Write your own reference: An innovative assessment strategy for quality self-reflections in Engineering Education

Miao Li and Euan D Lindsay
Engineering, Faculty of Business, Justice and Behavioural Sciences, Charles Sturt University, Panorama Avenue, Bathurst, NSW 2795, Australia.
Corresponding Author Email: mli@csu.edu.au

STRUCTURED ABSTRACT

CONTEXT
Quality self-reflections form the core of quality teaching (Lorson, Goodway, & Hovatter, 2007). Traditionally designed reflection activities in engineering classrooms do not sufficiently prompt thoughtful self-awareness or foster future learning (Rodríguez-Triana et al., 2017). Students only describe their learning activities and fail to connect cognition of their learning behaviour with expected professional growth. Lorson et al. (2007) voiced that students' self-reflection needs to be directed and structured to be meaningful.

PURPOSE
This assessment pair is intended to direct the students' reflections towards how they want to be perceived by the stakeholders of their work, while requiring them to consider both the present and future versions of themselves and others to achieve these goals.

APPROACH
At the start of a semester-long project, students are asked to imagine themselves as the clients of (successful) projects at the end of the semester and write the reference letter they wish to receive at the end of the project. At the end of the semester, students revisit this reference letter and reflect on whether this reference letter is how their clients actually now perceive them as a result of their conduct and achievements in the project. In this way, students self-identify tangible competency gaps for their ongoing professional development.

RESULTS
The reference letters produced by the students are largely of sufficient quality that they could be endorsed by their clients. Students are able to adopt the perspectives of their future clients, and identify the clients' future expectations of themselves and consequently raise their self-expectations in planning for their semester-long projects.

CONCLUSIONS
By using a reference letter and a corresponding reflection, the assessment pair replaces conventional reflection models in engineering classrooms. Requiring students to consider perspectives other than their own, at points in time other than today, causes students to set aspirational goals that anchor in work placement values and criteria and that they take full ownership of, to anticipate their learning needs, and improves the quality of their reflections on their progress towards their goals.

KEYWORDS
Innovative assessment strategy; Reference letter; Self-reflection

Introduction

"We do not learn from experience. We learn from reflecting on experience" (Lagueux, 2014) is a very concise paraphrase of *How we think* by John Dewey (1933) – a prominent 20th-century educational philosopher. Quality self-reflections form the core of quality teaching (Lorson, Goodway, & Hovatter, 2007). Reflective practice has been early identified as an important learning dimension in education (Schon, 1987). Felder, Woods, Stice, and Rugarcia (2000) asserted that students acquire knowledge and skills through active approaches including practising and reflecting. Practice and reflection benefit long-term retention of knowledge and skills, comprehension, and motivation of students' learning. Woods, Felder, Rugarcia, and Stice (2000) identified reflection as one of the seven activities to promote the establishment of an effective learning environment for students. Williams (2002) and Woods et al. (2000) both emphasised that reflection is a metacognitive process of critical thinking about past actions and experiences and consequently inform future learning.

Williams (2002) voiced the concerns that the importance of reflection is not sufficiently recognised as part of traditional undergraduate engineering education. Traditional engineering curricula reward students for memorising equations and theorem and offers little motivation for self-reflection. They do not prompt thoughtful self-awareness or fostering future learning (Rodríguez-Triana et al., 2017). Hence, a majority of students lack the skills of meaningful reflection and cannot reflect on their academic growth or drive needs for improvement. They only describe their learning activities and fail to connect their learning behaviour with expected professional growth. Lorson et al. (2007) argued that students' self-reflection needs to be directed and structured to be meaningful. Stevens and Cooper (2009) advocated for educators to "*find ways to foster reflection*".

Current forms of reflections mostly involve casually asking students to describe how their achievements improve problem-solving and the quality of their delivery (Woods et al., 2000). Williams (2002) introduced portfolio in engineering assessment, instructing students to purposely document a collection of their work, progress, and evidence of reflection. Stevens and Cooper (2009) found that journal keeping is a well-established reflective strategy across a broad range of disciplines. There is a scarcity in the literature on applying reflective activities to formally assess engineering students' academic performance.

In this paper, we present an innovative assessment strategy to promote quality self–reflection in Engineering education. In this innovative strategy, an assessment pair, consisting of a reference letter at the start of a session and a written reflection at the end, was developed. The reference letter asked students to picture themselves at the end of the session, apply a perspective shift and write a reference letter from the perspective of their future employer. At the end of the session, students were to revisit the reference letter and reflect upon the statements made in the reference letter as they have now completed the subject.

Methodology and Materials

The subject ENG261 Engineering Challenge 3 offered to second-year engineering students at Charles Sturt University, provides an encouraging environment for the development and implementation of the assessment pair. The subject consists of a semester-long project where students work in teams of three or four to solve a real problem for a real client. In the subsequent semester, students then commence a cadet placement in the industry; as such throughout the project, they are aware of their need to project themselves well to external employers.

At the start of the subject, the students are asked to imagine themselves as the clients of their (successful) projects at the end of the semester and write the reference letter they wish to receive at the end of the project. At the end of the semester, students revisit this reference letter and reflect on whether this reference letter is how their clients now perceive them as a result of their conduct and achievements in the project. In this way, students self-identify tangible competency gaps for their ongoing professional development. Detailed descriptions of the assessment pair are presented in **Table 1,** including the tasks, rationales and marking criteria etc. They are to provide students with clear instructions on the significance and key features of the assessment pair.

The assessment pair corresponds to John Dewey (1933)'s description of the four modes of thinking: i.e., *imagination*, *belief*, *a stream of consciousness* and *reflection*. More specifically, the reference letter, being students' conceptualising of their acquired qualities and identity ahead of time from their clients' perspective, matches "*imagination*". Throughout the session, students work on their projects, experience

inevitable difficulties, transform their prior beliefs in the reference letter and develop cognition of their achievements and identity. It is not until the students reflect at the end of the session that they settle into a clear and coherent state of mind and are able to derive meaningful and profound insights for future learning. The relationship amongst *experience*, *reflection* and *learning* described by Dewey (1933) is formulated by this assessment pair as:

$$Imagination + Experience + Reflection \Rightarrow Learning$$

Table 1. Key features of the assessment pair: a reference letter and a reflection

	A reference letter	A reflection
The time frame of submission	The first week of the session	The last week of the session
Value	10%	10%
Task description	Look forward in time and imagine yourself at the end of this session, you need to approach your project client to write you a reference letter for your work placement applications. What would you expect them to say about you? Now please write this reference letter from the perspective of your project client.	Revisit your reference letter drafted at the beginning of this session and reflect upon your roles as a student engineer as you have now completed the design process in ENG261. Reflect how this design process has changed you and how this might continue to change as you move into work placement.
Rationale	• demonstrate an awareness of the broad range of document types encountered by engineers in their professional practice, and the distinctions between the different audiences they are targeted towards; • develop and reflect on their emerging identity as student engineers, and how this will change as they move into placement in industry	

The pedagogy behind this assessment pair is also substantiated by Kolb's learning model (1984), which was reproduced in **Error! Reference source not found.**.

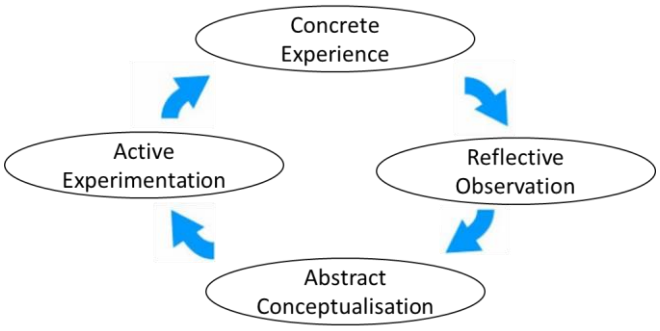

Figure 1. Kolb's theory of experiential learning cycle (1984)

In the CSU context, the assessment pair situated in ENG261 formulates the initial cycle of the experiential learning model before students transition to work placement in the subsequent session. Students formulate abstract conceptualisation in the reference letter on how they will have applied their technical and professional competencies and attributes in an engineering project (through the eyes of their clients). Students then experiment with these skills by actioning in a real project to acquire concrete experience. Subsequently, the reflection on the experiment and the experience inform future learning. This initial cycle can be unfolded as shown in Figure 2.

It is expected that by working on this assessment pair from the start of the semester through to the end, students are able to produce "authentic" reference letters in which they set aspirational goals and outlook for the semester. The assessment pair also provides opportunities for students to analyse their experience and to inform future learning.

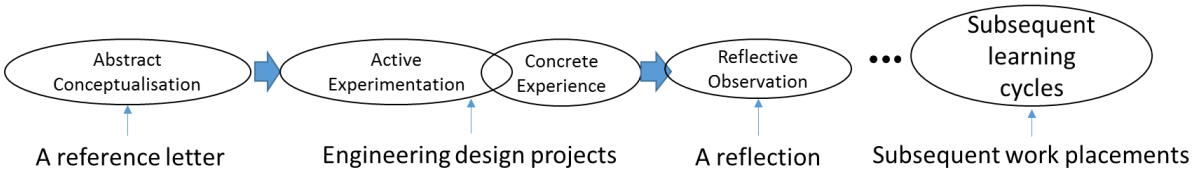

Figure 2. Kolb (1984)'s learning cycle formulated by the assessment pair

Results

This assessment pair has been offered twice at CSU Engineering in the context of a design subject: Engineering Challenge 3. This assessment activity brings to the students' awareness that the nature of an Engineering document goes beyond merely reporting data and/or equations. This assessment pair also promotes students to ruminate on what a good engineering profession involves. The reference letter at the beginning of the session offers an opportunity for students to conceptualise their achievements at the end of the session from the perspective of their clients. This motivates the students to set aspirational goals that anchor in work placement values and criteria that the students can take full ownership of, and frame a meaningful, positive and aspiring outlook at the beginning of the semester.

It was clear from the reference letters collected from students' submissions that the students were able to adopt the voice of the client in order to produce the reference letter, writing in the third person about themselves. They also understood that the letter needed to be a promotional artefact that spoke well of themselves, and not just a "data dump" of tasks they had completed. Students chose a wide range of technical skills to emphasise in their reference letters:

–"including structural design of residential slabs, timber and steel framing elements, structural and architectural drafting and preparing bills of quantities for tendering documents for civil works projects."

–"Through his ability to navigate and operate a number of CAD and three-dimensional packages such as SolidWorks, Autodesk Inventor, and AutoCAD he has learnt to operate 3D printers, laser cutters and milling machines."

Students used descriptive vocabularies which formulated a positive and motivational mindset at the start of the semester:

–"Through practical lab-based exercise, Xxxx has shown that he is both enthusiastic and capable of conducting a variety of soil tests."

–"As Xxxx has progressed through her studies, she has shown a commitment to her growth as a professional engineer.

–"His capacity to clearly convey and communicate technical knowledge to both ends of the industry sector is to be commended."

– "it is clear that she is aiming to be the best she can be"

In addition to committing to technical outcomes, many students also chose to emphasise professional skills in their reference letters. Comments were on reflective practices, communication, teamwork and leadership skills.

–"Through the use of her weekly reflections, and seeking feedback from the relevant academic on assessment items,"

–"He has exhibited his ability to work in a team environment through his success in the four engineering challenges presented to him throughout the duration of the course, showing leadership, compatibility and the desire to complete any and all work to the highest possible standard."

–"Xxxx displayed exciting communication skills. He was comfortable presenting to a large crowd consisting of non-engineers, as well as more intimate professional conversations about intricate engineering details.

The final reflection at the end of the semester is a self-assessment guided by the reference letter, challenging students to examine their actual achievements compared with their intended achievements from the start of the session, and evaluate whether their actual achievements would let their client endorse those statements about them. The final reflection is purposeful and structured. It encourages meaningful reflections on their behaviour and informs their future learning as they transit to the next stage of their professional development. Students' reflections at the completion of the subject showed that they feel that they have indeed developed the skills that they promised in their initial reference letters:

Technical skills:

-"Utilising online tools such as eSPADE to help identify soil characteristics is helpful, and I gained an understanding on desk study before commencing any physical work on site."

-"Now having completed a project for a real client, I can proudly say that I have applied my understanding of geotechnical engineering in conjunction with the newly developed water engineering knowledge to a cultural conservation project for the Bathurst Wiradyuri community and a social enterprise for the region."

Professional skills:

-"With reference with this semester's first assessment, I predicted that attitudes I would need to possess as an engineer include being professional, diligent and confident. Nearing the end of this semester, I feel that I have improved these attributes greatly, for example, I was tasked with frequently contacting and communicating with our client in a professional manner. I have enjoyed this task and feel that it will serve me well in the workplace. I have surprised myself with my new-found confidence when presenting my work to an audience and my ability and desire to work on a project until it is complete to a high standard."

-"Reflecting back to the beginning of the semester, I can see a growth in my project management and scoping abilities, communication with team members and clients, and in my self-confidence. One of the most notable skills which I have developed through this challenge, I believe, is my ability to write and communicate information in a succinct way."

As students visualise their future professional identity ahead of time through the eyes of their clients, it is very meaningful to see what clients' true testimonials are about students' work. At the end of the semester, clients' feedback was collected upon their receiving students' delivery of workable solutions to their problems. Clients' feedback, as shown in below examples, demonstrates that clients were indeed willing to endorse the reference letters that the students had written at the start of the project.

-"The group have taken to all tasks with enthusiasm and what seems to be a thirst for gaining new skills and knowledge related to the many different facets of which I think is quite a tricky project."

-"The students have proven to be highly professional in aspects of the service they pledged and highly proficient in all interactions that we have had and their ability and eagerness to communicate information and milestones (either verbally face-to-face or in written form) is a credit to their knowledge, abilities, planning, professionalism and maturity."

Discussion

This assessment pair trained and validated students' ability to produce "authentic" reference letters and meaningful reflections. Students were able to shift their perspectives as if they were their clients of (successfully) completed projects, and spoke in the tone of their clients about their achievements. The letters produced by students incorporated not only specific technical skills associated with particular projects, but also professional skills favoured in workplaces, including communication, management and teamwork skills. The quality of the reference letters was enhanced by students' use of inspiring, descriptive phrases such as "highly recommended", "approaches all tasks with due diligence and

respect", "enthusiastic", and "exciting". The reference letter contributed to students' learning experience and achievements in that the letters projected a positive outlook that students took ownership of, and held themselves accountable throughout the semester to reach the aspirational standards they set for themselves. The reflection concluded students' design experiments during the semester while opening another chapter of an informed learning path for continued career development.

The assessment pair offers a simple and safe practice model, in a university environment, for students' future career endeavours, such as the employee development and review process. In another scenario, students in the future may encounter the opportunity to write a reference check for their colleagues. In addition, this assessment pair also brought to the awareness of students the different types of engineering documents. It broadened students' belief about engineering documentation by showing that they can extend beyond technical data, numbers and equations, to also develop an appreciation of work placement values, professional conduct and identity.

Conclusions

Quality reflections form an indispensable component of scholarly learning and teaching. Traditional engineering curricula do not foster reflective activities. An innovative assessment strategy situated in a design subject was proposed to reinforce intentional reflection in students' learning process. An assessment pair, consisting of a reference letter and a reflection, promotes an aspirational outlook at the start of the session and facilitates students to derive meaningful actions for future learning as they transition to the next stage of their professional development.

It has been found from students' submissions that students are able to project their achievements and acquired qualities in time, from the perspective of their clients. Students are able to look beyond the engineering discipline, and acknowledge skills required in a workforce profession such as communication, teamwork and management. The testimonials collected from clients at the end of the session validated students' statements in the reference letter. The assessment pair corresponds well to the pedagogical principles proposed by John Dewey (1933) and David Kolb (1984). By continuing to nurture this innovative and effective reflective strategy, for example in the career development, planning and reviewing processes, students expect to see continued growth in their profession.

References

Dewey, J. (1933). *How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process*. Boston, MA: D.C. Heath & Co Publishers.

Felder, R. M., Woods, D. R., Stice, J. E., & Rugarcia, A. (2000). The future of engineering education II. Teaching methods that work. *Chemical Engineering Education, 34*(1), 26-39.

Kolb, D. A. (1984). *Experiential learning : experience as the source of learning and development*: Englewood Cliffs, N.J. : Prentice-Hall.

Lagueux, R. C. (2014). A spurious john dewey quotation on reflection. Retrieved from http://www.academia.edu/17358587/A_Spurious_John_Dewey_Quotation_on_Reflection

Lorson, K., Goodway, J. D., & Hovatter, R. (2007). Using goal-directed reflection to make reflection more meaningful. *Journal of Physical Education, Recreation & Dance, 78*(4), 42-47.

Rodríguez-Triana, M. J., Prieto, L. P., Vozniuk, A., Boroujeni, M. S., Schwendimann, B. A., Holzer, A., & Gillet, D. (2017). Monitoring, awareness and reflection in blended technology enhanced learning: a systematic review. *International Journal of Technology Enhanced Learning, 9*(2-3), 126-150.

Schon, D. A. (1987). *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions*: Wiley.

Stevens, D. D., & Cooper, J. E. (2009). *Journal Keeping: How to Use Reflective Writing for Learning, Teaching, Professional Insight and Positive Change*. Sterling, Virginia: Stylus Publishing.

Williams, J. M. (2002). The engineering portfolio: Communication, reflection, and student learning outcomes assessment. *International Journal of Engineering Education, 18*(2), 199-207.

Woods, D. R., Felder, R. M., Rugarcia, A., & Stice, J. E. (2000). The future of engineering education III. Developing critical skills. *Chemical Engineering Education, 4*, 48-52.