
# Workshop

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# ADDRESSING AMBIGUOUS TERMINOLOGY AND FUZZY CONCEPTS TO IMPROVE CONCEPTUAL UNDERSTANDING IN ENGINEERING EDUCATION

**E. A. F. Brady [a, 1], N. Wint [b], I. Direito [c]**

[a] School of EEME, University of Bristol, Bristol, UK, 0009-0003-5443-2669
[b] STEAPP, UCL, London, UK, 0000-0002-9229-5728
[c] TEMA, University of Aveiro, Aveiro, Portugal

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## ABSTRACT

Engineering educators and researchers use terminology to communicate specific ideas with the intention of disseminating knowledge effectively. Despite this, some terms are understood and conceptualised differently by different individuals, resulting in miscommunication. Concepts which are not well-defined or may have multiple definitions can be known as 'fuzzy concepts' (Ragin, 2000).

This workshop highlighted the existence of fuzzy concepts used in engineering education. Such understanding allows practitioners to recognise the potential for misinterpretation and the need to define key terms in order to improve the clarity and consistency of their communication. The workshop activities encouraged participants to share which terms they use in teaching practice that they believe may be fuzzy.

Participants were prompted to consider the practical implications of utilising fuzzy concepts within intended learning outcomes, teaching practice, assessment and graduate outcomes, as well as in education research. They identified uses for FCs in collaborative learning, which would improve students' problem solving and team working abilities, as well as creating discussions in industry settings through which organisational cultural norms could be identified and addressed.

[1] *Corresponding Author*
*E. A. F. Brady*
*erin.brady@bristol.ac.uk*

# 1 BACKGROUND AND RATIONALE

## 1.1 What are Fuzzy Concepts?

Key terms and concepts are often chosen to communicate specific ideas. Sometimes these terms can lack precision or can be understood in different ways, and the meaning derived from them can thus differ from that intended. Such concepts are often referred to as “fuzzy” (Zadeh, 1976). The term Fuzzy Concepts (FCs) originates from the mathematical field of “fuzzy logic” whereby multi-valued set logic is used to describe concepts with an ambiguous degree of membership to a set (Lee & Kang, 1997). The study of such interpretation and meaning is referred to as “fuzzy semantics” (Wang, 2022).

## 1.2 Sources of Ambiguity and Subjectivity in Engineering Education

Lönngren et al. (2023) note that both the phenomena studied in Engineering Education Research (EER) and the interpretation and transferability of findings, as well as theory development, are impacted by the range of different disciplinary theories that Engineering Education (EE) researchers employ. A widely used term which has found relevance within EER, but for which a variety of interpretations exist, is resilience. In EER, the way resilience is conceptualised by EE teachers and researchers is diverse (Winkens & Leicht-Scholten, 2023; Wint & Direito, 2024), and has been proposed to be associated with both adaptability to change, as well as resistance to change.

Resilience is a key term used in employability as well as in EER, which has implications on graduate outcomes. The Future of Jobs Report 2025 (World Economic Forum, 2025) fails to explicitly define resilience, despite listing it as the second most highly ranked core skill that employers require of their workers, alongside “flexibility and agility”. The intended meaning of resilience is inferred as relating to a need to “(adapt) to uncertainty and (manage) complex social dynamics”. This grouping of resilience with other terms could also suggest that it should operate similarly to “flexibility” and “agility”. A clear definition would provide insight into the specific behaviours and attributes that employers desire from employees.

The lack of a singular definition for resilience also arises from cultural differences. Prevailing Western conceptualisations of resilience include “a dynamic process encompassing positive adaptation within the context of significant adversity” (Luthar et al., 2000) while the Palestinian cultural value Sumud (Abuelaish & Yousufzai 2023) specifically describes communities’ ability to alter their reality rather than adapt to adverse circumstances. Sumud can be translated as ‘resilience’ from Arabic to English, but this risks losing its specific meaning. Using the same word to describe different conceptualisations provides a clear example of how fuzziness can arise when parties are not aware of the others’ understanding.

A wide range of contextual factors can underpin both the intended and interpreted meaning for FCs including resilience. This has implications for those who are unfamiliar with such terms - these being particularly relevant to educational settings where students’ ability to use contextual clues to infer meaning may be limited and unlikely to be sufficient to clarify FCs.

### 1.3 Clarifying Fuzzy Concepts

Where FCs are present in educational outcomes (including learning outcomes, assessment outcomes and graduate outcomes), what is expected of students can be unclear. Various solutions to address the problem associated with this lack of clarity have been found in literature on education research.

Two studies have measured the achievement of qualitative Learning Outcomes (LOs) using fuzzy logic processing (Bouslama et al., 2006; Venkatesan & Fragomeni, 2008), where fuzzy logic methods were applied to assess students' achievement of LOs at the point of summative assessment. This provides some insight into students' interpretations of the learning outcomes, but providing clarity around the concepts used to communicate LOs at the start of a course could improve the consistency of how different students understand what is required of them in the assessment. This approach can also be particularly helpful for formulating problems which themselves are ill-defined or "wicked" (Rittel & Webber, 1973) like improving design for sustainability (Seager et al., 2012).

Given how miscommunication can arise when using FCs, the workshop described in this work aimed to support EE practitioners, from a variety of backgrounds, cultures, and roles, in understanding the sources of confusion when concepts have not been comprehensively and explicitly defined. This is relevant for teaching practice and curriculum design in aiming to prepare graduates for the workplace, and to improve communication and dissemination of research findings (Roland et al., 2015).

## 2 WORKSHOP OBJECTIVES

### 2.1 Target Audience

Attendees with an interest in improving their impact in teaching or research practice were encouraged to attend; their familiarity with FCs before the session was not known. Suggested preparation for the workshop was to ruminate on terms' definitions which they or their students find confusing.

### 2.2 Expected Outcomes

By the end of this workshop, it was expected that participants were able to:

1. Recognise concepts which may be fuzzy in teaching or research practice.
2. Understand the effects of concepts' fuzziness on others' interpretations of teaching and research communication.
3. Experiment with techniques from the workshop to clarify FCs in their teaching and/or research practice.

## 3 WORKSHOP DESIGN

### 3.1 Time Plan

The structure of the workshop is provided in Table 1 below.

*Table 1. Structure of the workshop.*

| Duration | Activity | Notes |
|---|---|---|
| 5 min | Introduction:<br>What are FCs? | Introduction to session structure including the learning outcomes and FCs definition. |

| | | |
|---|---|---|
| 15 min | Group-Based Worksheet: Effects of Applying FCs in Different Contexts | Worksheet-based activity exploring definitions of specific FCs. |
| 10 min | Whole Room Discussion: Implications of FCs in Teaching and Research | Groups' feedback and discussion on results of the previous activity using the following question: What are the differences in the conceptualisations of your group's FC? |
| 20 min | Whole Room Discussion: How to Tackle Confusion Associated with FCs | Participants invited to propose other FCs in the further discussion using the following question: Which approaches to clarifying FCs are effective and feasible for you to implement? |
| 10 min | Plenary: Summary and Key Takeaways | Discussion points summarised, then participants are provided guidance on addressing the topic in future. |

**3.2 Procedure**

The 18 individuals who attended the workshop were randomly allocated to three groups as they arrived. After an introduction covering the purpose and structure of the workshop, participants were asked to complete a brief activity which involved writing responses to prompts within the three groups of four or more.

Each group was allocated a different FC: creativity, resilience, or success. Within their groups, different attendees completed each of the prompts in four stages, swapping the sheets for each stage so that the four prompts on each sheet were completed by four different people. The prompts below were developed to address key inconsistencies identified in the Introduction, where "CONCEPT" was replaced by "creativity", "resilience" or "success" respectively.

1) Write up to 10 words or ideas that you associate with CONCEPT.
2) Briefly describe 1 way in which CONCEPT could be measured or assessed.
3) List up to 5 behaviours or actions you would expect from someone who shows CONCEPT.
4) Describe how you think something can benefit from CONCEPT.

Approval to collect data from the workshop was obtained from a UCL departmental research ethics committee (UCL) (project ID 1743). Four of the worksheets collected were concerned with creativity, six with resilience, and seven with success – on the remaining worksheet, consent had not been given so the results were not recorded.

Following this, participants were asked to share how they defined each concept within the group, the implications that any differences would have for research, industry and teaching practice, and methods which could be used to clarify FCs, as part of a wider discussion. The facilitators supplemented this discussion with actionable solutions, like juxtaposing definitions against their opposites and giving examples of how a concept may be operationalised.

Care was taken to avoid leading participants' conceptualisations throughout the workshop: for example, the introduction used the term "sandwich" as a fuzzy concept as it does not relate to teaching or research practice. It was explained that different descriptions of a sandwich could result in items being assigned various degrees of membership to being a "sandwich", which makes it fuzzy.

## 4 WORKSHOP RESULTS

### 4.1 Worksheet Reponses

There were notable similarities in responses on the worksheets across groups, with some responses to Prompt 1 including the reference to FCs allocated to the other groups (e.g: creativity was mentioned as related to success, and success was related to resilience), and some definitions were used for more than one FC (e.g., 'hard work' was considered related to both resilience and success.

- The contextual applications in which the FCs were considered to be used were related to STEM education, industry, leisure, engineering design work, and stalking (for resilience).
- It is interesting to note that contradictory definitions were given for both resilience and success. In comparison, there was less deviation in the conceptualisations of creativity; it was defined in a more singular way.

Table 2 shows some of the ideas associated with the FCs, alongside measurements.

*Table 2. Summary of participant responses from the worksheets.*

| | **Creativity** | **Resilience** | **Success** |
|---|---|---|---|
| Associated words | Innovation<br>Innovative<br>Art | Hard work<br>Overcome Struggle<br>Strength Confidence | Hard work<br>Winning<br>Use creativity and having novelty in work.<br>Completion |
| Evaluation | Diversity of outputs from a design or problem-solving activity. | Understanding ability to endure hardship and subsequent recovery. | Rubric used to measure the extent to which criteria are met.<br>Social perception |
| Benefits | Bringing diverse perspectives.<br>Using limited resources to solve problems effectively.<br>Breaking down systemic barriers. | Makes things more predictable and less dependent on external conditions.<br>Avoid total failure and destruction.<br>Get things done. | Viable products<br>Easier access to funding.<br>More students thriving.<br>Creates new perspectives and concepts. |
| Behaviours | Reflection<br>Talkative<br>Curiosity<br>Not giving up when something is not perfect.<br>Critical analysis.<br>Being active | Being able to finish a given task.<br>Consideration for wellbeing.<br>Seeking help from teachers.<br>Enthusiasm | Humility<br>Being ostentatious<br>Generosity<br>Confident body language.<br>Asking questions in the classroom.<br>Satisfaction |

### 4.3 Whole Room Discussions

Attendees mostly expressed an appreciation for FCs rather than frustration arising from miscommunication. Some stated that they "lack trust" in precise definitions given for FCs as they believed that a concept should be used with an awareness of its multiple definitions. One attendee justified this belief in relation to Gödel's incompleteness theorem (Hosch, 2025): their analogy being that no single definition for an FC can encompass all of its possible conceptualisations.

Everyone understood the conceptualisations of FCs presented by others, even for definitions that differed from their own. This understanding did not appear to arise from explicit conversations or justifications; it appeared to be unprompted or presumed. Nevertheless, they did identify the significance of cultural and contextual influences generally affecting students' and professionals' understanding of FCs.

Many attendees agreed that discussing the definitions of FCs in classroom could improve students' conceptual understanding. In problem-solving scenarios, developing a more complex understanding of a fuzzy concept could increase the scope of feasible solutions to the problem. Additionally, students dissecting their own presuppositions in group conversations could help with understanding others' perspectives and building mutual respect. This was linked to industry too, where similar activities could be used to increase awareness of organisational culture and highlight norms to be challenged.

### 4.4 Conclusions

Attendees' appreciation for FCs was more positive than expected, as illustrated by their desire for retaining an awareness of multiple meanings to develop an expansive understanding of concepts. They identified that discussing implicit conceptualisations could be useful for addressing norms in engineering classrooms and in industry, which aligns with the use of Common Ground in recognising presuppositions (Stalnaker, 2002).

There was no evidence of the extent to which responses on the worksheet reflected attendees' own experiences (their cultural and contextual background especially). Because of this, although the groups' proposals for using FCs were relevant for teaching and research practice, their utility for the individuals attending is not clear.

## 5 CONCLUSIONS AND FUTURE WORK

The findings point to a number of potential avenues for future work.

- Development of activities which involves discussion of FCs to improve students' conceptual understanding
- Development of activities aimed at establishing common ground with peers, something which may be useful in light of increasing globalisation and need for engineering to adopt interdisciplinary approaches
- A study motivated by the lack of discussion around attendees' tacit conceptualisations could explore how individuals' backgrounds, and their awareness of these, affect their conceptualisations of FCs.

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