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Towards a Complexity Literacy Model

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ABSTRACT

CONTEXT
Professional practice often requires engineers to manage and work with complexity. To develop these skills, students need to be able to identify complex problems and apply suitable tools and approaches. Students therefore need a language to discuss and understand complexity as a concept affecting their behaviour and experiences. Providing an authentic context in which to teach these concepts can motivate and engage students. Previous research has identified that the complexity inherent in group work may provide this context. This research explores whether introducing complexity frameworks to students in the context of group work develops their ability to identify, discuss and deal with complexity and what might enable or inhibit this development.

PURPOSE
The paper reports on a study introducing complexity frameworks to students undertaking group work projects. The purpose is to identify whether explicitly linking an understanding of the framework to the practice of students' group work develops their ability to a) differentiate between complicated and complex group work situations, and b) apply the techniques identified in the framework for managing the situation accordingly.

APPROACH
Two cohorts of students undertaking group work projects were selected for the study: students in an undergraduate design engineering subject; and a postgraduate project management subject. Students were introduced to the Cynefin framework and a similar simplified complexity framework in class in the beginning of the semester/term. The frameworks were explicitly discussed in the context of group work projects. They were requested to reflect on the framework in developing group charters for their groups, and to anticipate the type of challenges and opportunities group work may present. A survey was undertaken after the project was complete. The survey asked students to reflect on the complexity framework and identify complicated or complex situations they had encountered in their group work and how they managed them. The open responses were analysed for emerging themes to indicate whether students could differentiate complex and complicated situations and could apply the framework techniques for managing the situations.

OUTCOMES
Responses indicate that while students have developed an ability to differentiate complex and complicated situations in the context of group work, there has been limited application of the approaches for decision making in these contexts. Using groupwork as a context to teach complexity is a promising path, however this research illuminates the possible effect of the affective domain in inhibiting students taking action in applying complexity framework strategies.

CONCLUSIONS
An increased understanding of how to identify, and respond to, the demands of a complex situation based on the specific context is a step forward in developing student understanding of the interplay of context and decision making. However, there is more work to be done to help students understand the importance of a) applying appropriate decision making approaches and b) investigating whether the learning is transferred from the group work context to other aspects of professional practice. This paper begins to explore a complexity literacy model to capture the components which influence whether students take action in complex situations.

KEYWORDS
Complexity, group work, Cynefin

Introduction

The future of professional practice will involve increasing complexity (Crosthwaite, 2021, Whyte et al., 2022). The ability to identify this complexity, understand the implications for decision making in a complex contexts and devise solutions to complex problems is a transferable skill critical to professional practice. How to enable the development of these skills in students is an emerging focus for both engineering and project management education practice and research (e.g., Reilly & McBain, 2022, Thomas & Mengel, 2008). Students are uncomfortable with managing complexity and resist activities that include ambiguity and uncertainty that cannot be fully resolved (Willey & Machet, 2018). In attempting to address this, complexity frameworks are being introduced into classrooms to develop students' understanding of their own learning and of how dealing with complexity differs from deterministic, complicated problems often encountered in their engineering science studies and which they feel competent to solve (Willey & Machet, 2018, Reilly & McBain, 2022).

In engineering education, the discussion of complexity is often linked to the engineering profession's role in solving 'wicked problems' (e.g. Byrne & Mullaly, 2014). However, engineering is a collaborative endeavour which involves solving problems for humans. The result of this dual focus is that even in cases where the problem space is clear and the science behind it known, the fact that engineers are designing solutions for people, and with people means that we are often unavoidably working in complexity. People bring their own unpredictable influence to the problem space and this affects the way problems are defined and how solutions are designed, developed, delivered, implemented and used. The management of these type of projects requires engineering and project management graduates to be able to identify and manage complexity.

Keeping this in mind, we have identified group work as a potential context for teaching students about complexity because a) working with and for people is inherently complex, and b) students are known to resist learning about complexity. This paper reports on preliminary data investigating the effectiveness of using group work as a context to introduce complexity frameworks and developing students' ability to identify complex (vs complicated) scenarios and applying appropriate strategies to work effectively with uncertainty.

What has emerged from this study is an indication that there are additional factors at play in students' resistance to taking action when working with complexity, and these go beyond simply having a language to understand complexity and being able to identify complex scenarios. The data indicates the role of affective responses to dealing with complexity (particularly in group work). We propose that three factors being a) interaction of an appreciation for the context, b) feeling competent about making judgements and c) student affective disposition, all interact to enable or inhibit taking action in resolving problems in a complex context.

Background

Derived from the domain of knowledge management and initially used to assist in guiding leadership decisions, the Cynefin framework has shown to be useful across a range of fields and applications. The framework defines five decision making domains: clear (or simple), complicated, complex, chaotic and confusion (or disordered) (Snowden & Boone, 2007). The domains are differentiated by their contextual characteristics. The framework as a whole proposes that in order to make effective decisions, individuals need to both identify the context in which they are operating and apply relevant strategies to arrive at solutions. Of particular interest is the differentiation between the complicated and complex domains. 'Complicated' refers to domains in which the relationship between cause and effect is clear, but some of these factors may not yet be known by all. There may be multiple correct answers, and it takes expertise to sense and analyse the situation to uncover the unknowns and then respond accordingly. In the 'complex' domain however, cause and effect relationships are not clear and can only be seen in retrospect (if at all), and not all the factors in the context are known or knowable. Managing complex contexts requires an approach of probing, sensing and responding to situations, and gaining multiple perspectives before taking action, and knowing that, only after action has been taken, will its efficacy be known (Kurtz & Snowden, 2003).

As noted above, it is known that students (not only those in engineering) resist working with complexity (Brookfield, 2017). We also know that engineering students operate competently in the complicated domain using expert knowledge to analyse and respond in order to uncover knowable (if sometimes challenging) solutions. However, when shifting to the complex domain (where there is always uncertainty ahead of implementing any solution), they struggle with appreciating the learning opportunities provided. This may be because students do not feel competent when engaging with uncertainty which inhibits their motivation as per Deci and Ryan's self-determination theory (Deci & Ryan, 2008).

At the University of Technology Sydney, students are introduced to interdisciplinary, group work projects which belong in the complex domain in a large cohort (350-650 students per semester) second-year, professional practice subject. The group design project gives students agency to choose a problem they would like to solve within the given context, fulfilling the factors of autonomy and relation in the self-determination theory model, but potentially lacking the third pillar of competence. In order to improve student motivation to engage with complexity in this subject, we have been introducing a simple complexity framework (drawn from Cynefin) which differentiates between working in absolutes vs complexity and emphasises that these learning activities differ and that working with complexity always result in residual uncertainty (as in Figure 1). This aims to develop students' sense of competence for handling the uncertainty in the project by giving students and tutors a language to describe, question and understand this different context for learning. This approach aligns with other research introducing students to complexity frameworks to increase their awareness of complexity and build their comfort with engaging in these tasks (Reilly & McBain, 2022).

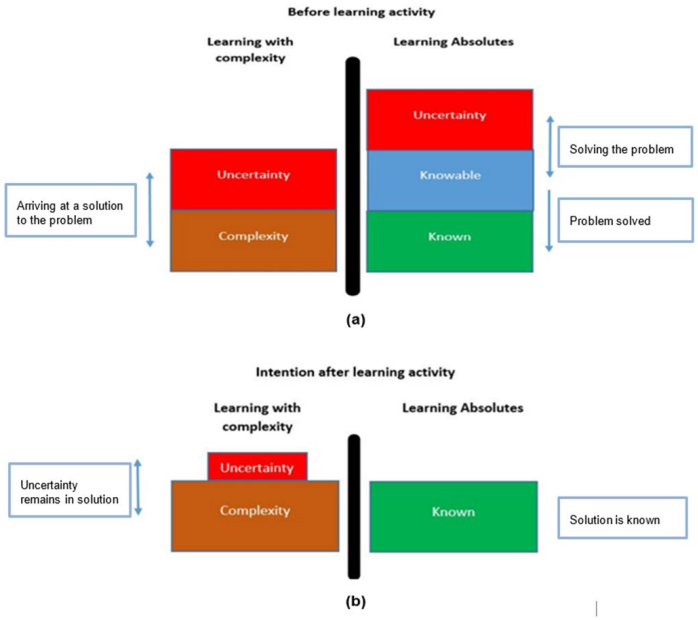

Figure 1: Simplified Complexity Framework (adapted from Willey & Machet, 2018)

In researching the effectiveness of introducing the framework, we found that the students continue to have challenges in identifying which situations are complex (Machet et al, 2021). However, when asked to identify complexity in their projects, many students did select group work challenges as examples of complex problems. As an example, students in the study identified the situation of disagreement on a project idea when the group was evenly split on the decision. In that situation, there will always be residual uncertainty in the outcome of any decision, and when this is combined with all the other decisions and tasks in a project, the cause-and-effect relationship between the disagreement and the project outcome may not be clear even in retrospect. Still, having identified complex situations, the students were largely unable to clearly identify *what* made these situations complex, and were unclear about how to apply suitable strategies to solve them. The results of the study pointed to the potential that group work may provide a good context for students to learn about complexity. Since students are a) familiar

with group work and b) can see the direct value in successfully managing group projects, it is proposed that introducing complexity frameworks in a context students see as valuable and immediately relevant to their learning, will assist in motivating them to engage with and use these frameworks. It also has the potential to improve student engagement with, and learning from, group work project experiences.

Context

To facilitate effective group work, devoting teaching and activity time to understanding and developing what constitutes good group work practice can improve both team satisfaction and overall performance. At the University of Technology Sydney (UTS) this is a feature of the professional practice subjects that identify aspects of team work as a learning outcome. This emphasis on allowing time and space in the curriculum to develop good team work practice is applied across faculties in both undergraduate and postgraduate subjects. In considering how best to incorporate the complexity frameworks into group work, we considered two subjects which meet this goal - a large engineering undergraduate second-year subject (mentioned previously), as well as a postgraduate project management subject that includes a significant group project and learning outcomes related to good team work practice.

We reviewed the existing activities in both subjects to identify a suitable approach to introduce complexity, and selected group charters. A group charter is a “codified plans for how a team will manage teamwork activities” (Mathieu & Rapp, 2009 p91) and their development has been identified as an effective tool to teach and engage students in good practices. The process through which a team negotiates these plans and makes decisions on aspects of teamwork provides an opportunity for exposing and discussing the elements of group work that make it so complex. In our subjects group charters are already part of the group work process, introduced to teams after team formation as the very first team work activity that contributes to course outcomes. While the team charters themselves are not assessed, engagement in the process and the production of a team charter is monitored and reviewed by teaching staff. Common issues that students face in group work (such as uncovering misaligned motivation, communication preferences and concern for their own and others’ psychological safety) are discussed with students before the team charter activity. Students are encouraged to include these components into the charter in terms of initial expectations and how it will be managed through the course of the project.

Introducing the Cynefin framework and simplified complexity frameworks within the discussion of the group charter, allows us to highlight the components of complexity that are a feature of group work - the uncertainty around team members individual circumstances, the understanding that not all of the factors that affect behaviour can be known, the fact that any group on a new project is by definition unique and the outcome cannot be predicted with certainty.

Methodology

This project explored whether group work provides a useful context to help students learn about complexity. A measure of this was deemed to be whether students understood critical components of the frameworks (such as differentiating between a complicated and complex scenario), and whether they were able to apply this in their approach to group work (in their group charter, and in managing their group work activities).

Students were presented with the complexity frameworks in subject workshops by the researchers (who teach into these subjects). They explained the history of the frameworks, introducing the language and gave examples of how it has been - and can be - used. Explicit links were made to group work and how it can demonstrate the characteristics of a complex context, especially in unexpected situations and when things go wrong. In class activities, students in both cohorts were then asked to refer to what they had learnt about complexity and collaborate in their groups to develop group charters identifying for example, their goals for the project, how they would reach consensus on decision through the project, and how they would

manage team members who failed to meet the group charter agreements. A debrief of the chart activity included the tutor drawing out the complex characteristics of the group work.

During the semester, if teams had challenges identified by (or brought to the attention of) the teaching staff, they were referred to their team charters. Discussions with the team (or individuals) to resolve any issues included a reference to the complexity framework and prompted students to consider the strategies they could use to understand the issue (is it complex or complicated?) with suggestions on how to use relevant strategies to solve the problem.

Data for this research was collected using a survey with a combination of rating and open-ended questions. At the completion of the group project, students were invited to participate in the anonymous survey. The survey included an image of the complexity framework as a reminder prompt and asked participants to reflect back on their group work experience in the subject to:

- describe what they liked best and found most challenging about the group project,
- briefly describe a situation when managing their group work had been complicated, and one where it had been complex,
- rate their perceptions of the usefulness of the complexity framework and explain their rating,
- describe examples (if any) of when during the project they had made use of the framework,
- describe whether their group charter covered any situation they had described,
- consider the factors that were at play when they felt the group work was going well, and when it was not and rate these in terms of the impact they had.

Data was analysed to identify whether students were able to differentiate between complex and complicated situations and students' perceptions of the usefulness of the complexity framework in a group work. Additionally, anecdotal evidence from in-class observations, student queries and escalations, and student feedback were used to triangulate any findings. At the time of writing this paper, only five students had fully completed the survey and were included in the data analysis. While this is a low number of respondents given the size of the cohorts, the data and preliminary findings do indicate patterns that are useful in progressing this research and further responses will be analysed as they become available.

Results

The data showed that those respondents who experienced or expressed positive viewpoints to group work liked the authentic nature of the projects. All students found balancing team members' competing demands on time and misaligned motivations in terms of marks most challenging and it was clear from the responses that they had not all had successful projects in terms of their team dynamics.

Some students indicated that the framework could be better described to help understanding. The responses indicated an interest in the frameworks (some students looked for additional information outside of class) but even those students did not find it useful in managing their group work. One participant captured this well:

> *".. understanding/seeing how complex [a] situation is and being able to manage/doing something to mitigate it, are two wholly different things. "*

In class discussions and in the data, the respondents could correctly identify a complex as opposed to complicated situation, which was found to be a challenge in previous research. As an example, one participant indicated that a complicated scenario was student's managing their schedules in order to attend class (information here is knowable and cause and effect often clear), while the complex scenario was that he felt his teammates did not fully understand the project requirements. The survey did not ask students to identify chaotic situations which could be argued to occur during group work and future surveys should consider this aspect which may illuminate student understanding and application of strategies.

None of the respondents found the group charter useful. The one student who identified the value in drawing up team charters also indicated that in their team, the student had written it alone so

their appreciation for the value was not supported. No students linked the group charter to the complexity framework.

Respondents indicated strongly that “support from university staff” had the largest impact at times when they felt the project was going well. Reflecting on when the project was not going well, the responses indicated that “real/apparent time pressures” and “difficulty in agreeing actions to achieve closure of the project” had the largest impact.

What emerged clearly from all the responses was the emotive reactions these students had to their perceived unsuccessful group work. Aspects of the affective domain (that is participants' feelings, personal values and motivations, feelings of value) were expressed clearly in their answers. These included long explanations of the problems these students had faced with their team members that highlighted the emotional effort it took to manage interactions and achieve the outcomes they wanted. Extracts as examples are:

> *“Personally, I feel angry and disappointed that I even found myself feeling compelled/forced to give up, after sacrificing so much precious sleep, mental sanity, resources & effort on this group project.”*
>
> *“Wrangling 2 other members is like dealing with spoilt children”*

This is a small data set, but it confirms what we find anecdotally in the class. Those groups who have problems that escalate to the attention of staff, have often not engaged in the group charter and have not implemented the strategies we present for managing group work. It seems that for these students, the complexity framework is another tool that they do not find themselves able to use, or chose not to use, for guiding any action to resolve challenges with group work dynamics.

Discussion

In analysing these results, it appears that using group work as a context for introducing complexity has assisted in developing the ability to differentiate between complicated and complex group work situations. This is a step forward in our research and shows promising signs that introducing complexity in the context of group work may help students engage and understand the frameworks.

However, this preliminary data indicated that the context has not facilitated students' ability to apply the techniques identified in the framework for managing the situation accordingly. Students are failing to take appropriate action when needed. Strikingly, there is a significant affective response when students are asked about how complexity frameworks may support their understanding and management of complex group work situations.

Combining these results with previous research, we see parallels to other education models which include the affective domain as a component in the ability of students to take action to support their learning. Carless and Boud (2018) have developed the feedback literacy framework (shown in Figure 2) which may be useful in understanding what is happening with students’ ability to learn complexity.

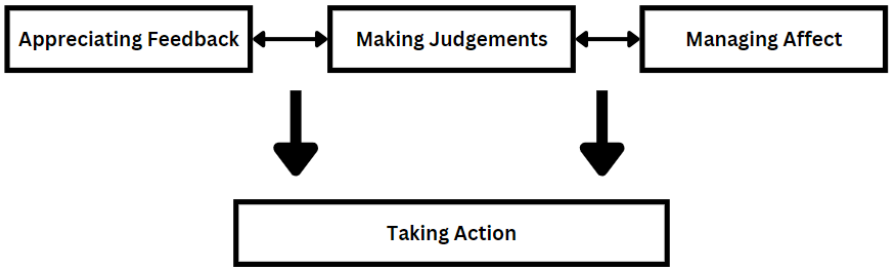

Figure 2: Feedback Literacy Framework (adapted from Carless & Boud, 2018)

Carless and Boud describe feedback literacy as “the understandings, capacities and dispositions needed to make sense of information and use it to enhance work or learning strategies” (Carless & Boud, 2018) a concept which we could similarly apply to the outcome we are looking for in teaching students how to make decisions in complex situations. That is, do students have the

“understanding, the capacities and the dispositions” to make sense of complexity and use the frameworks to take action to “enhance [their] work and learning strategies” in these contexts. This research has highlighted that students’ *disposition* may be what is preventing them from engaging fully and being able to take action.

The low response rate to the survey is itself a data point that may support this: the students that *did* respond felt very strongly about the challenges their teammates presented and yet they could not, or did not, use the complexity frameworks in any way in their charters or managing the team.

The literature on feedback and the feedback literacy framework itself capture a longer term “process” of developing this literacy which applies to complexity. Reilly and McBain (2022) in their research on using frameworks to develop engineering students’ ability to understand working in complex systems, highlight that this learning should be distributed across a curriculum. Developing this understanding is a process that takes time and exposure to varied learning opportunities. Boud et al (2013, 2015) suggest that to improve judgement, students need extended (over time) opportunities for comparison and self-evaluation (Boud et al, 2013, 2015). While Boud and Molloy (2013) report that students are more likely to change their approach and actions when they have formed their own judgments that this a necessity (Boud & Molloy, 2013).

Using the parallels to the feedback literacy framework, we can propose that there is a similar process involved in developing student skills in handling complexity including comparable components to appreciation of feedback, making judgments and managing affect which can maximise the potential of students to take appropriate action in a complex situation.

Appreciating feedback/complexity: according to Carless and Boud (2018), this is a process that involves students recognising the value of feedback as well as understanding that they take an active role in this process. In our case, the parallel is in understanding the value of being able to identify complexity and understanding that they have a role in managing complex contexts. That is, as their actions and decisions impact emerging outcomes. Similarly to feedback, many engineering students come to university with “absolutist” views that make them resist engaging in complex situations where there is no single correct predictable answer. Appreciation of feedback requires that students develop an understanding of academic language (Sutton 2012) and this has parallels to developing student understanding of complexity - without the language to understand, question and explain the characteristics of learning in complexity, students are unable to develop competency in identifying and managing complexity (Willey & Machet, 2018).

Making judgements: for both feedback and working with complexity, evaluative judgement is needed. This is central to the concepts of managing complexity in that is necessary to a) identify that the context of the decision making is complex, b) evaluate information using the understanding of the characteristics of a complex context, c) make judgements as a result of the evaluation, and d) self-assess the outcomes of their decisions and incorporate this learning into future judgements. This process would encapsulate the “probe” and “sense” components of the Cynefin framework for managing decisions in complexity.

Managing affect: Similarly to Carless and Boud’s description of feedback, students often resist engaging in complexity in the classroom, displaying defensiveness (Willey & Machet, 2018, Reilly & McBain, 2022) which impacts their engagement with the learning activities. Complexity challenges students. While the challenge may not be as direct and obviously personal as it is in the case of feedback, student’s feelings of competence can be challenged when working in a complex context and this affects their motivation and engagement. In addition, the results in this paper add to the evidence that student’s feelings and emotions provide resistance to engaging in complexity. This may be particularly relevant when using group work as a context, given the strong feeling that group work challenges provoke in some students.

Taking action: To effectively manage complexity, students need to take action (or “respond” as Cynefin suggests) to reduce uncertainty and progress towards a solution. This requires students taking agency and some ownership of outcomes. In this research the lack of agency is evident in the group work scenario. Students do not feel competent, or responsible, for taking action in line with the complex scenarios they find themselves in. In considering complexity, “taking action”

feeds back to student's appreciation of complexity, their ability to make judgements and influence their affective response to challenging situations (for example by increasing their feeling of competence and motivation to engage in complex scenarios).

These parallels suggest an emerging complexity literacy model that may be developed and tested. It highlights the importance of developing, not only students' appreciation of the value of being able to manage complexity and their understanding of how to apply complexity frameworks, but also that we need to carefully consider their disposition, and any of these factors can enable or inhibit students taking action in applying appropriate decision-making approaches when working in complex contexts (such as group work).

Other frameworks have been developed building on the work on student feedback literacy that could further inform a model. Frameworks have been produced for academic or instructor feedback literacy (Carless & Winstone, 2020, Nash & Winstone, 2017, Boud & Dawson, 2023). Interpreting their work on feedback in the context of complexity, Nash and Winstone (2017) comment that instructors are responsible for equipping students with strategies for taking productive action while students have responsibility to engage with and use the frameworks previously discussed to think about and manage complexity. Similarly, translating Carless and Winstone (2020) observations about feedback to our context, academic complexity literacy could be described as the knowledge, expertise, and dispositions to design activities in ways which enable students to use and apply the complexity framework to promote the development of their complexity management skills. This aligns with work looking at how to develop educators' competency in complexity frameworks (Willey & Machet, 2019) and would hopefully result in more learning activities (through the students' academic progression) that present authentic opportunities to solve complex problems using the Cynefin approaches of experimentation as they probe, sense, and respond.

Hence while our previous work has focused on developing a framework to provide students with a language to understand, think about, assess, and develop their capacity to manage complexity, the poor uptake by students of these resources demonstrates that we have not convinced students of their value, nor their need to be proactive in using these resources. The answer may be that we have arguably not paid enough attention to developing academic and instructor complexity literacy to support students in this development.

Conclusion

The research reported in this paper adds to the understanding of how to support students learning to identify complex situations and apply suitable strategies to make decisions when dealing with complexity. Preliminary data of participant responses to using group work as a context for investigating complexity has shown that students mostly did not find they were able to use the strategies presented by the complexity frameworks to assist in constructing their group charter or resolving their group work challenges. The responses highlighted a large affective response by the participants which suggested parallels to the feedback literacy framework. This paper argues that the feedback literacy framework may inform our understanding of the features that support students learning about complexity and is a first step in developing a model for complexity that may be used in future.

Future work will look at collecting additional data to refine a complexity literacy model that can be used (along with complexity frameworks) to introduce complexity to students, and to train and develop tutors, in such a way that we take advantage of a context they are familiar with (such as group work).

References

Boud, D. and Dawson, P. 2023, What feedback literate teachers do: an empirically-derived competency framework, Assessment & Evaluation in Higher Education, 48:2, 158-171

Boud, D., and Molloy, E. 2013. "Rethinking Models of Feedback for Learning: The Challenge of Design." *Assessment & Evaluation in Higher Education* 38 (6): 698–712

Boud, D. Lawson R, and D. Thompson, D. 2013. “Does Student Engagement in Self-Assessment Calibrate Their Judgement over Time?” *Assessment & Evaluation in Higher Education* 38 (8): 941–956

Boud, D., Lawson R, and D. Thompson. 2015. “The Calibration of Student Judgement through Self-Assessment: Disruptive Effects of Assessment Patterns.” *Higher Education Research & Development* 34 (1): 45–59

Brookfield, S. (2017). Becoming a critically reflective teacher. San Francisco, CA: Jossey Bass

Byrne, E. P., & Mullally, G. (2014). Educating engineers to embrace complexity and context. In *Proceedings of the Institution of Civil Engineers-Engineering Sustainability* (Vol. 167, No. 6, pp. 241-248). Thomas Telford Ltd.

Carless, D. & Boud, D. 2018 The development of student feedback literacy: enabling uptake of feedback, Assessment & Evaluation in Higher Education, 43:8, 1315-1325

Carless, D., and N. Winstone. 2023. Teacher feedback literacy and its interplay with student feedback literacy, Teaching in Higher Education, 28:1, 150-163

Crosthwaite, C. (2021). Engineering futures 2035 engineering education programs, priorities & pedagogies. *Australian Council of Engineering Deans, Report*.

Deci and Ryan (2008). Self-Determination Theory: A macrotheory of human motivation, development, and health. Canadian Psychology/Psychologie Canadienne, 49, 182-185

Hunsaker, P., Pavett, C. and Hunsaker, J. 2011. Increasing student learning effectiveness with team charters. Journal of Education for Business, 86: 127–139.

Kurtz, C. F., & Snowden, D. J. (2003). The new dynamics of strategy: Sense-making in a complex and complicated world. *IBM systems journal*, *42*(3), 462-483.

Nash, R., and N. Winstone. 2017. “Responsibility-Sharing in the Giving and Receiving of Assessment Feedback.” Frontiers in Psychology 8: 1519.

Machet, T., Willey, K., & Leigh, E. (2021, January). What do students say about complexity?. In *REES AAEE 2021 conference: Engineering Education Research Capability Development: Engineering Education Research Capability Development* (pp. 1073-1081). Perth, WA: Engineers Australia.

Mathieu, J. E. and Rapp, T. L. 2009. Laying the foundation for successful team performance trajectories: The roles of team charters and performance strategies. Journal of Applied Psychology, 94: 90–103.

Reilly, W. A., & McBain, B. (2022). Teaching complexity; moving between parametrics, paradigms and paradoxes. In *33rd Australasian Association for Engineering Education Conference* (AAEE 2022): *Future of Engineering Education* (pp. 700-708).

Snowden, D. J., & Boone, M. E. (2007). A leader's framework for decision making. *Harvard business review*, *85*(11), 68.

Sutton, P. 2012. “Conceptualizing Feedback Literacy: Knowing, Being, and Acting.” *Innovations in Education and Teaching International* 49 (1): 31–40.

Thomas, J., & Mengel, T. (2008). Preparing project managers to deal with complexity–Advanced project management education. International journal of project management, 26(3), 304-315.

Whyte, J., Naderpajouh, N., Clegg, S., Matous, P., Pollack, J., & Crawford, L. (2022). Project leadership: A research agenda for a changing world. Project Leadership and Society, 3, 100044.

Willey, K., & Machet, T. (2018). Complexity makes me feel incompetent and it's your fault. *Australasian Association of Engineering Education*.

Willey, K., & Machet, T. (2019). Assisting tutors to develop their student's competence when working with complexity. In *Proceedings of the 8th Research in Engineering Education Symposium, REES 2019-Making Connections*.

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