Data-Driven Approaches to Student Retention: Analysis of Dropout Trends in the Measurements Laboratory

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Abstract: This paper presents a data-driven investigation of student dropout in the Measurements laboratory, a core course in electrical engineering education. By analysing decades of performance and motivation data, with a focus on recent years, we identified key social, Curricular, and infrastructural factors influencing dropout. We highlight student attitudes and instructional conditions that strongly affect retention. The research aims to reveal intervention strategies that foster active student participation and competence development while maintaining academic standards and promoting long-term retention.

Keywords: student dropout, data-driven analysis, measurements laboratory, electrical engineering education, Curriculum development; motivation and retention

1 Introduction

"It is not enough to recruit the student; you need to retain them!" is more often said at faculty, department, or educational committee meetings where dropouts, defined as students who fail to meet course requirements, are the main focus. Based on the experience of recent decades, it has become clear that student retention is not only an educational policy issue but also a matter of methodology, institutional culture, and the social environment. Seemingly simple solutions, such as easing requirements, simplifying the examination system, or making accountability more 'approachable,' appear to offer a way forward, yet they can also lead to a reduction in professional standards. Education, particularly in engineering, is not a market-driven solution in the long term.

The measurements course is one of the fundamental pillars of electrical engineering education, which develops the fundamental competencies of practical engineering: data collection, analytical thinking, error estimation, and accurate documentation. Based on our written records from educational practice over the past 40 years, a long-lasting trend emerges: early school leaving approaches 25% annually. About half of this, i.e. 12-15%, represents the proportion of students who do not attend laboratory sessions, fail to submit mandatory reports, or have no contact with teachers. The remainder – around 10-13% – is due to educational inadequacy, i.e. formal but incomplete fulfillment of the requirements. In recent years, we have conducted various investigations at both institutional and departmental levels to identify the causes of the phenomenon. Motivational surveys and questionnaires mapping study habits and student attitudes clearly indicate that the level of early school leaving is significantly influenced not only by the difficulty of the learning content but also by student engagement, learning self-efficacy, community embeddedness, and teaching communication style. The purpose of this article is to determine how to reduce drop-out rates based on decades of experience and empirical data from recent years, and whether this can be achieved without the active involvement of students. (Spoiler Alert: No)

The history of measurements course also reflects changes in electrical engineering education. From the outset, the course matter has been part of the core curriculum: it aims to provide students with the practical knowledge essential to engineering in a laboratory environment. As a result, detailed records of the courses teaching – and thus student performance – have been available for decades, and measurements have evolved in recent years. This is in itself a great advantage: it provides an opportunity to analyze trends over time and draw predictive conclusions. However, conducting such historical comparisons is challenging. The educational environment, the composition of the student body, social and market expectations, and curriculum structures have changed over the past 10-15 years to such an extent that historical data alone no longer provide adequate insight into the current situation.

The transformation of the social and economic environment, in particular the digitalization of industry, automation, and the rise of artificial intelligence, requires new competencies from electrical engineers. While two decades ago the focus was on knowledge of analogue circuits, operation of handheld measuring devices, and traditional laboratory protocols, today the focus is on data processing, the integration of sensor systems, digital signal processing, and the automated evaluation of measurements, sometimes augmented by artificial intelligence. The modern electrical engineer therefore perceives not only a ‘measuring’ process but a system, interprets data, and is able to incorporate measurement results into a complex AI-enabled process.

Adapting the curricula of higher education institutions, including the Kálmán Faculty of Electrical Engineering, reflects this change. The new curricula incorporate competence-based approaches, project-oriented education, and practice-oriented course structures. However, this shift in metrology education is particularly complex, as laboratory education is heavily burdened both in terms of human resources and infrastructure. A laboratory requires dozens of identical devices, measuring instruments, and sensors, the maintenance, repair, and updating of which consume significant financial resources. At the same time, there is uncertainty on the human resources side: as experienced trainers retire, replenishment is difficult, there is often a lack of a proper competency framework, and the training of young educators is often not systematic. This situation has a negative impact not only on the maintenance of professional standards, but also on student motivation. In the case of a course that is essentially practice-oriented, the lack of physical presence, leading by example, and mentoring are particularly detrimental to student engagement.

Against this background, early school leaving is not only a problem of educational methods but also a systemic challenge. However, change is always possible. Within the framework of the current curriculum, we can also implement fine-tuning measures that improve efficiency, reduce dropouts, and enhance the student experience, without undermining professional standards. The aim is to restore Kando’s status as a higher education institution that preserves its prestige with dignity and is proud of its traditions, while remaining modern, open, and attractive to young engineers. [1]

The paper therefore not only discusses the causes and motivational aspects of early school leaving but also seeks to highlight ways to sustainably improve the effectiveness and experience of the measurements course by fine-tuning educational structures, resources, and student attitudes. “Because it is not enough to recruit the student – they must be retained.” And this retention is not just a matter of the curriculum but a shared responsibility of the community, the teacher, and the student.

All in all, due to the changes in the environment surrounding the student, comparing the data currently measured with historical data is only possible with a high degree of approximation. In many cases, we have attempted this, but the conclusions drawn from the results have almost always been flawed. It should be noted that the two half-year measurements currently in use were developed through the efforts of more than a dozen professionals over the past decades. Although continuous changes occur year after year, they are primarily reflected in how knowledge is processed by students and in the form of the digitalisation of accountability.

2 Purpose and Tasks of the Measurements Laboratory

The measurements lab is one of the most important practical **courses** in electrical engineering education, which aims to equip students with the basic theoretical and practical knowledge **required** to measure electrical and non-electrical quantities. Laboratory work is the stage of electrical engineering training where theoretical knowledge is converted into **practical experimentation, observation, and analysis**. Here, students are first confronted with the fact that **electrical quantities** are not just calculation tasks, but are realistically measurable physical quantities **subject to measurement uncertainty**, the precise definition of which is the basis for industrial, research and development processes. Accordingly, the primary task of laboratory professionals is to **ensure the practical understanding and application** of the principles of measurement of basic electrical quantities, such as voltage, current, resistance, power and energy. During the lab, students should learn the principle and treatment of different measuring instruments, such as analogue and digital multimeters, oscilloscopes, **function generators**, power supplies, signal generators. They should also learn the correct interpretation of technical data, the determination of measurement limits and accuracy, and the **selection** of the appropriate measurement method for a given problem and task.

More broadly, the aim of the Lab is not only to practise the use of instruments, but also to develop a comprehensive engineering approach. Students are required to make decisions in every measurement exercise (not as isolated choices, but by learning the underlying principles, applying the guideline-proposed solutions, and validating their conclusions): what method is used, how measurement error is minimised, how the result is validated, and how the measurement process is documented. This decision-making develops analytical thinking, problem-solving skills and responsible engineering practice.

The laboratory's tasks include the presentation of techniques for measuring non-electrical quantities, such as temperature, pressure, displacement, velocity. These measurements are often carried out through sensors, transducers and sometimes measuring amplifiers, thus giving students an insight into the foundations of sensor technology and signal processing. In parallel, they will learn about the foundations of measurement automation: they learn how to connect measuring instruments to computer systems, how data are collected, digital signal processing and automated evaluation of results.

During the lab measurement exercises, students will also learn about modern applications of artificial intelligence (AI). The measurement results, in particular when measuring non-electrical quantities, are processed and evaluated using AI algorithms. AI tools enable the automated implementation of noise filtering, error calculation and data correlation, thereby improving students' data analytics competences and digital engineering mindset.

During the Lab, students acquire a number of core competences:

- **Professional competencies:** practical knowledge of measuring electrical and non-electrical quantities, safe and professional use of measuring devices, correct interpretation of measurement data.
- **Methodological competencies:** design of measurement procedures, error calculation, accurate management of measurement report, validation and presentation of results.
- **Digital competences:** computer control of measuring instruments, recording of data, AI-based data processing and understanding of automated measuring systems.
- **Personal and social competences:** self-employed and collective work, responsibility, time management, communication and cooperation.

The aim of the laboratory work is to provide students with technical skills and to help them understand the essence of engineering: the relationship between measurement, interpretation and decision-making. The Lab is therefore not merely a practical course, but one of the most important fields for shaping the professional identity of an electrical engineer, where students learn that precise measurement is not only a technical issue but also a matter of engineering judgement.

3 What are the reasons for Student dropout?

Student dropout, particularly in the field of technical and engineering training, is a complex, multifactorial phenomenon that cannot be attributed to a single cause. On the basis of the written documentation, meeting minutes, teachers' reports and feedback from students over the past 40 years, as well as the surveys of recent years (motivation data, self-efficacy measurement, learning style data), it is clear that not only learning gaps, but also social, motivational, methodological, organisational, and infrastructural factors contribute to laboratory dropouts in metrology. [2]

It is important to emphasise that the purpose of the paper is not to identify those responsible, but to systematically identify the problem in order to identify the points where intervention, change or improvement is possible. (The paper is also intended to assist efforts to reduce drop-outs in similar laboratories.) The reasons listed often do not appear in isolation, but produce negative effects by strengthening each other and compounding each other. Sequential numbering reflects both the ease of identification and the relative order of frequency and importance. [3] [4] [5] [6] [7]

1. Lack of active involvement – lack of motivation

The most common and most striking reason is the lack of active participation. If the student does not appear in the lab, does not take part in the exercises, does not prepare a report or does not contact the teacher, student dropout is almost inevitable. Lack of motivation often occurs at the beginning of the semester: the student does not see the practical benefit of the course and does not perceive it as relevant to his or her future career. This attitude strengthens the 'not important, next year' approach, which ultimately leads to the abandonment of the course. We would like to mention that even in the social situation mentioned below (working alongside studies), we may never meet the student. The lecturer does not have the time or resources to contact all students who are permanently absent and offer them a tailor-made solution to complete the course. See proposed solutions.

2. Changing social context

Today's students grow up in a different social and cultural context than their peers up to ten years ago. Digitalization, instant access to information and the proliferation of online learning have also changed learning behaviour and learner expectations. Traditional face-to-face laboratory education is often unfamiliar to them. The need for quick feedback, the "short attention span" and the multitasking culture make sustained, precise work, which is essential in measurement, more difficult.

3. Work-Study overload

More and more students are forced to work alongside their studies, whether on a part-time or full-time basis. This is primarily due to financial necessity, but it results in a lack of laboratory visits, fatigue, divided attention, and a deterioration in academic performance. The Measurements Lab, which is linked to fixed times, preparations and precise work, is particularly susceptible to this problem.

4. Timetable conflicts

Scheduling conflicts, parallel laboratory times, or late evening lab assignments often lead students to treat the metrology laboratory as dispensable. The priority is logical: students tend to choose a course where attendance is less mandatory or where performance can be replaced more easily.

5. Insufficient basic competencies in public education

One of the deepest problems in technical training is the lack of basic mathematical and physical competencies from school education. Understanding measurement principles, circuit behaviour, error calculations or logarithmic relationships (logarithms are no longer part of secondary-school graduation requirements) is difficult for many students because the theoretical background is not solid. This uncertainty can easily lead to an experience of failure and ultimately to the abandonment of the course.

6. Lack of problem-solving competency

The measurements lab requires not only rote knowledge, but also creative problem-solving. The student will often have to respond to unexpected situations, such as erroneous measurements, malfunctioning devices, noisy signals, or incorrect reported values. Those who do not have the right analytical or deductive thinking tend to freeze and lose motivation as a result of failure.

7. Changing entry requirements, curriculum instability

The continuous adaptation of higher education curricula, the adaptation of the credit system and the introduction of new course structures often create uncertainty. The student does not know what is mandatory, when the lab has to be completed and what prior knowledge is required for it. This curriculum ‘movement’ also generates confusion on the instructional side, so the requirements are not always consistently applied.

8. 8. Curriculum errors and course conflicts

It sometimes occurs that students pass prerequisite courses without fully mastering the material, or that instructors explain theoretical concepts in a different way than the approach we intend to build upon in the measurements laboratory. As a result, students may enroll in the measurements laboratory without possessing the necessary and reliable theoretical background (e.g., a solid understanding of basic electrical engineering). In such cases, interpreting and carrying out the laboratory assignments can be challenging, which may ultimately lead to student attrition.

9. Changing learning habits

The modern student studies differently: relies on short digital content, video sources, and quick search. However, the Lab requires structured, step-by-step thinking. Measurements require patience, accuracy and protocol discipline, which are often lacking in today's students, who are accustomed to an immediate sense of success.

10. Not knowing One's own learning methods

Some students fail not because of a lack of ability, but because of a lack of effective learning methods. They do not know how to process, take notes, repeat or prepare independently for a laboratory. The lack of learning techniques often leads to low motivation and loss of self-confidence.

11. Excessive requirements and limitations

Teachers sometimes impose excessively rigid requirements that do not take into account student heterogeneity. The "everyone does the same" approach does not take into account different prior training, interests and learning background. Such rigid expectations can easily demotivate students who in the end tend to drop the course.

12. Educational diversity and inconsistency

Due to the large number of students, the Measurements course is taught by several instructors, each of whom—within certain prescribed limits—teaches it differently. Divergent evaluation criteria (e.g., for laboratory reports), communication styles, and the misinterpretation or neglect of certain requirements create situations that may be perceived as discriminatory. In courses taught by 'lenient' instructors, students tend to pass with insufficient mastery, whereas courses taught by 'strict' instructors often exhibit a high failure rate. This imbalance undermines the credibility of the instruction and erodes students' trust.

13. Lack of instructor alignment and uniform assessment standards

Although instructor autonomy is a value, certain courses—particularly laboratory-based instruction—require standardized expectations. The absence of uniform requirements, scoring rubrics, and ethical guidelines results in unpredictability, which generates uncertainty and mistrust on the student side. We note that in the case of the Measurements course we are actively working to mitigate these effects through unified grading rubrics, a consistent schedule, and standardized assessment practices.

14. A wide range of assessments and performance checks

The variety of assessment forms—such as preliminary quizzes, on-the-spot pop-tests, laboratory notes, appendices, and measurement tasks—can easily overwhelm students. When these assessment elements do not operate within a coherent and transparent system but appear ad hoc, students may quickly lose motivation due to lack of clarity and increased stress. The subjective nature of evaluation further contributes to dissatisfaction. Meanwhile, other course components tend to be under-assessed.

15. Lack of laboratory familiarity

The Lab is an unfamiliar environment. Some students come without ever having visited the lab – they do not know where the devices are, how the measurement bench works, or what to do and what is not. This creates uncertainty and fear that hinders active participation.

16. Lack of familiarity with the Instructor

The lack of personal contact is also a significant factor. If the student is not familiar with the teacher's style, expectations, communication style, it is more difficult to adapt. The lack of trust between the lecturer and the student often amplifies the fear of error – so the student tends to avoid confrontation and does not come to the lab.

17. Initial attitude: "can suffer through it for a few credits"

Student attitudes are one of the strongest indicators of early school leaving. If the course matter appears from the outset as an 'additional burden' in the eyes of the student, the effort required to complete it appears disproportionate. Such an initial attitude leads easily to leaving the laboratory.

18. Obsolete assets, infrastructure

The ageing of the laboratory equipment stock is not only a technical problem, but also a motivational one. Students come from a digital environment where technology develops rapidly – if they meet 30-year-old instruments in the lab, their belief in the relevance of education is undermined. Moreover, outdated infrastructure increases the likelihood of error and reduces measurement accuracy.

19. Changed interfaces and modes of contact

The modern student expects immediate digital communication. The organisation of the laboratory, the flow of information and its feedback only by traditional means (e.g. a wall notice, e-mail) can easily lead to a loss of information. Consequence of inappropriate communication: lack of information, misunderstanding of deadlines, omitted laboratory.

20. Problems with quantitative assesments

Surveys often do not measure competences, but rather memorised knowledge. The aim of the measurements lab would be to assess practical skills, yet the focus may be on formal error checking rather than understanding. This creates frustration, a sense of unfairness, and reduces the prestige of the course in the long term.

As can be seen from the list, early school leaving is not the result of a single factor, but is the result of a number of interrelated factors. Motivational, infrastructural, curriculum, teaching and student factors play a role in ensuring that a student reaches the successful completion of the course. It is important to stress that systemic solutions should be sought rather than individual culpability.

4 Possible solutions to the identified causes

Student dropout, whatever its deep roots in the education system, is not an unchanging phenomenon. Our experience, analyses of recent decades, and modern educational methods have shown that effective institutional, teaching, and student cooperation, deliberate organisation, and the smart use of technological opportunities can significantly reduce the problem. However, achieving meaningful change requires commitment and adaptation from all stakeholders: pedagogical renewal from lecturers, greater responsibility and engagement from students, and a more flexible organisational and infrastructural framework from the university. Building on the twenty-one reasons presented in the previous chapter, possible solutions, proposals, and directions for improvement are set out below. [4] [5] [6] [7]

1. Addressing the lack of active involvement – strengthening motivation

The key to increasing student activity is to enhance student motivation. This requires emphasising the relevance of the laboratory: at the beginning of the classes, the instructor should briefly outline how the laboratory tasks relate to real industrial practices. It is advisable to introduce “engineering exercises” where students solve simulated industrial problems. Gamification elements (e.g. measurement challenges, point collection, ranking lists) can also be used to foster greater individual accountability. Out-of-lab activities – online preparation, short preliminary questions – also increase engagement.

2. Adaptation to changing societal contexts

Education should align with the learning habits of the generations of students (generation Z). To this end, the active use of the lab-related digital learning environment (LMS, Moodle, Teams) is essential. Video demonstrations, interactive notes, and online measurement guides for laboratory tasks help students prepare, reducing uncertainty. In-person education can thus focus on problem-solving, not on basic explanations, if students review these materials. Unfortunately, in many cases this is not even the case, so even if the trainer is trying to adapt, these efforts may still fall short.

3. Reconciling work and learning

Supporting students who study alongside employment is also the university's social responsibility. Flexible management of laboratory schedules, provision of make-up opportunities, and the introduction of online laboratory simulations where the student can use virtual tools and platforms are recommended. In addition, there is a need to balance students' workload – the course requirements should be designed taking into account realistic time commitments. Students who are permanently absent should be contacted by a dedicated faculty-level team and jointly identify joint solutions to prevent course withdrawal. (This is already the practice of leading Western universities – which can directly contribute to reducing student dropout.)

4. Solving timetable problems

At the level of the study system, timetable conflicts should be prevented. Centrally coordinated management of laboratory schedules and communication between lecturers are essential. Involving students in the design of schedules (e.g. through a preliminary survey) increases the willingness to participate.

5. Strengthening core competencies

Gaps resulting from prior educational preparation need to be filled with catching-up courses. The online module 'Preparatory measurements' should be introduced to cover basic physical, mathematical, and statistical concepts. This may be complemented by a self-assessment test to help the student assess their own competence.

6. Developing problem-solving competence

In the lab, students should not receive predefined solutions, but rather engage in self-directed analysis. To support this, a methodology for "measurement incidents" should be introduced, in which students receive deliberately erroneous measurement data and their task is to identify the cause of the error. This also improves analytical thinking and engineering reasoning.

7. Curriculum stability and communication

Frequent curriculum changes make requirements difficult to follow. Advance communication and standardised documentation are important: curriculum changes should be presented annually in a single faculty forum and communicated to students in a clear and accessible manner. Transparency creates a sense of security.

8. Handling curriculum inconsistencies and course conflicts

A precise review of course prerequisites and dependencies is essential. The measurements laboratory should be accessible only to students who have successfully completed all required prerequisite courses. In addition, coordination meetings among instructors should be organised to ensure alignment between theoretical instruction and practical laboratory content.

9. Adapting to learning habits

It is possible to keep modern students engaged with brief, focused, visually rich teaching materials. The lab-related micro-contents – short videos, infographics, tips – help support independent preparation. The role of the instructor in the lab thus becomes a facilitator who supports rather than merely assesses the learning process.

10. Development of learning techniques

Universities and educators should support the development of learning-methodology competencies. Within the context of the course, a short introductory module or workshop would be useful to show how to effectively take notes, take structured notes, and perform error calculations. Learning to learn is as important as measuring itself. The F-curriculum includes several courses in the first and second semesters. There is limited evidence regarding its effectiveness, but it should play a clear role in developing learning techniques, including the use of AI-enhanced technologies.

11. Balancing requirements and flexibility

Course requirements should be clear yet adaptable. The objective is not ‘selection’ but competence development. It is advisable to introduce a requirements template for instructors, which provides guidance while still allowing for pedagogical creativity. Differentiated assessment practices may be applied, taking into account individual rates of student progress.

12. Reducing instructor inconsistency

It is beneficial to organise joint methodological workshops for instructors teaching the course, in which evaluation criteria, communication policies, and expectations are aligned. A shared approach helps harmonise the quality of instruction and reduces perceptions of unfairness.

13. Establishing a uniform set of requirements and a Code of Ethics

A department-level code of ethics and professional conduct can support greater consistency. Such a framework should include principles of assessment, guidelines for instructional behaviour, and provisions for the protection of student rights. A unified system increases transparency and predictability in the course.

14. Standardising accountability and evaluation

Instead of relying on a wide variety of assessment formats, a competence-based assessment model should be introduced—one that evaluates not only theoretical knowledge but also practical skills, problem-solving abilities, and autonomous work. Assessment should be transparent, with a predefined scoring scheme for each laboratory measurement task.

15. Development of laboratory familiarity

A "laboratory introduction session" should be held at the beginning of the semester, where students learn about tools, rules, and the working environment. A short interactive tour or video overview reduces anxiety and increases comfort. It is important to note that if students were to visit the laboratory under the 'knowledge' component of another course early in the academic year, the frustration resulting from a lack of laboratory-specific knowledge could be significantly reduced.

16. Teacher knowledge and communication

Strengthening interpersonal interaction is essential. The presentation sessions at the beginning of the semester, where the instructor shares their professional experience and expectations, build trust. Empathy, supportive communication, and regular feedback from the instructor are key. As a result, students feel they are partners in the learning process.

17. Change Initial Attitude

The assessment of the course should be shaped during the first session. The relevance of the measurements lab should be illustrated with real industrial examples: how it appears in everyday technology, automation, medicine, or energy. If the student feels valued, their attitude is likely to be more positive.

18. Development of infrastructure

MODERNISATION OF THE LABORATORY EQUIPMENT IS ESSENTIAL. Modern, computer-driven instruments, AI-based data processing systems, and digital labs increase not only efficiency but also student motivation. It is also important to maintain laboratory hygiene and the physical environment: an orderly, modern space conveys professionalism. It is an acknowledged challenge that we are lagging behind in this area. (e.g., regular cleaning in the laboratory is required; otherwise, only waste bins are emptied for weeks, which is unacceptable.)

19. Modernisation of communication channels

The communication platforms used by students (WhatsApp, Messenger, Discord) should be integrated into the educational process. The laboratory information, deadlines, and evaluations should be available in a single interface. Prompt notifications help prevent loss of information.

20. Rescaling accountability

The final evaluation of the laboratory should be competence-based and reflective. Students should not only provide measurement results, but also assess their own performance: what they did well, where they made mistakes, and what they learned. Such self-reflection tasks promote deeper learning and help reduce purely formal forms of failure.

Conclusion

If the solutions described above were to be implemented systematically, the measurements lab would have a completely new face. Students would not experience the course as a burden, but as a challenge. Educators would work with a common methodology, a motivating environment and modern tools, while the chair and university would operate a flexible student-centred system. The Lab would not be an intimidating but an inspiring space: a real engineering workshop where students can safely make mistakes, learn from each other and educators. Collaborative education would restore the prestige of engineering education and students would leave university as competent, autonomous and creative professionals. Although early school leaving is a complex problem, the solution lies in the community – where teachers, students and institutions work for a common goal: to ensure that knowledge is not lost but grows.

Authors' Declaration

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