The Cost of a Laboratory Programme

Why a Science Degree Cannot Be Taught Cheaply

Sofia Marchetti

Sofia Marchetti, Dipartimento di Ingegneria Meccanica e Aerospaziale, Politecnico di Torino, Turin, Italy

The price that a funding formula pays for a student in engineering is a multiple of the price it pays for a student in history, and the multiple is smaller than the difference in cost. This article examines the economics of a laboratory programme: the four cost drivers that a formula does not capture, the group size that determines whether a laboratory teaches anything, the equipment whose life is shorter than a degree, the technician who is the most valuable and least counted member of staff, and the safety and accreditation obligations that arrive without a budget. It argues that a laboratory programme is either funded at its cost or delivered as a demonstration, and that a system which funds it as a demonstration has produced graduates of a lecture about engineering.

Contents **Page**

1. The Multiple and the Cost **44**
2. Four Cost Drivers **44**
3. The Group Size **44**
4. The Equipment and Its Life **45**
5. The Technician **45**
6. The Safety and the Accreditation **46**
7. The Data **46**
8. The Digital Substitute **47**
9. The Small Programme **48**
10. The Industry Partnership **48**
11. The Teaching Load **48**
12. The Report and the Assessment **49**
13. The Space **49**
14. The Comparison Across Disciplines **50**
15. The Graduate Who Cannot Practise **50**
16. The Sequence of a Reform **51**
17. Conclusions **51**

1. The Multiple and the Cost

Every funding system in Europe pays more for a student in a laboratory discipline than for a student in a classroom discipline, and the multiple is justified by an intuition rather than by a calculation.

The intuition is correct: a laboratory programme consumes equipment, consumables, technicians, space and staff time in a quantity that a lecture programme does not. The multiple in use, however, was set in a period when the equipment cost less and the cohorts were smaller, and it has been adjusted by negotiation rather than by accounting.

The consequence is that the most expensive programmes are cross-subsidised by the cheapest, and the cross-subsidy is called a university. The instrument is a cost calculation by programme, from the accounts, with the four drivers of this article separated, published and used to set the multiple.

2. Four Cost Drivers

The cost of a laboratory programme is produced by four drivers, and a formula that treats them as one produces an average that fits no programme.

The first is the group size: a laboratory session of sixteen students with one supervisor costs four times a session of sixty-four in a lecture hall. The second is the equipment: an apparatus that costs fifty thousand euros and serves a hundred students a year is a cost of five hundred per student, and an apparatus that is obsolete in five years is a cost of a hundred more.

The third is the consumable: the reagents, the specimens, the components that are used once and bought again. The fourth is the technician: the member of staff who maintains the equipment, prepares the session and supervises the safety, whose cost is fixed and whose work is invisible to the formula.

3. The Group Size

The group size of a laboratory is the variable that determines whether the session teaches a competence or demonstrates a procedure.

In a group of eight, a student performs the operation with her hands and receives the correction of a supervisor who sees her. In a group of thirty, she watches a demonstration and reproduces a protocol that someone has prepared. The two sessions are called a laboratory and only the first produces the competence that the programme claims.

The consequence is an expansion of the cohorts that is funded at the price of the demonstration. The instrument is a maximum group size stated in the accreditation of the programme, with the number of the supervisors and the equipment per group, and a rule that a cohort above the maximum is taught in two groups or not admitted.

4. The Equipment and Its Life

The equipment of a laboratory programme is depreciated over a period that is shorter than the working life of the graduate who is trained on it.

An apparatus is current for five to seven years, it is maintained for ten, and it is replaced when the maintenance exceeds the value. A programme that buys equipment from its annual income replaces it in a cycle of crisis rather than in a cycle of investment, and the crisis is met by a reduction of the practical work.

The instrument is a capital plan of the programme, with the life of each apparatus, the cost of its replacement and the year in which it falls due, funded through a separate line rather than from the teaching budget. A plan of that kind converts a crisis into a schedule and it permits a ministry to see the year in which the bill arrives.

5. The Technician

The most valuable member of the staff of a laboratory programme is the technician, and she is the member whose work no indicator counts.

She prepares the session, maintains the equipment, orders the consumables, supervises the safety and teaches the student who has broken something at four in the afternoon. Without her the laboratory closes, and her post is the first to be cut in a budget reduction because it produces no publication and no course.

The instrument is a ratio of technicians to laboratory places, stated in the accreditation, with the ratio applied to the funded places. A ratio of

one technician to eighty places is the difference between a laboratory that works and a room with equipment in it.

6. The Safety and the Accreditation

The obligations of safety and of professional accreditation arrive with the laboratory and they arrive without a budget line.

A programme that is accredited by a professional body must maintain the hours of practical work, the qualifications of the staff and the state of the equipment, and an inspection verifies the three. The obligations are the cheapest part of the cost and they are the first to be met from the teaching budget when the total is short.

The consequence is a programme that meets the obligations until the year in which it does not, and loses the accreditation that its graduates need. The instrument is a separated line for the compliance work, with the hours of the staff who maintain it counted, and a statement of the cost of the accreditation in the annual report of the programme.

7. The Data

A system that funds laboratory programmes can compute four figures from the accounts, and the four are the basis on which the multiple should be set.

The first is the cost per student place by programme, with the four drivers separated. The second is the ratio of the students to the supervisors in the practical sessions, by programme. The third is the age of the equipment against its expected life, by laboratory. The fourth is the ratio of the technicians to the laboratory places.

The four are available in every institution and they are published almost nowhere. Their publication is the instrument through which a formula can be corrected with the evidence of the institutions that operate it.

Driver	Nature	Instrument
Group size	Recurrent	A maximum in the accreditation
Equipment	Capital	A replacement plan with its years
Consumables	Recurrent	A cost per student per session
Technician	Fixed	A ratio to laboratory places

Table 1 Four cost drivers and the instrument each requires

8. The Digital Substitute

The digital simulation of a laboratory is offered as a substitute and it is an instrument of a different kind.

A simulation permits an experiment that is dangerous, expensive or slow, and it teaches the model of a phenomenon with a clarity that a bench does not. It does not teach the competence of the hand: the calibration, the contamination, the noise, the failure of an apparatus under the fingers of the person who operates it.

The consequence is a programme that teaches the model and calls it the practice, and a graduate who has never broken anything. The instrument is a stated proportion: the simulation is used for what it does better, the bench for what only the bench can do, and the proportion is a decision of the programme recorded in its description.

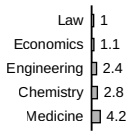


Figure 1 Cost per student place by programme, relative

9. The Small Programme

A laboratory programme with twenty students is more expensive per place than one with two hundred, and the difference is not a difference of efficiency.

The equipment is the same, the technician is the same, the laboratory is the same, and the fixed cost is divided among a tenth of the students. The consequence is that the small programme is the first to be closed in a consolidation, and the closure removes the only provision in a region.

The instrument is a funding of the fixed cost of a laboratory programme irrespective of the cohort, with a minimum size for the maintenance of the accreditation. A rule of that kind costs the system less than the closure of the programme and it preserves a capacity that cannot be reconstituted quickly.

10. The Industry Partnership

The part of the cost that industry can meet is the equipment that it manufactures and the problems that it needs solved, and the partnership is more limited than the policy assumes.

A company will lend an apparatus in order to have a cohort trained on it, and it will not pay for the technician who maintains it or the consumable that the students use. The consequence is a partnership that supplies capital and leaves the recurrent cost to the institution, which is the larger part.

The instrument is a negotiated package: the apparatus, the training of the technician and a contribution to the consumables for the period of the loan, with the conditions stated in a contract. A package of that kind converts a donation into a partnership and it prevents the gift that costs money to receive.

11. The Teaching Load

The teaching load of a member of staff in a laboratory programme is heavier than the hours of the timetable suggest, and the model does not count the difference.

A session of three hours requires the preparation of the apparatus, the supervision of the safety, the marking of a report per student and the maintenance of the equipment in the days between. The four are the practice of the discipline and they are recorded nowhere.

The instrument is a multiplier for the practical teaching in the workload model, stated in the agreement with the staff, with the preparation and the marking counted separately. A multiplier of two for a laboratory hour is a decision about the cost of the programme and it is taken, at present, by the goodwill of the teachers.

12. The Report and the Assessment

The report of a laboratory session is the instrument through which the competence is assessed, and it is the part of the programme that generative systems have made most difficult.

A report that describes a protocol and a result can be produced from a manual and a data set that a colleague supplies. A report that requires the observation of what happened at the bench — the anomaly, the deviation, the failure — can only be produced by a student who was there.

The instrument is a report designed around the observation: three questions about what the student saw that the protocol did not predict, and a defence of the answers in the session. The design costs an hour of the teacher's time and it makes the practical work the evidence of the laboratory.

13. The Space

The space of a laboratory is the cost that the formula of most systems attributes to the building and that the programme experiences as a constraint.

A laboratory that serves a cohort of a hundred and twenty requires a bench per two students, a fume cupboard, a store and a room for the preparation, and the four occupy a floor that a classroom does not. The consequence is a space per student that is a multiple of the institutional average, and a utilisation rate that the estate department reads as inefficiency.

The instrument is a space standard for the laboratory programmes, stated in the estate plan and funded in the capital allocation. A standard of that kind prevents the conversion of a laboratory into a lecture room in a year of enrolment growth, which is a decision that costs a decade to reverse.

14. The Comparison Across Disciplines

The comparison of the cost of programmes across disciplines is politically difficult and it is the foundation of any honest funding system.

A programme in medicine costs a multiple of a programme in law, and the multiple is not a claim about the value of the two to society. It is a statement about the resources that the formation requires, and a system that does not fund the difference funds the cheaper programme at the expense of the dearer one.

The instrument is a published cost per place by discipline, with the drivers, accepted by the conference of rectors and used in the allocation. A publication of that kind makes the cross-subsidy visible and a visible subsidy can be a policy rather than an accident.

15. The Graduate Who Cannot Practise

A laboratory programme that is delivered as a demonstration produces a graduate who holds a degree and cannot perform the operation that the degree names.

The consequence is visible in the first year of employment: the employer who receives the graduate provides the practical training that the programme was meant to provide, and the cost is transferred to the employer and to the graduate. A system that has saved on the laboratory has spent on the training.

The instrument is an assessment of the practical competence at the end of the programme, conducted on the bench, by an examiner who is a practitioner, with the result published for the programme. An assessment of that kind is the instrument through which a programme learns whether its laboratories taught anything.

16. The Sequence of a Reform

An institution that decides to fund its laboratory programmes at their cost can do so in a sequence, and the sequence begins with the calculation.

The first step is the cost per place by programme, with the four drivers. The second is the maximum group size and the ratio of the technicians, written into the accreditation. The third is the capital plan with the years of the replacements. The fourth is the multiplier for the practical teaching in the workload and the separate line for the compliance work.

A sequence of that kind takes three years and the first step is a table that the finance office can produce from its own accounts. A reform that begins with a new price per student produces a negotiation and leaves the drivers unexamined.

17. Conclusions

A laboratory programme is either funded at its cost or delivered as a demonstration, and a system that has chosen the second has produced the graduates of a lecture about engineering.

Three conclusions follow. The cost must be computed: the four drivers separated, the cost per place by programme published, and the multiple of the formula set from the accounts rather than from a negotiation. The capacity must be protected: a maximum group size and a ratio of technicians in the accreditation, a capital plan with the years of the replacements, a minimum size for the small programme, and a space standard in the estate plan. And the competence must be assessed: a practical examination on the bench at the end of the programme, conducted by a practitioner, with the result published.

An institution that has done the three knows what its laboratories cost and what they teach. An institution that has done none of them has a room with equipment in it and a timetable that calls the session practical.

References

[1] Marchetti, S. (2023). The economics of laboratory teaching in Italian engineering education. Turin: Politecnico di Torino Press.

[2] European University Association (2021). The cost of teaching: disciplines and funding. Brussels.

[3] Higher Education Funding Council for England (2019). The costs of teaching in higher education. Bristol.

[4] OECD (2022). Resourcing higher education: challenges and responses. Paris.

[5] Jongbloed, B., & Vossensteyn, H. (2016). University funding and student funding: international comparisons. Oxford Review of Economic Policy, 32(4).

Biography:

Sofia Marchetti is a researcher at the Politecnico di Torino working on the costs of laboratory teaching, engineering education and the funding of expensive programmes.