

Title: Balancing Efficiency and Effectiveness: Learning in Large Class Electronics Laboratories

Authors: Dr Leah Ridgway (<https://orcid.org/0009-0006-9296-9231>), Prof Derek Molloy

DCU School/ Unit: School of Electronic Engineering

Keywords: laboratory teaching; large class; engineering laboratories, electronic engineering

Corresponding author email: Leah.Ridgway@dcu.ie

What?

Engineering laboratories are grounded in constructivist pedagogy; there is value in the experience of participating; this scaffolds learning and teaches unique skills (Feisel & Rosa, 2005). The massification of higher education means we are welcoming more diverse students (Hornsby & Osman, 2014), ultimately producing engineers who better reflect the societies they design for. Maintaining pedagogically valuable laboratory experiences can be challenging with large cohorts. We discuss our approach for two separate laboratory curricula within Electronic Engineering for undergraduate students at DCU. Practicals for each module are facilitated by one academic (the module convenor), one technical officer, and three/four postgraduate demonstrators (usually Masters students).

- EEG1004: Introduction to Electronics. 5 ECTS credits, year-long, ≈ 250 first year students (all engineering disciplines).
- EEN1022: Digital & Analogue Electronics. 5 ECTS credits, semester 1, ≈ 200 second year students (Electronic and Computer Engineering, Mechatronic Engineering, and Physics).

We focus on *pedagogy as planned* in the design of sessions and *pedagogy as enacted/experienced* (Nind et al., 2016) in the delivery.

So What?

With large classes, efficient laboratory design is critical. Detailed instructions/manuals provided in advance, highlight common mistakes and guide fault-finding, empowering students to help themselves. EEG1004 incorporates automatically graded “pre-laboratory” assessments; based on laboratory instructions so students arrive prepared (Rollnick et al., 2001) these are ‘summative assessments with a formative flavour’ (Broadbent et al., 2018) providing timely and individualised feedback.

It is difficult to know students individually in large classes, so pedagogical design addresses collective patterns of understanding, scaffolding students in developing mastery (Woollacott et al., 2014). Laboratories also offer active learning experiences which can be otherwise challenging to deliver in large cohorts (Felder, 1997), (Hornsby & Osman, 2014).

Planning for failure is built into activity design; learning from mistakes is valuable (Edmunds & Leggett, 2024), but only if students can understand the cause and take this learning forwards (Molloy et al., 2020). This is balanced with keeping students motivated while waiting for help in large classes. Sessions are designed to minimize destructive or frustrating failure; circuits may not fully work, but will partially work, allowing students to locate errors more easily.

[Balancing Efficiency and Effectiveness: Learning in Large Class Electronics Laboratories]
[Leah Ridgway & Derek Molloy]

Circuit construction requires developing skills with unfamiliar technologies and processes. Scaffolding novices to develop competency starts with structured work to build familiarity, gradually increasing difficulty and complexity as students gain independence. Experts model the skills, reducing cognitive load on students (Atkinson et al., 2000). EEN1022 begins with a step-by-step cohort construction of the first circuit to increase confidence, ensuring early success for everyone. EEG1004 starts with “what you see is what you get” images of circuits. Later, circuit schematic diagrams are introduced, increasing in complexity throughout the module as students develop interpretation skills.

The physical laboratory space is an invaluable pedagogical tool for developing identity and community among engineers (Winberg & Winberg, 2021). Students experience excitement and achievement when their constructed circuits work. Laboratories develop student feedback literacy; providing space to benchmark work and observe peer progress.

Now What?

Large group laboratories require compromise between the efficiency of rigidly structured procedural construction, and the development of higher-level skills such as independent investigation and creation (key to Bloom’s taxonomy and engineering accreditation). Both modules achieve this compromise by providing more structure initially and becoming more open-ended later. Laboratories are important for developing disciplinary specific skills (construction and fault-finding) and act as a learning forum. Students report enjoying laboratories; therefore, further investigation into pedagogy as experienced by our students is warranted as we continue developing curricula.

References

- Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from Examples: Instructional Principles from the Worked Examples Research. *Review of Educational Research*, 70(2), 181–214. <https://doi.org/10.3102/00346543070002181>
- Broadbent, J., Panadero, E., & Boud, D. (2018). Implementing summative assessment with a formative flavour: A case study in a large class. *Assessment & Evaluation in Higher Education*, 43(2), 307–322. <https://doi.org/10.1080/02602938.2017.1343455>
- Edmunds, K., & Leggett, H. (2024). Active learning in the undergraduate laboratory: Giving students a safe space to experience low-stakes failure. *Open Scholarship of Teaching and Learning*, 3(2). <https://doi.org/10.56230/osotl.107>
- Feisel, L. D., & Rosa, A. J. (2005). The Role of the Laboratory in Undergraduate Engineering Education. *Journal of Engineering Education*, 94(1), 121–130. <https://doi.org/10.1002/j.2168-9830.2005.tb00833.x>
- Felder, R. M. (1997). *Beating The Numbers Game: Effective Teaching In Large Classes*. 2.89.1-2.89.5. <https://peer.asee.org/beating-the-numbers-game-effective-teaching-in-large-classes>
- Hornsby, D. J., & Osman, R. (2014). Massification in higher education: Large classes and student learning. *Higher Education*, 67(6), 711–719. <https://doi.org/10.1007/s10734-014-9733-1>

[Balancing Efficiency and Effectiveness: Learning in Large Class Electronics Laboratories]
[Leah Ridgway & Derek Molloy]

Molloy, E., Boud, D., & Henderson, M. (2020). Developing a learning-centred framework for feedback literacy. *Assessment & Evaluation in Higher Education*, 45(4), 527–540.

<https://doi.org/10.1080/02602938.2019.1667955>

Nind, M., Hall, K., & Curtin, A. (2016). *Research methods for pedagogy*. Bloomsbury Academic, an imprint of Bloomsbury Publishing, Plc.

Rollnick, M., Zwane, S., Staskun, M., Lotz, S., & Green, G. (2001). Improving pre-laboratory preparation of first year university chemistry students. *International Journal of Science Education*, 23(10), 1053–1071. <https://doi.org/10.1080/09500690110038576>

Winberg, C., & Winberg, S. L. (2021). The role of undergraduate laboratories in the formation of engineering identities: A critical review of the literature. *The Journal for Transdisciplinary Research in Southern Africa*, 17(1), 12.

Woollacott, L., Booth, S., & Cameron, A. (2014). Knowing your students in large diverse classes: A phenomenographic case study. *Higher Education*, 67(6), 747–760.

<https://doi.org/10.1007/s10734-013-9664-2>