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Engagement in quantitative subjects: Forms of student engagement

What is student engagement?

In this article, we shall consider different modes of student engagement, and then discuss in particular how we can model, and thus nurture, cognitive engagement.

Before proceeding, you should consider what it is you mean by student **engagement**. This concept has seen many different definitions in education literature. While these differ on many fine points, many concur that engagement is something more than just **participation**, though the latter might often be used as a crude proxy for the former. (Trowler, 2010) contains a nice survey of many of these definitions and what motivates their use.

Types of student engagement

While we might associate the word engagement to cognitive activities, student engagement can manifest in many different ways. Awareness and acknowledgement of these may help in designing and delivering effective teaching sessions.

Engagement type	Description
Cognitive	Deep processing, use of cognitive strategies, self-regulation, motivation and effort
Behavioural	Work and study behaviours, persistence
Emotional	Interest and feelings towards learning (e.g. sense of belonging)
Agentic	Constructive contributions from students to their own learning

See (Trowler, 2010) for more on these types.

General strategies for fostering student engagement

Krause (2005) identifies various working principles for institutions to enhance student engagement. Of these practices, those that are relevant to the classroom (or lecture theatre) include:

1. **Create and maintain a stimulating intellectual environment.** Consider ways to stimulate discussion between students. Use and frame learning activities to encourage exploration and discovery (as opposed to just practice and application).
2. **Monitor and respond to demographic subgroup differences and their impact on engagement.** This requires teachers to first get to know their students, including their learning needs, aspirations and motivations. These can help teachers identify and monitor differences in engagement across subgroups of students and develop strategies in response to these differences.
3. **Ensure expectations are explicit and responsive.** Expectations (on students) should be communicated clearly and consistently both at the start of the course, but reiterated several

times throughout the course. Some element of negotiation should be employed as well, asking students to identify their expectations and adopting or adapting where appropriate.
4. **Foster social connections.** In small groups: increase opportunities for active and collaborative learning, such as small group work, problem-solving activities, classroom discussions. In large lectures: foster student interaction through Q&A sessions and interactive activities (e.g. using quiz sites like Mentimeter) as well as small group, or paired, activities.
5. **Acknowledge the challenges faced by students.** Let students know that you are aware of the pressures they face, e.g. juggling course student commitments against other demands on their time. Be explicit and proactive in dealing with issues and challenges that potentially jeopardise student engagement.

The remaining principles are applicable at the course, programme and institutional level, and are omitted here for focus.

Taxonomies of cognitive engagement

When it comes to cognitive engagement, many taxonomies have been suggested in order to understand and gauge the differing levels of cognitive demand that educational activities place on learners.

Perhaps the most commonly known one is Bloom's (revised) Taxonomy, which uses verbs to express a hierarchy of levels of cognitive demand from remembering (at the lowest end) through understanding, applying, analysis, evaluating and ultimately creating (at the highest end).

However, educators in quantitative fields have found it challenging to apply this in practice and several other taxonomies have been introduced to better reflect the particular characteristics of this domain.

(Smith and Stein, 1998) proposed the following classification for mathematical tasks:

1. **Memorisation**, where students are predominantly asked to either memorise or reproduce datum (e.g. rules, formulae, definitions, etc). E.g. "State the Intermediate value theorem."; learning common trigonometric values, such as $\sin(30_{\circ})$, $\tan(\pi/4)$.
2. **Procedures without connections**, where students are directed to carry out specific procedures or algorithms, but without either having to make direct connections between the mathematical task and the underlying theory or too explain the procedure and how they are applying it. E.g. "Use the method of linear regression to..."; "Use the substitution $u=\ldots$ to find the integral ...".
3. **Procedures with connections**, where students are only given (either implicitly or explicitly) broad general procedures which requires some cognitive effort before students can start work. E.g. "Model this situation as a differential equation and solve using appropriate methodology."
4. **Doing mathematics**, which broadly covers tasks that require complex, or non-algorithmic thinking. Such tasks might also emphasise students' metacognition, requiring self-monitoring or self-regulation. Examples might include complex projects or applications of problem-based learning, which sets ill-formed problems (i.e. problems with initially incomplete information about solution methods or theory) and require students to fill in the blanks by identifying what learning is required to start solving the problem.

(Smith et al, 1996) adapt Blooms into a non-hierarchical division of knowledge and skills into 3 groups, with their ordering depending on the **nature** of the activity, and thus being applicable regardless of the intrinsic level of difficulty of the tasks.

Group A – Routine procedures	**Group B – Using existing mathematical knowledge in new ways**	**Group C – Application of conceptual knowledge to construct mathematical arguments**
Recall of factual knowledge / fact systems Comprehension Routine use of procedures	Information transfer Application in new situations	Justifying and interpreting Implications, conjectures and comparisons Evaluation

Examples

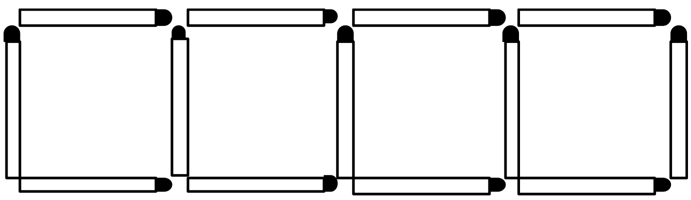
A simple early stage example is enough to show how we might increase the cognitive demands of a given problem. Starting from a simple calculation task for area:

> Mrs. Brown wants to recarpet her bedroom, which is 15 feet long and 10 feet wide. How many square feet of carpeting will she need to purchase?

Compare to the following which, while it gives more information and instructions, nonetheless places a greater cognitive demand on students

> Ms. Brown's class will raise rabbits for their spring science fair. They have 24 feet of fencing with which to build a rectangular rabbit pen to keep the rabbits.
>
> - If Ms. Brown's students want their rabbits to have as much room as possible, how long would each of the sides of the pen be?
> - How long would each of the sides of the pen be if they had only 16 feet of fencing?
> - How would you go about determining the pen with the most room for any amount of fencing? Organize your work so that someone else who reads it will understand it.

(Lithner, 2017) considers a two versions of a problem in which a row squares are constructed using matches. As an example, 4 squares are constructed as follows



Compare the original text

> If x is the number of squares then the number of matches y required can be calculated by the function $y = 3x+1$.
> **Example:** 4 squares can be made using $y = 3x+1 = 3\times4+1 = 13$ matches.
> **How many matches are needed to get 6 squares in a row?**

to the following revision

> **Example:** 4 squares can be made using 1313 matches.

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How many matches are needed to get 50 squares in a row?

Next steps?

Take a standard homework or assessment problem your course and, using one of the taxonomies mentioned above, identify what tasks it requires of students and what levels of cognitive demand these tasks place on them.

Can students approach the task successfully with a lower level of cognitive demand than intended?

How might you rewrite the problem to increase the level of cognitive demand actually required from students (e.g. for classwork)?

References

Krause, K.L. (2005) Understanding and Promoting Student Engagement in University Learning Communities. A keynote Address 'Engaged, Inert or Otherwise Occupied? Deconstructing the 21st Century Undergraduate Student' at the James Cook University Symposium 2005, Sharing Scholarship in Learning and Teaching: Engaging Students. James Cook University, Townsville/Cairns.

Lithner, J. (2017). Principles for designing mathematical tasks that enhance imitative and creative reasoning. ZDM - Mathematics Education, 49(6), 937–949. https://doi.org/10.1007/s11858-017-0867-3

Smith, G. et al. (1996) Constructing mathematical examinations to assess a range of knowledge and skills. International journal of mathematical education in science and technology. [Online] 27 (1), 65–77.

Smith, M.S. and Stein, M.K. (1998). REFLECTIONS on Practice: Selecting and Creating mathematical Tasks: From Research to Practice. Mathematics Teaching in the Middle School, 3(5), 344–350.

Trowler, V. (2010). Student engagement literature review. Higher Education, November, 1–15.