Reflect, Review, Note, Act and Test: E-Portfolio for Engineering Students

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Introduction

Prior to 2017, e-Portfolio was only a part of the USQ Master of Engineering Practice, where experienced technologists were transitioning to professional engineering careers. In the MEPR program students are given the opportunity to both expand to a wider discipline based foundational engineering knowledge, record their industrial experience to test it against Engineers Australia accreditation standards, and demonstrate a deeper sub-discipline depth by use of higher degree research methodology to innovate to contribute to their discipline strand or industry workplace. Here the e-Portfolio has three roles, i.e. to collate their relevant industrial work integrated learning (WIL) experience to:

- demonstrate that their project-based work had reached Engineers Australia Stage 1 professional engineering work level;
- demonstrate they already carried specific defining activities based on USQ course learning objectives and topics to garner additional exemptions / credits;
- benchmark their experience and Master's degree thesis to Engineering Australia Stage 2 Experienced Engineer accreditation standards.

From the longitudinal study undertaken in the MEPR program, it was decided in 2017 to begin testing e-Portfolio work with the Bachelor honours and Master's by coursework students as part of their two capstone residential professional practice courses. This was undertaken in the context of developments in the Australian Council of Engineering Deans and Engineers Australia 5 yearly higher education accreditation processes. Male and King (2013) in the 'Enhancing Industry Engagement in Engineering Degrees,' which was led by the Engineers Australia Council of Engineering Deans, recommended for consideration the development of e-Portfolios for student undergraduate and students undertaking formative master's degree by coursework. Since then, this has become a part of the Engineers Australia 2019 accreditation criteria for tertiary section educational engineering programs. E-Portfolio has since been introduced into the USQ engineering undergraduate and graduate programs incrementally over the academic years 2017 to 2019, with incremental continued integration into all USQ engineering programs to 2021.

Why is e-Portfolio Needed?

Why was there a perceived need for an engineering student e-Portfolio? The USQ schools of Engineering recognised there was a need for professional engineering graduates to develop their reflective thinking and writing abilities. This reflective process also leads to better graduate abilities to crystallise their thoughts to communicate and share experiences with other peers, professionals and public.

Ancient humans tended to use this reflective ability to join experiences into means of inter-generational communications, especially by story and legend telling. As developed by Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) in their educational resources, *Our Land, Our Stories,* our own Australian Indigenous First People's culture used totem, geographic significant landforms, artwork, stories, astronomical star formations and bora rings to encode such reflections based on many generations' observational knowledge/discovery and adaptation to changing various climate periods of this island continent. Taonui (1994) reports the Hawaiian indigenous peoples have their great oral epics that record great sea journeys, where their traditions come from and migratory knowledge that are passed on from generation to generation. Madagascar also records lessons learnt during the the settlement of Madagascar and records significant observation of events. These event locations and oral history of changes in Madagascar are also recorded in ancient erected stone markers or sacred places as a witness for future generations; along with cultural prohibitions that remind of the risk outcomes learnt in such events. The associated reflective oral Malagasy records as reported by McElroy (1999)

were a means of storing societal experience, which was the forerunner to scribe-copied reproduction in linguistic records. To this day, young Malagasy girls' practice *Tantara Vato*, a reflective oral self-dialogue or group game with stones representing people and leaves the dialogue, which allows cathartic resolution of any difficult emotional or relationships issues they experience as they grow from children to young women. This reflective process and game allow the ability to gauge how serious a problem can be, as well as allows revision over retelling the oral tale until emotional solution is reached to re-establish equilibrium in their lives.

Scribe based reflective knowledge would later explode into printed matter when the printing press revolutionized storage of human history and phenological observations gathered from around the globe. All these developments were means to share reflective learning practice through millennium between over 50,000 generations of humans. These historic human abilities of phenomenological observation and reflective practices also form the foundations from which the sciences came from initially, and that now underpin engineering technical and professional practice.

As described by McFarlane (2010), in this modern age of data storage and instant access, there is a loss of reflective abilities that in the past propelled humankind from the ancient to the modern technological world of today. This loss manifests itself in a society that uses modern technology, but where now most users have a complete disconnect between the use of technology and actual understanding how the technology works. There is a complete loss of history of the technology development from crafts people and the long knowledge journey based on the reflections of past scientist, mathematicians and engineers that formed technological innovation. Similarly, the ability to identify false information is becoming blurred. There is a significant lack of ability to reflect to bring convergence of information from many sources and different experiences, i.e. to have some surety there is a significant element of truth in electronically published papers, articles or social forums. Challenging engineering students, to think reflectively in our modern 'instant' world is part of USQ's engineering professional development program. In the world of instant communication, the ability to reflect and join past experiences is required to highlight your own skills, abilities and their development, recognise deficits or poorly developed skills for remedial personal action in your educational journey to graduation. The USQ e-Portfolio is a challenge to the engineering student to record their own engineering program journey, and then to recognise the value of professional and personal reflection of past experience (including from others) in forming their future career and life. USQ engineering programs had long ago developed in their Bachelor (Honours) programs and Master's degree by course work programs, two residential week long courses that brought students in their last two years of study together as a peer and networking group. Included in these programs is an annual two-day engineering project conference, where final year students present their capstone research project as seminars to provide peer feedback, networking and multi-discipline interaction in engineering across very diverse subjects and industries. The USQ student group is quite unique in terms of 70% or more across all engineering programs come from engineering industry-based jobs from varying careers of advanced engineering trade or technicians to associate engineering and technologists' positions; to even some with senior engineering positions. USQ engineering students represent a significant cohort of students entering USQ engineering programs who due to work reasons of career progression, normally choose external part-time studies. These residential professional practice events bring together hundreds of students to be introduced and undertake professional development workshops, lectures and continuing professional development activities.

The engineering practice courses are core engineering courses in all programs and majors. It was during 2015 the Executive Dean of USQ Health, Engineering and Science appointed an Engineering Practice Leader to assist the two Heads of the engineering schools in the development of professional practice, and interface with Engineers Australia as the external engineering program accrediting body along with other engineering industry based professional and technical societies. One of the first tasks for this position was to review and continue development with the Post-graduate Program Coordinator of the USQ Master of Engineering Practice (MEPR). In this program, e-Portfolio work had been undertaken since its inception in 2003. During 201/16 this program's e-Portfolio work was fully updated to the significant 2012 Engineers Australia accreditation changes of 2012-2017 that have occurred for Engineers Australia Stage 1 Professional Engineer and Stage 2 Experienced Professional Engineer.

In 2017, from this work on the MEPR program, the Engineering Practice Leader (Helwig 2017) introduced Student Professional E-portfolio (i.e. Employability Portfolio) work for the Master's degree by coursework Professional Practice residential program. Then Helwig, et al, 2018 introduced the first e-

Portfolio trial into the bachelor (honours) professional practice program, as the major assessment of participation by the student in the week long residential school program. Detailed review and analysis of the 2018 e-Portfolio outcomes for a BENH program cohort of 173 revealed some serious deficits in the domestic undergraduate engineering student's reading and communications ability:

- 22% of students had difficulty reading the instructions and devolving them on a personal level into staged tasks they could then progress quickly and complete. These students required coaching to understand the requirements to begin their e-Portfolio.
- Another 17% of students could understand the requirements, but they did not develop reflective practice producing only 'work logs', noting their written professional engineering English was very poor.
- 42% of students did a reasonable first attempt.
- 19% of students handled the task well and produced professional e-Portfolios.

The 2018 master's degree by coursework (MENS program) professional practice exhibited the following for a cohort of 63:

- 22% of students (noting for the majority of this cohort, English was a second language) had difficulty comprehending the instructions and devolving them on a personal level into staged tasks they could then progress quickly and complete. These students required coaching to understand the requirements to begin their e-Portfolio.
- Another 8% of students could understand the requirements reasonably well, but again they did not develop reflective thinking to provide logical reasoning and progression in their reflective narratives; and their written professional engineering English was very poor.
- 64% of students did a reasonable first attempt.
- 8% of students handled the task well and produced professional e-Portfolios.

Noting that a significant majority (i.e. 92%) of Master's degree students are international students, for whom English is their second language; surprisingly, this second group's overall assessment in terms of initial successful first attempt was slightly better than the domestic undergraduate student cohort. But the results for both professional practice programs raised concerns that some graduate engineers would be ill-equipped in terms of written English professionalism for the workforce on graduation. Hence it was decided that e-Portfolio should be introduced as early as possible in engineering programs so that graduate Associate Engineers, Technologists and Professional Engineers were given the challenge and opportunity to develop reflective thinking / writing during their engineering studies. The second issue that arose from this trial, was a defined need to streamline and scaffold the development of what an e-Portfolio contained, and to convey to students how to use their own self-assessment abilities to master reflective professional practice; i.e. the students themselves have to see an advantage to developing such skills in terms of career attainment and advancement.

E-Portfolio Development

At the end of academic year 2017, the development of e-Portfolio was reviewed with the Heads of Schools of Engineering. This review was coincident with drafting of new USQ engineering programs' and graduate disciplines' capabilities. In early 2018, this development continued to progress in defining the elements (of competency) that supported the graduate capabilities for every program major discipline. These were completed by midyear by the engineering academic staff, with each major discipline strand having its four distinct technical competencies and elements. Similarly, each engineering program's also had the four shared core generic professional practice capabilities and elements (of competency) finalised. All of these graduate capability elements had been likewise mapped onto the EA Stage 1 competencies.

This provided a major step forward for the e-Portfolio development, and precipitated a short trial to gauge outcomes of the new graduate capabilities and elements with both Alumni and Honours Engineering program students. Instruction was firstly provided for these graduates and students. The first step was the development of the diary of reflective snippets of significant technical, laboratory practice and professional development courses that these students considered contributed and built the individual competencies of their program. The students undertaking the trial were then mentored in how to construct their reflective narratives from the reflective diary entries. This proved successful, and the eight reflective narratives were successfully professionally completed for this e-Portfolio trial.

The trial revealed how the "reflective snippet" diary was basically a memory placeholder for students. It is composed of short sentences that remind the student of the significant progress they made towards course learning outcomes and allows self-reflection and self-assessment of achieving the desired outcome. Part of the reflective self-assessment process is also if the student identifies intended performance outcomes were not achieved, or to identify the gap in knowledge and then decide what they want to do about it. The process is for the snippets diary basically:

- **Reflect:** Self-assessment i.e. did the student achieve the course learning objectives and desired grade/competency the student wished to attain? How does this relate or build on other courses the student has undertaken and successfully completed?
- **Record:** Write the diary reflective 'snippets' or memory reminders of course outcomes contribution towards your graduate capabilities element/s, and verification artefacts.
- **Note:** When a gap in knowledge is recognised, the student to develop a response/plan to fill this gap.
- **Act:** Student to put plan in action how to fill a perceived gap in knowledge.
- **Test:** Student to close the gap and revisit how successfully they achieved their goal.

To facilitate this process for students, as part of the new graduate capabilities development, each discipline major's mandatory course in the enrolment pattern was mapped for its contribution and the blooms taxonomy level of engagement towards the graduate capability. A single page summary of this mapping of contribution to the USQ engineering graduate capabilities has been provided to students per discipline major on their respective Engineering Program Community StudyDesks. Within the e-Portfolio templates developed for every major discipline of every program, there is a list of significant contributory courses to each of the graduate capabilities. This provides a quick start reference of the substantial courses' outcomes require to be aggregated towards their final reflective narratives. Figure 1 provides a general outline summary of the significant contributors and processes that were involved in the e-Portfolio development and implementation.

To expedite development of the student's e-Portfolio, specific engineering practice courses for every program and major were selected to have some formal assessment to provide feedback to student on how their reflective snippet diary and reflective review and recording writing style was developing; and whether they are recording evidential artefacts, i.e. course assessment grade, or specific significant assignments, workshops or practicals completed. During the latter part of each program, progressive development is undertaken of the all eight reflective narratives. The final e-Portfolio is completed and submitted in all programs (with the exception of the MEPR) during their Work Experience course, and is a necessary item to complete in a satisfactory manner to graduate.

As examples, in the Bachelor Honours and Master's by coursework program, e-Portfolio is used as an assessment item in the two professional practice / project conference residential schools. Here progressive reflective competency narrative writing is undertaken. Review and feedback is provided to encourage students in achieving a professional narrative writing style, which includes a logical line of reasoning on how they believe different coursework, industrial work experience and laboratory work demonstrates their graduating capabilities. This is where many students struggled in their reflective narrative development in the initial trials and surveys in the professional practice residential schools of 2017 and 2018. Many students try to write a 'work log' of courses, but miss the point of how and which coursework learning objectives achieve and demonstrate the elements (of competency) of their reflective narrative for a specific graduate capability. So, taking opportunity in the latter half of any engineering program to begin to fully draft reflective narratives is a means to provide scaffolding with guidance and encouragement in the feedback to students. Subject to students taking advice from such feedback, then the task of completing their full e-Portfolio for submission and review with their work experience courses is not onerous. This was a much better incremental process of e-Portfolio completion, compared to the students trying to develop the full set of reflective narratives to chart their demonstrated pathway to the graduate capabilities at the end of their program to attain ready-to-graduate status.

E-Portfolio Implementation

From the review of e-Portfolio initial trials in residential professional practice courses, it was found that many undergraduate students have not yet developed their professional engineering written English. This alone was a major issue when it comes to developing professional reflective narratives.
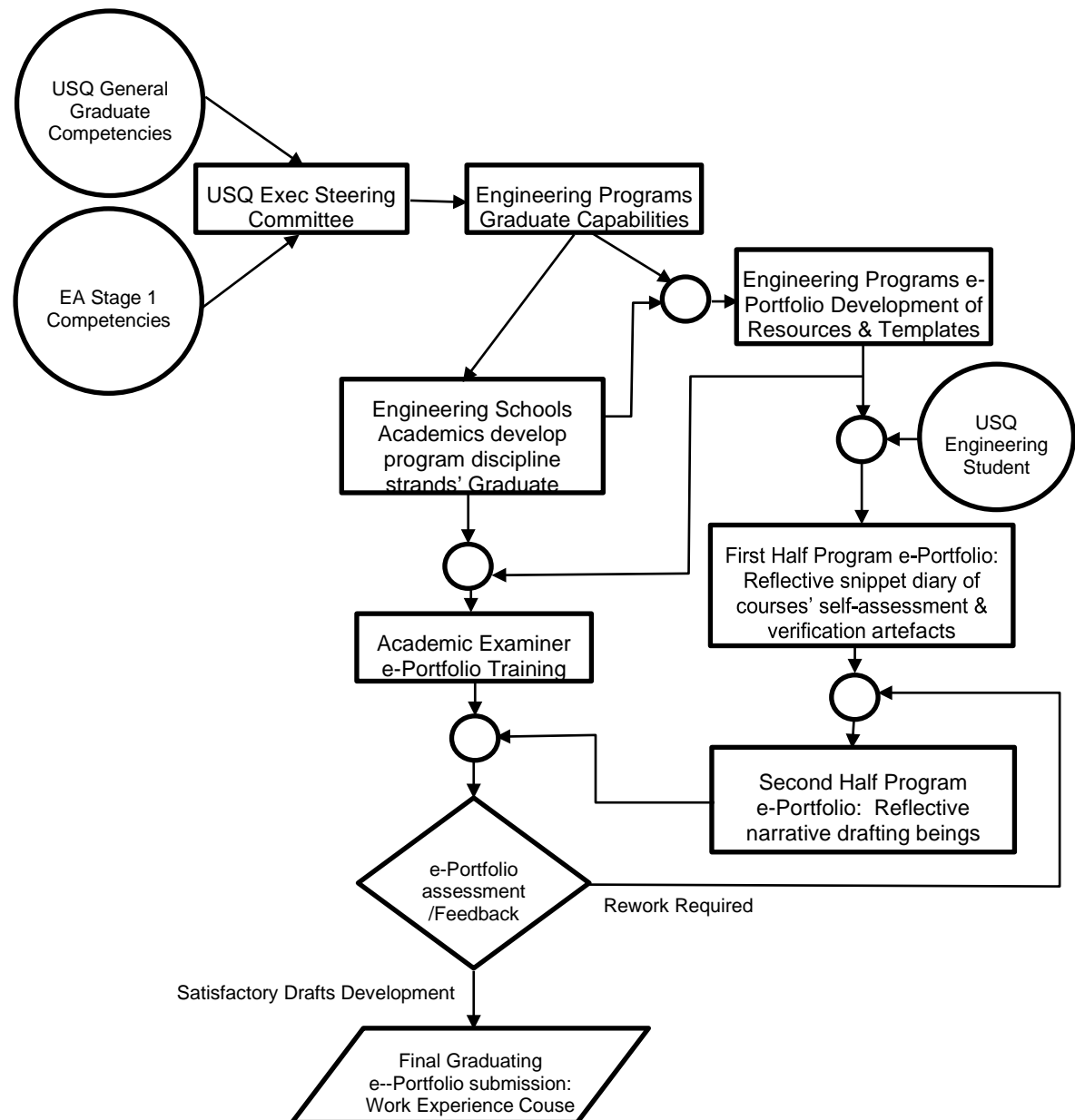
Figure 1: General Outline Summary of e-Portfolio Development and Implementation

From the graduate capabilities and elements (of competency) developed for each USQ engineering program, three important high-level resources were developed:

- A composite table that shows how each program core and major strand course contributes to the given discipline strand graduate capabilities. Purposely, this table per discipline major strand, did not go down to the detail of the elements associated. This is to give opportunity, on their own individual learning pathway to identify what they believe in their learning experience demonstrates best which element that underpins the overall graduate capability.

- The e-Portfolio template contains an extract list of courses that very significantly per major contribute to a given graduate capability. These would normally, along with some elective courses and their capstone project form a major theme structure for initial draft of the individual student's reflective narratives that summarise how their personal engineering program outcomes integrate together and demonstrate a graduate capability.

- A list of professional practice courses was established for each program and then each discipline strand, where specific assessment would touch base with the student and their e-Portfolio development to provide feedback on the success or otherwise of their reflective and written records developed. This was to provide encouragement and guidance as needed to further develop these abilities in preparation for post-graduation professional accreditation.

- All e-Portfolio information, instructions, sample material is made available on a special engineering specific program-based community StudyDesk, whee access is available once a student enrols.

From these resources, the structure of the e-Portfolio is scaffolded through the first half of their programs. Helwig (2019) introduced the e-Portfolio by and Introduction Booklet, USQ Faculty HES SoCES & SoMEE Professional Practice E-Portfolio Resource Book, and a collection of program / discipline major templates. These resources provided the means for students to understand the scaffolding to be used in developing a diary of their short reflective statements. An example of the reflective diary and the final associated reflective narrative has also been provided to help students better understand the short scope 'reflective snippets' compared to the role of the reflective narratives. The student's e-Portfolio template diary section allows for the collection of 'reflective snippets' at the completion of a course, to ponder typical questions such as:

- Did I understand the courses learning volume of topics covered for me to extend my skills to achieve the learning objectives of the course?
- Were their significant learning experiences, i.e. workshops, teamwork, assignments or simple the overall incremental accomplishment of achieving a high passing grade? Can I use these as verification artefacts?
- Did I achieve the result I desired?
- If not, are there identified gaps in my knowledge that I need to undertake?
- It is then on the student to act and self-test any personal actions or interactions with engineering academic, resources available from Engineers Australia if they are a student member, or if in the engineering workforce already with more senior engineering team members they can access.

These questions are posed to students in professional practice video lecture learning resources, currently developed for two programs and being developed for the remaining two USQ programs. Again these videos are available for use by academic staff and students from the program based community StudyDesks. Such resources basically, are challenging the student in each their program courses to self-assess their own pathway to life-long learning. The answers to these typical questions are quite personal and are clearly defined that there should be no more than two or three sentences for these reflective snippets. The reflective snippets are in fact memory artefacts collected in the e-Portfolio diary section. Along with these, the student is also to collect their course results, and any course activity they consider significant that is a verifiable artefact to demonstrate their self-assessment outcomes. This diary of memory and verification artefacts builds up over the Student's first half of the program. Various course academic examiners will also give small assignment e-Portfolio assessment to prompt students to become familiar and undertake this self-assessment and reflective diary development. The student can also use their engineering program community StudyDesk to discuss issues on the associated forum to seek advice or discuss perception with other students in the engineering program (i.e. peer interaction); or via the forum ask advice or clarification from the USQ Engineering Practice Leader. At the reflective diary level, this is very much the self-assessment process of RRNAT that builds from foundational course and then links to subsequent courses to complete at capstone discipline and core program-based courses as shown in figure 2.

During the second part of a student's engineering program, specific professional practice courses of each program, opportunity is given to begin to draft reflective narratives to demonstrate the pathway and development of their personal journey to achieve the graduate capabilities, addressing all the elements. This reflective writing is to allow students to practice integrating courses that staged this development, and aggregate the journey in a line of reasoning, based on significant learning events (related to course learning objectives). These narratives are based on addressing or demonstrating the elements (of competency) that underpin the breadth of any specific graduate capability. These practice reflective narratives are provided with feedback and suggestions on how improvement may be undertaken during particular professional practice course assessments.

Over the second half of the program, the student builds their eight reflective narrative drafts, to finally finish their e-Portfolio submission, including a graduating CV during their capstone year industry experience course (i.e. during their industry experience placement).

Graduating e-Portfolio Program Breadth and Content

The important contents of the USQ e-Portfolio Templates, which a ready-to-graduate student's e-Portfolio will contain are as follows:

- Reflective diary of personal self-assessment course-based outcomes, with verification artefacts to support their conclusions. This self-assessment is a collective record of their personal RRNAT processes.
- A collection of eight reflective narratives that validate the integration of their technical knowledge of their discipline major, with their professional practice development to demonstrate the achievement, aggregation and integration of four discipline major based graduate capabilities and elements, plus four generic specific engineering program based professional practice capabilities.
- Their graduate Curriculum Vitae.
- A diary of continuing professional development undertaken both through USQ professional practice courses, external engineering professional society attendance, Engineers Australia On-Line Webinars and PD events and industry based professional development activities in line with Engineers Australia CPD recording process.
- *Optional for students already working within engineering industry careers*, to develop their draft Engineers Australia Stage 1 Accreditation assessment career episode reports for review and advice from accredited USQ CPEng academic staff.

(The e-Portfolio reflective snippets diary records linked self-assessment and reflections through a program Major Discipline strand from foundational knowledge to discipline major capstone courses.)
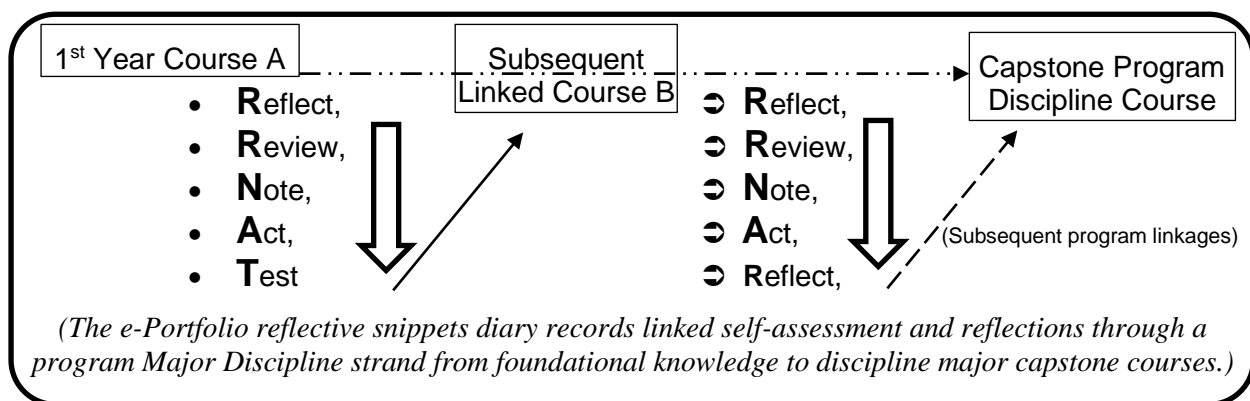
Figure 2: Reflective Diary is a self-assessment and aggregation process of course linkages.

The USQ e-Portfolio program aligns with the engineering programs and articulation for continuing career development, covers Stage 1 development of Associate Engineers, Stage 1 Technologists, Stage 1 Professional Engineer, and for the Master of Engineering Practice also develops an e-Portfolio benchmarked to Engineers Australia Stage 2 Experienced Professional Engineer.

Conclusion

The overall undergraduate or post-graduate experience of the engineering e-Portfolio is to develop the reflective practice needed for both research, job application, career promotion and professional accreditation. During an engineering professional's career, these are necessary skills that allow progression in industry careers, or if lacking typically will block or choke career progress. Students commencing engineering programs from 2019 academic year, must attempt their full e-Portfolio and submit with their Professional Work Experience to graduate. Failure to do so will result in delays to graduation until this is submitted. Note an attempt is not meant to be a literary work of art, but a working document that demonstrates satisfactorily that the graduating student has grasped, and demonstrated practice in the ability to reflect, self-assessment abilities, and to record this in summative writing that reflects Engineers Australia later accreditation submission requirements in their professional careers. Feedback is based on assessment of how far the student has progressed these skills. Such feedback is not critique based, but given in light of encouragement and helpful hints in how to fill gaps in these developing abilities.

As with the USQ Master of Engineering Practice, which prepared its graduates for accreditation submission with Engineers Australia, the e-Portfolio is available over all programs and will provide opportunity for students to develop their reflective writing and recording abilities. This prepares the students who have appropriate engineering experience to fast-track their career accreditation to Stage 1 Professional Engineer by developing their career episode reports. Similarly, for students from a matriculation entry, it prepares them to develop the ability to collate experience and professional development activities to be prepared when applying for Engineers Australia Stage 1 accreditation.

Reflective practice also enhances research, development and innovation in industry. Hence e-Portfolio is one vehicle to develop integration, aggregation and connection to self-assess as well as technically assess wide knowledge and experience bases that combine personal technical abilities and experiences with those of a host of other engineering and professional knowledge and teamwork's overall experience. Reflective thinking and recording is a skill that also permits engineers to crystallise thoughts from the inner-self voice or self-conversation, to then be able to communicate these in a manner that other engineers and professionals can receive, examine and review. This is an important skill needed for all engineers. Otherwise if this is lacking, they will have little influence in major decision making.

Future work will be reviewing and analysing student outcomes for e-Portfolio as incrementally, every student in any USQ engineering program develop their reflective abilities, reflective narrative recording and integration of foundational to capstone volume of technical and professional practice learning. This shall be the subject of more analysis and review, to be reported by USQ schools of engineering educational paper publication nominally in 2022.

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