ASSESSMENT APPROACHES FOR EXPERIENTIAL LEARNING IN COMPUTING PROGRAMMES

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Abstract

We review the role of assessment from the perspective of experiential learning and propose a default assessment approach for computing degree courses. We discuss a proposed format for assessment for learning for computing programmes. Our central objective is to analyse assessments and identify how assessments enhance learning. We review different assessment types and evaluate their role in achieving New Zealand Qualifications Authority (NZQA) academic level requirements for academic levels 5 (first year of degree) to 7 (third year) in New Zealand polytechnics. The key points discussed include skills, knowledge and application of knowledge and how these academic requirements are met by each assessment type. The discussion of assessment for learning roles includes portfolios, group projects, case studies, assignments, essays, simulations, tests, exams, posters and screencasts. We also discuss the impact of blended learning, analytics and technology enhanced learning. We conclude with a proposed assessment regime and an example of how to implement it.

Keywords: experiential learning, soft skills, employability, constructive alignment.

1 INTRODUCTION

Assessment is at the heart of student learning and, in the student's view, what really counts in a course [1, 2]; what we assess is the most influential factor on what skills and knowledge the student will learn. There are many forms of assessment, such as formal written examinations, workplace assessments, essays, assignments, etc. We review assessment types and propose a default assessment “shape” for degree courses. We do not propose that all courses use this pattern, but consider it a starting point with variations made and justified on a case-by-case basis.

Globalisation has had a profound effect on the skills and knowledge required for many occupations [3]. Moreover, advances in computing technology have reduced the need to memorise facts and placed a greater emphasis on capabilities. Prominent among these are communication, collaboration, creativity and critical thinking. This shift is echoed by employers who value so-called “soft” skills such as working effectively in a team, communicating clearly, and trusting and supporting co-workers [4]. Meanwhile, educators have changed from seeing learning as the transmission of knowledge from expert to novice towards an approach where the learner is central and the teacher takes the role of a facilitator [5]. The teacher helps the learner develop lifelong learning skills in addition to exploring subject content [6]. The New Zealand Qualifications Authority (NZQA) endorses this goal of lifelong learning [7, p. 3] and the development of capabilities [7, p. 30]. The NZ Ministry of Education [8] echoes the need for self-directed learning and reduced teaching contact time. Rather than passively absorbing knowledge, the learner is seen as an active agent seeking knowledge [9], [10]. The intention is that learners ultimately become independent of the teacher and can pursue self-directed learning throughout their life. The teaching focus is on what the student does and there is a clear alignment between objectives, teaching and assessment [11]. We take the view that there is no single best assessment form. However, different assessment forms affect what the student actually does and thus have different consequences. If the goal is simply to be able to recall knowledge, then simple tests and examinations may be appropriate. However, essays, projects, investigations, assignments, case studies, simulations and portfolios may be more appropriate to demonstrate higher-order skills. Authentic assessment tasks mirror the real world and are integrated with learning. In such assessment, learners are active participants and the criteria are open and negotiable [12], [13]. The goal is to engage learners in both assessment and learning. This assists learners to develop better learning and self-evaluation. Given the central role of assessment in learning, one might be tempted to conclude that if assessment fosters better learning then more assessment will mean more learning. According to Plimmer [14], it may indeed result in more learning of skills, but is likely to result in less
intellectual development as the self-management and self-assessment that is integral to intellectual maturity will be neglected. The quantum of assessment is thus part of our recommended approach.

Because assessment largely determines what students will do and learn, we examine the notion of assessment for learning [15]. The Ministry of Education [16] defines it as: “best described as a process by which assessment information is used by teachers to adjust their teaching strategies and by students to adjust their learning strategies”. We regard this notion as more important than the accreditation function of assessment of learning. This resonates with the Ministry of Education which states: “The primary purpose of assessment is to improve students’ learning and teachers’ teaching as both respond to the information it provides” [16]. This leads us to look at each assessment and ask: how does this enhance learning? We value authentic tasks, experiential learning and the development of capabilities needed in the workforce. As humans, our perceptions are shaped by our culture and values [17] and we, in turn, create and shape our culture and values. Learning is a reflexive social dialogical process in which our learning environment shapes us, we shape the environment [18] and teachers are co-learners with students in a dynamic adaptable learning environment.

Feedback is central to the learning process [19]. Effective feedback must be timely and the learner able to act upon it [20]. The learner should be actively involved in contributing to assessment criteria and judgements [21]. Feedback is thus an on-going dialogue between learner and teacher that fosters better understanding on both sides. Students in today’s classrooms have a diverse mix of backgrounds. Although the learning outcomes remain constant, this argues for flexibility in the learning routes students take and how they are assessed. Diversity also brings richness to the learning environment and helps foster creativity by exposing students to multiple worldviews. Making positive use of this requires a classroom in which students feel a sense of belonging, give and receive feedback appropriately, and feel valued by their classmates. Despite differing routes, the destination remains to achieve the intended academic level. As Biggs notes [11, p. 58], “Good teaching is getting most students to use the higher cognitive levels that the more academic students use spontaneously”.

In New Zealand, polytechnic degree programmes are accredited by the NZQA. The nature of the required knowledge, skills (processes and solutions) and application (self-management) is specified in the New Zealand Qualifications Framework and varies by level. Broadly speaking, level 5 corresponds to the first year of a degree, 6 to the second year and 7 to the final year. At level 5, the framework targets broad knowledge in a field. At levels 6 and 7, the emphasis in the framework shifts to specialised knowledge with depth. For processes, at levels 5 and 6, the framework suggests selection and application of a range of standard and non-standard processes relevant to the field of work or study. At level 7, the term adapt is added. The expectation for solutions at level 5, is to select and apply a range of solutions to familiar problems. At levels 6 and 7, the learner is expected to analyse and generate solutions. Familiarity with problems also varies familiar and sometimes unfamiliar problems (5) though familiar and unfamiliar problems (6) to unfamiliar and sometimes complex problems (7). Complete self-management of learning and performance is expected at all levels. The learner is expected to take some responsibility for the learning and performance of others at level 5 and to demonstrate leadership in dynamic contexts at levels 6 and 7

There have been recent calls for a shift towards greater use of blended learning and placing more emphasis on formative assessments. Blended learning requires an appropriate mix of face-to-face time, online learning, workplace learning and technology-enhanced distance collaboration. With limited contact time, it makes sense to use contact time mainly for activities that work best in a face-to-face context, such as discussion. Discussions can be started in class and continued on Wikis and online forums. Other activities suited to face-to-face time include oral presentations, peer-review and project planning. In contrast, self-paced exercises and assignments work best outside contact time, with online forums used to support any issues students encounter. Both help build confidence in the use of online forums for collaboration and supporting learning –an essential 21st-century skill.

Assessment is formative when the purpose is “informing teachers, students, and educational stakeholders about the teaching and learning process.” [22, p. 3] and summative when “establishing a student’s academic standing relative to some established criterion” [22, p. 3]. Thus, formative assessments provide “on-going feedback with the aim to improve teaching and learning” [23, p. 2336]. This is essentially the Ministry’s definition of assessment for learning. Most assessment types can be used directly as formative assessments and formative elements can often be incorporated into summative assessments to create feedback opportunities. However, online learning brings a particular challenge. Learners work at their own pace, but it is easy to lose direction without confirmation that the learning is on-track and an educator may worry that learners might not understand the material appropriately. Where the assessment covers foundational knowledge, learning management systems
can offer support for feedback through closed form questions, but where the assessment requires higher level skills, feedback requires judgement which generally requires a person to review the work and generate feedback. Although historically, done by an educator [24], placing an educator on the critical path makes it difficult to achieve timely feedback and misses the opportunity to deepen the learning of other students. One solution is for students to give feedback [21] using an online forum. Students can post work to this forum and others can peer-review the work. The educator monitors the forum and moderates the feedback, but otherwise allows the forum to be student-directed.

2 RELEVANT TECHNOLOGY

Recently, many industries have been transformed by the use of big data and analytics which Campbell, DeBois, and Oblinger define as marrying “large data sets, statistical techniques, and predictive modelling … to produce actionable intelligence.” [25, p. 42]. Although widely used at the institutional level to enhance accountability, the use of learning analytics to improve teaching and learning is still at an early stage [26]. Nevertheless, we expect more tools to become available over the coming years. For example, analysis of learner-produced data trails in online systems can provide valuable insights into the learning process and how educators can make improvements.

Technology-enhanced learning (TEL) focuses on how technologies add value to learning and teaching processes. Relevant technologies include gaming, mobile learning platforms, virtual environments, educational technologies, interactive videos, internet technologies and traditional office productivity tools. Technology can enhance learning by activating the learner. Learning is maximised when the learner is active, engaged, participating and interacting with the material. Dror [27] identified three critical aspects: control, challenge and commitment. The control of technologies must allow the students to control the pace and time of learning. The technology also must be challenging enough to achieve desired levels of performance. Commitment could be enhanced by use of technology, such as game based learning [28] and wearable technologies [29]. Access to mobile, connected and personal devices can create a continuity of learning experiences across different environments, termed seamless learning [30]. Students can learn whenever they want in a variety of settings (group or individually) and using different scenarios. Exploration and investigation in a seamless learning space can extend formal learning time from the classroom into informal learning time and help embrace opportunities for out-of-class learning driven by the personal interests of students such as interacting with an online learning community or participating in community projects [31]. Technology enhanced learning facies complex pedagogical rather than technological questions in knowing why and how to use technologies effectively in educational practice [32]. Research suggests that it is easier to replace, reinforce, or supplement existing teacher-centred practices with technologies than to reassess the fundamental basis of their practices. This usually leads to translation of existing practices as opposed to transformation [33]. The literature suggests that learning enhancement in technology-rich learning environments is reported mostly as quantitative improvements (more has been learned) and does not reveal much about deeper qualitative understandings. For example, many practitioners choose easy-to-implement assessments, such as multiple choice questions or short answer questions, which are unlikely to reveal qualitative changes in learner’s understanding, rather than using harder-to-implement, but deeper, assessment forms. An assessment regime should be chosen to enhance qualitative improvements in learner’s development and not just quantitative improvements [32], [34].

Dror [27] contrasts technologies that support the access, sharing and encoding of information with those that enhance how we communicate information. Students today can share, interact and immerse themselves online with others through social media networks and virtual worlds and interact with other users by blogs, wikis and social media. They can create identities and user-generated resources that potentially have world-wide audiences. Online technologies can support learner inquiries, new forms of literacy, innovative thinking, problem solving, collaboration and publication of their work to authentic audiences [35], [36]. These can be effective in supporting group work activities where the team members have difficulty meeting on campus or are distance students. Learning can be enhanced through technology in group projects with collaborative technologies, online communities and peer-assessment. These encourage students to learn from other students as well as from the lecturer. Peer-learning may involve cooperation, communication and giving and receiving peer feedback. It emphasises the sharing of knowledge and ideas between students in a reciprocal partnership [37]. It promotes lifelong learning and is linked to the generic capabilities of teamwork and interpersonal skills that employers view highly [38]. E-portfolios extend the idea of portfolios to include digital media and allow sharing electronically with others, such as potential employers. They can capture extra-curricular activities and experiences and build evidence of life-long learning, experiences
and developed skills [39]. Technologies can allow students to control the pace and time of learning. However, they should be chosen carefully to enhance qualitative improvement in the students’ learning. The guiding philosophy here is learning oriented assessment [37], [40].

3 IMPLICATIONS FOR ASSESSMENT

The foregoing accreditation requirements and beliefs have consequences for how courses should be organised to foster the desired student capabilities. The first need is to empower learners with greater autonomy regarding how they learn and are assessed, subject to meeting the learning outcomes. The second is to structure the course and assessment so that learners can demonstrate the necessary learning outcomes while developing the desired capabilities. Capabilities should be built progressively throughout the qualification, starting with significant scaffolding in earlier stages and revisiting with less scaffolding and greater depth in later stages [41]. For example, communication skills could start with presenting to a study partner or in small groups, building towards presenting to a class and ultimately a wider audience. There is a natural synergy with flipped classroom approaches [42]. How things are assessed is a major motivator for students and learning happens best when there is a constructive alignment between content and the intended capabilities and values [43]. We believe each course should have an element of group-directed work and a mix of teacher-directed and student-directed work. The mix will vary across courses and levels with less teacher-directed work at higher levels.

3.1 Portfolios and group projects

Portfolios allow a shift of focus from assessment as something done to learners, towards seeing learners and teachers as co-assessors [15]. Learners take responsibility for selecting, presenting and justifying samples of their work as evidence of achievement of learning outcomes. Our recommended approach is to build learner capability in this area by starting with structured teacher-directed portfolios in early courses, and then progressively adding greater learner autonomy in later courses.

Group projects provide a context in which many desired values can be fostered. Apart from the obvious goals of teamwork and problem-solving [47], they provide naturally for peer instruction [48] and can promote a culture in which students build trust in their fellow students as co-workers. They sit naturally with problem-based learning (PBL) and project-based learning, and can provide an authentic environment in which many work-related issues can be explored. One technique that can help avoid over-specification is for the teacher to role-play a client and for the team to interview such a “client” so as to elicit requirements and prepare a specification. In later courses, real clients can be used.

3.2 Tests and Examinations

Tests and examinations can give a learner early feedback on core skills and capabilities. It may be useful to have an early test before starting a group project. Associated feedback should be early enough in a course that learners may act on the feedback to change their approach to learning. The educational value of such tests and examinations falls as the course progresses.

3.3 Assignments and Investigations

As with tests and examinations, assignments can give learners feedback on their mastery of core skills and capabilities. It may be useful to have an early assignment before starting a group project. Assignments also provide an opportunity for self-paced learning and have a good fit to online learning. The essential ingredient, especially for larger assignments, is to provide a feedback mechanism that helps a learner understand whether they are on-track or have missed the point of the assignment. Peer and self-assessment can play a useful role here. Investigations allow learners to take control of
their learning. They learn how to take a systematic approach to discover, synthesise and present findings [49] and build critical thinking skills as a basis for lifelong-learning. In-class presentations build oral communication skills and a final report builds written communication skills.

3.4 Essays, case studies and simulations

Essays can occupy a similar role to assignments. They can measure understanding, synthesis and evaluation, so long as the right questions are asked. They are relatively easy to set but creating feedback and marking can be time-consuming for a lecturer. Maintaining consistent standards can also be challenging. The key point of distinction is a focus on synthesis and creating a coherent argument. Essay outlines can also serve a useful role, either submitted at an early stage for formative feedback, or as an assessment form in their own right.

Case studies are complex scenarios that provide an opportunity for students to develop their critical thinking. They let the student demonstrate analysis, synthesis and evaluation. If the right questions are asked. They help develop their critical thinking skills. Critical thinking is a key skill for academic success, life-long learning and the potential employability of students. Critical thinking is often compared to the scientific method; it is a systematic and procedural approach to the process of thinking [50]. Just as students learn the process of the scientific method, they must also learn the process of thinking critically. Case studies enable students to apply their knowledge to new situations and are better indicators of understanding than true/false or standardized multiple-choice assessments [51].

Simulation aims to imitate reality whilst offering a skills-based experience in a safe and secure environment. Although a simulation is usually less complete than the real-world system, it can be more developed in some ways because desired situational features can be incorporated [52]. Simulation develops technical proficiency and can be tailored to students' specific needs. It is situated within a specific context, incorporates affective (emotional) aspects of learning and can be easily replicated to consolidate learning. Simulation tools in education have evolved from low-fidelity partial task trainers to medium-to-high fidelity full-scale simulations. Their range includes task training, peer-to-peer learning, screen-based computer simulators, virtual realities, haptic systems, role-playing and full-scale simulations [53]. Simulations help students learn, practice and gain competence in simple techniques or procedures and enable peer-to-peer learning. Computer software can be used to assess knowledge and to provide feedback related to knowledge and critical thinking skills. Use cases and role playing can also be used in the simulated learning environment. Using simulations has been shown to increase gains in knowledge, critical thinking, satisfaction and confidence in students [54].

3.5 Posters and Screencasts

Posters are self-contained visual displays of information created either by groups or individuals. They can combine varying amounts of text and images and serve as a clear and concise summary of a piece of work. They are a common means for professional communication in the sciences [55] and thus represent an authentic form of assessment. The limited space of a poster forces students to prioritise and focus their effort on key arguments and evidence, key themes, or key conclusions. They foster key skills related to the visual display of information, [56], [57], promote active learning [58], are practical for large groups [59], and can involve students in the assessment process [60]. Poster projects are also ideal for collaboration and group work [61], [62], [63], [64].

A screencast comprises a dynamic capture of a computer screen with a commentary presented as a video. They can be used for mini-lectures and presentations and are well suited to tutorials that demonstrate how to accomplish some task on a computer. They are often used by lecturers to support online learning, but they can also be created by students; the student can prepare a mini-lesson on how to accomplish a task in screencast format. The key rationale underpinning this approach is that learning-by-teaching (LBT) is a powerful way of learning. LBT has been used by Montessori schools for a long time and continues to be used today [65]. The depiction of LBT has changed over time. Gartner, Kohler and Riessman [66] called it the Helper Therapy Principle, which explains that the helper benefits more than the person receiving this help. This means that students engaged in teaching can learn through the teaching process. Hartman [67] suggested that social interaction induced by teaching can have cognitive benefits (perceiving, differentiating, selecting, storing, interfering, applying, combining, justifying, and responding) and build meta-cognitive skills (planning, monitoring, and evaluating). Involving students in teaching promotes meaningful and effective learning [68], [69] and encourages “lifelong learning, where the whole of the society becomes a learning resource for each individual” [70]. One form of LBT is peer-assisted learning that uses advanced
students to help others understand the material. Benefits include increased confidence, refined social and communication skills, attitude changes, motivation toward learning, having a higher sense of personal responsibility and enjoying their learning experience [71], [72]. LBT is also used in collaborative learning. Learning is achieved by promoting learning together through individual and group accountability [73]. Johnson and Johnson’s [74], [75] reviews of cooperative learning concluded that cooperative learning produced for students: greater achievement gains, higher self-esteem, promoted greater cognitive and affective perspective, and development of creative thinking.

4 PROPOSED ASSESSMENT SHAPE

Assessment should be aligned with the intended learning outcomes of a course [43]. Although we may specify many specified learning outcomes, there is often a broader outcome expressed in an aim. We believe that assessment should be based on a project aligned with such a broader outcome. For example, a software design paper would have a number of learning outcomes relating to the creation of software but the assessment could be centred on a project to create software and the project should be authentic, not just in content but in ways of working. For example, most industry software projects involve working in a small team, version control, code review of peer’s code, etc. Such elements can be introduced into courses from a programme’s outset. Feedback is reimagined as a dialogue among students, peers and educators rather than something transmitted from teacher to learner. It should provide information on how learning is happening promote dialogue, clarify expectations, deliver high-quality information and inform teachers of understandings achieved. Work can be submitted in stages with feedback at each stage. Assessment drives student learning and it is important to spread the workload over the semester. We see greater educational value in a single assessment with progressive staged submissions than equivalent separate assessments.

Our starting point for each course is thus a single large authentic project with staged submissions or review points at which feedback can occur. Having thus identified the central assessment for a course, we then analyse the learning outcomes to identify any that are insufficiently captured by a focus on this major assessment, creating additional assessment tasks accordingly. We would consider a single assessment, submitted in stages, to be an adequate quantum of assessment and three assessments to be an upper limit. More than this suggests that the course does not comprise a coherent body of skills and knowledge. Thus, we generally aim for one, two or three assessments in a course; we prefer one assessment to two and two assessments to three. There may be a need to have an early assessment to give individual feedback before starting on the major project. For each course, we would like to see a mix of teacher-directed assessment, group-directed assessment and student-directed elements with progressively greater student autonomy at higher levels.

Online resources can contribute to formative feedback. Factual knowledge can be tested by quizzes, tests and examinations. Online tests and quizzes can allow a learner to self-test on such material and provide automated feedback on what aspects of the body of knowledge the learner needs to study further. Technology can also support feedback on higher level skills. Students can submit work to an online forum for review by their peers. This is especially authentic for programming where the standard process in industry is for all code to be peer-reviewed throughout development. Although such use of students as peer assessors has clear learning benefits, some students may expect to receive marks for any activity required in a course. One way forward is to award marks for the quality of the review because showing good judgement is one way of demonstrating knowledge of a subject. Reflection can be added as a component in many assessment forms.

5 CONCLUSION

We have set out some values, principles and guidelines to inform assessment in computing programmes. We expect to make some departures from these, on a case-by-case, basis according to the needs of each course. We have assumed that the approach to teaching is grounded in a social constructivist framework that values greater student autonomy and the development of lifelong learning skills. Describing the approach to teaching is outside the scope of this document. Our focus here is on assessment: the most influential factor on what a student will do and learn.

REFERENCES


