Information Literacy for Higher Education (2015), place information literacy within a digital literacy framework and emphasise successful use of online resources to acquire knowledge as a key competency required by learners, but do not offer a nuanced understanding of developing IL attainment

(Limniou et al., 2021). Moreover, high levels of attainment would unquestionably go hand-in-hand with many key workplace skills. Attributes of IL such as critical appraisal, cognitive flexibility, judgement and decision-making are embedded in contemporary digital literacy frameworks (eg. CAUL Framework, 2020).

The rubric could be extended by providing a broader set of IL experiences that are linked explicitly to unit assessment at advanced levels of an undergraduate degree. In capstone units, which allow culmination of knowledge and skills across the whole degree, advanced IL skills could be better realised. A capstone experience in the form of either a research project or workplace integrated learning placement, for all final year students, may address the current lack of advanced and abstract level IL within the degree structure. By placing the student in a real-world situation and embedding learning activities with measurable IL outcomes they can experience advanced discipline learning whilst also practicing and developing information literacy skills in a contemporary digital landscape (Kenny, 2011).

Future Perspectives & Study Limitations

Digitally literate individuals in the workplace are not only expected to hold technology-based information and skills but also should utilise digital technologies effectively in their learning processes. Cognitive and meta-cognitive processes underpin students' information organising skills and form an integrative part of developing meaningful reasoning for combining the information obtained through online system and subsequent translation of material into digital communication modes. (Green, 2014; Demirbag & Bahcivan, 2022). The information literacy outcomes of *communication skills*, *mental flexibility* and *digital learning* including synthesising messages, choosing reliable sources and translating knowledge into different contexts, are three of the cognitive and digital fluency skills groups identified by McKinsey and Company report (2021) required in the future world of work. Synthesising messages in itself was the third highest proficiency related to chance of employment (Dondi et al. 2021). These higher order cognitive outcomes for information application can be clearly identified, independently of acquisitional skills in the relational and abstract levels of the SOLO framework (Biggs & Collis, 1989)

A systematic framework such as SAIL, with the rubric approach for auditing information literacy, provides a valuable and transparent tool for understanding the progression of IL competency gains in a tertiary curriculum and can help to identify gaps in assessment and advanced level instruction. This bridges the gap between the required information literacy threshold outcomes and embedding

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information literacy with progressive experience (Bauder & Rod, 2016), by providing a mechanism for attainment (Bakermans & Plotke, 2018). A recommendation of this study is that greater emphasis should be placed upon developing students' awareness and development of the interconnectedness of information acquisition and application with digital competences to enhance both academic success and transferrable skills (van Laar et al., 2020; Tang & Chaw, 2016; Ng, 2012). To achieve this, one strategy that warrants further investigation is development of information and digital literacy in undergraduate courses to culminate in a portfolio of transferrable skills and holistic degree appraisal (Walland & Shaw, 2020). Additionally, exploration of the value and appeal of the SAIL framework to other course designers of tertiary degrees is warranted, including a range of STEM disciplines, and disciplines with different rationale and processes for information acquisition, application and assessment. After multi-disciplinary assessment, a generic guide may be developed that allows course designers to audit learning and assessment opportunities and ensure that specific and progressive development of IL is embedded throughout a degree program.

While this study only captures the integration of the SAIL rubric into a single review iteration of one multidisciplinary degree, its constructivist aligned framework enables further curriculum designers, teaching focused academics and stakeholders with a scaffold for ongoing integration of graduate attributes during program development and revision. The integration of the SOLO framework (Biggs & Collis, 1987) provided a teaching and learning tool based on studies on student learning, whereby, graduate attribute attainment can be progressively identified across a curriculum. This approach also offers a critical discipline embedded view of graduate attribute outcomes during curriculum review and arguably is worth further evaluation by international practitioners of undergraduate holistic degree level and unit design, across a broad range of multidisciplinary programs. Whether IL is framed within a digital context, or the cognitive and metacognitive processes required for digital application, the integration of information is fundamental to learning. Assessment criteria and standards based on such evaluation could enable educators to identify feedback on student's progressive IL and potentially other graduate attributes.

Conclusion

It is imperative in an evolving digital world that IL attainment is developed systematically, but also dynamically in tertiary curricula to offer advanced level learning experiences to graduates. Hence degree level curriculum design and assessment activities need to be kept current in form and design so that they offer real world experiences in identifying, collating, interrogation, verifying, analysing,

synthesizing, critiquing, and presenting information. This study contributes to the curriculum development literature by demonstrating how SAIL's rubric, integrating Bigg's (1989), SOLO taxonomy, provides educators with a practical and repeatable approach to identifying IL development in units of learning progressively integrated through the constructive alignment of learning outcomes, learning activities, and assessment tasks, over the progression of an undergraduate degree. The framework and rubric ultimately identified gaps and opportunities in IL attainment, and thus warrants further application. Making sure these gaps are addressed and opportunities enhanced will ensure resilient and adaptable graduates in a digital dominant workforce.

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