Teaching Electricity and Magnetism in electrical engineering curriculum: applied methods and trends

Joaquín Mur, Antonio Usón, Jesús Letosa, Miguel Samplón, Sergio Artal

Electrical Engineering Department, Escuela Universitaria de Ingeniería Técnica Industrial, University of Zaragoza, María de Luna 3, 50018 (Spain).

Scope

- Share the experience of teaching fundamental concepts in Electromagnetics to freshmen:
  - Smooth changes from 1995, as adapting the course to the level of the incoming students, changes to increase motivation through real world applications and lowering the mathematical skills demanded.
- Methods with pedagogical advantages.
- Methods more suitable to the new European higher education environment convened in Bologna ➔ new curriculum and syllabus.

Introduction:
Zaragoza University

- Public university: 70% of its budget, € 188 700 000, coming form the national or regional budget.
- 2796 professors and lecturers (62% of them are civil servants).
- 1344 management and administration staff (84,5% of them are civil servants).
- 31 short cycle degree programs, 24 long cycle degree programs.
- 37258 undergraduate students (48,9% in short cycles, 51,1% in long cycles).
- Yearly cost of tuition and fees is around € 787.

Introduction: Industrial Engineering Tech. College

- 3700 short-cycle students, 169 professors and lecturers, 31 management and administration staff.
- Electrical, Mechanical, Chemical, Electronics and Industrial Design Engineering degrees.
- Its relation with the industry is low but it has strong links with the Professional Association of Industrial Technical Engineers.

Introduction: Electricity and Magnetism

- Two-semester course, 334 students
  - 3 weekly hours of regular classes for theory and conceptual applications (90 hours).
  - 1 weekly hour of regular classes for problem solving (30 h)
  - 15 hours of supervised laboratory work.
- Difficult to learn and teach:
  - Abstract and not intuitive concepts.
  - Electromagnetism phenomena cannot be experienced by human senses
  - Electromagnetism theory requires complex mathematical skills

Why and how did we change?

- Generalised complaint from the students about the underlying mathematical burden and the scarce real-world applications, especially from those students coming form vocational training
- Teaching is still based mainly on lectures, with demonstrations and new technologies
- Lecturing requires: wide teaching experience keeping the subject in perspective, good classroom discipline for adequate learning atmosphere.
- Progressive introduction of computer-based teaching

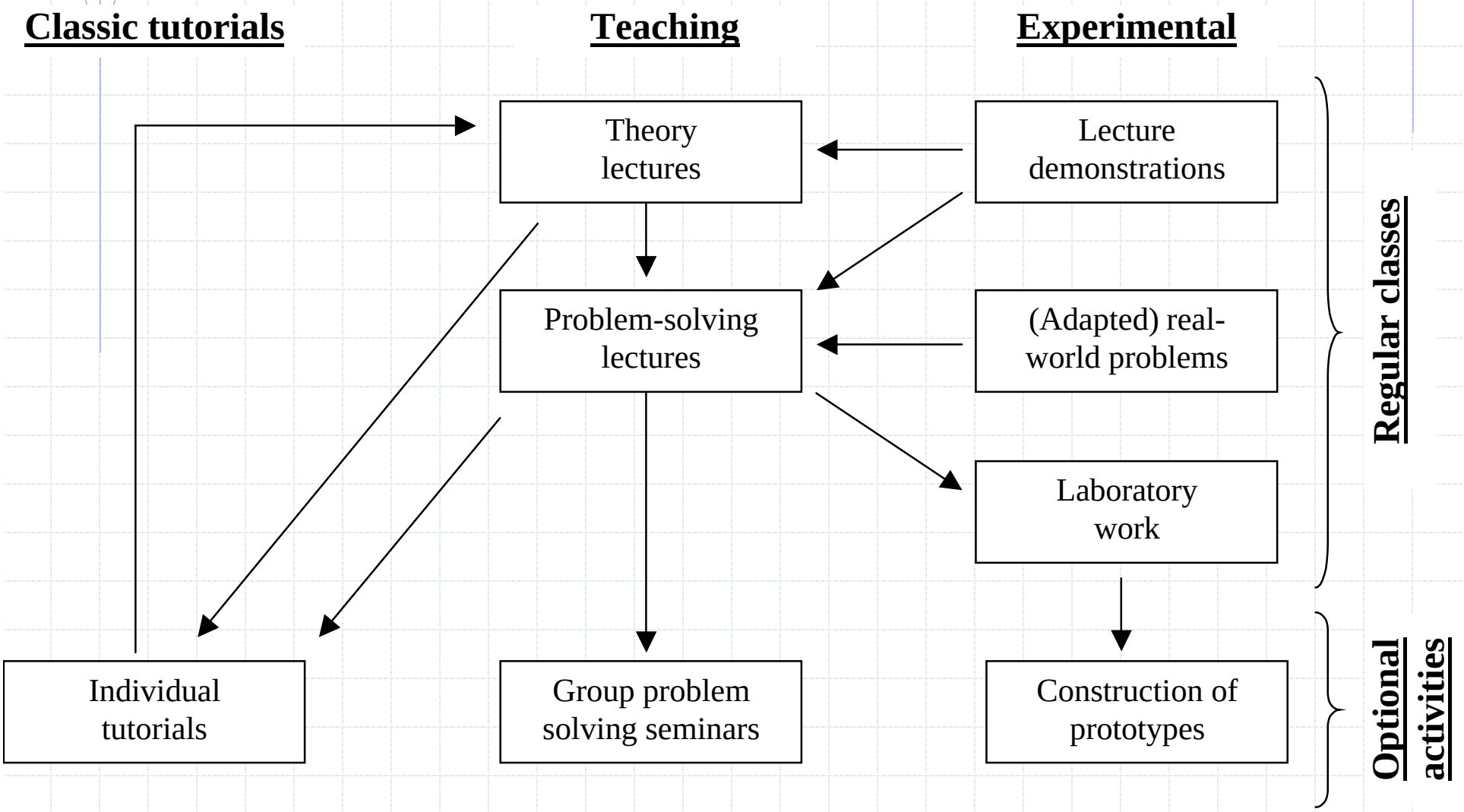
Our Experience Teaching Electricity and Magnetism (I)

- We move from the differential description to the more intuitive integral description.
- Progressive introduction of problems related to real-world engineering applications.
- Include suitable lecture demonstrations←PIRA.
- Optional laboratory assignment (usually construction of prototypes).
- New technologies ➔ excerpts from video collections, visualizations from MIT 8.02 E&M and interactive programs (interactive engagement) ➔ resources are organized in a web page.

Our Experience Teaching Electricity and Magnetism (II)

- Tutorials → optional seminars
  - Balance the initial skill differences among students
  - Test bed for educational innovations in small groups
- Laboratory supervised work restructured
- Systematization:
  - Documents with contents, objectives, assignments, reading list, useful Internet links and study recommendations
  - Estimation of the workload for students and lecturers →European Credit Transfer System (ECTS)

Flowchart of activities

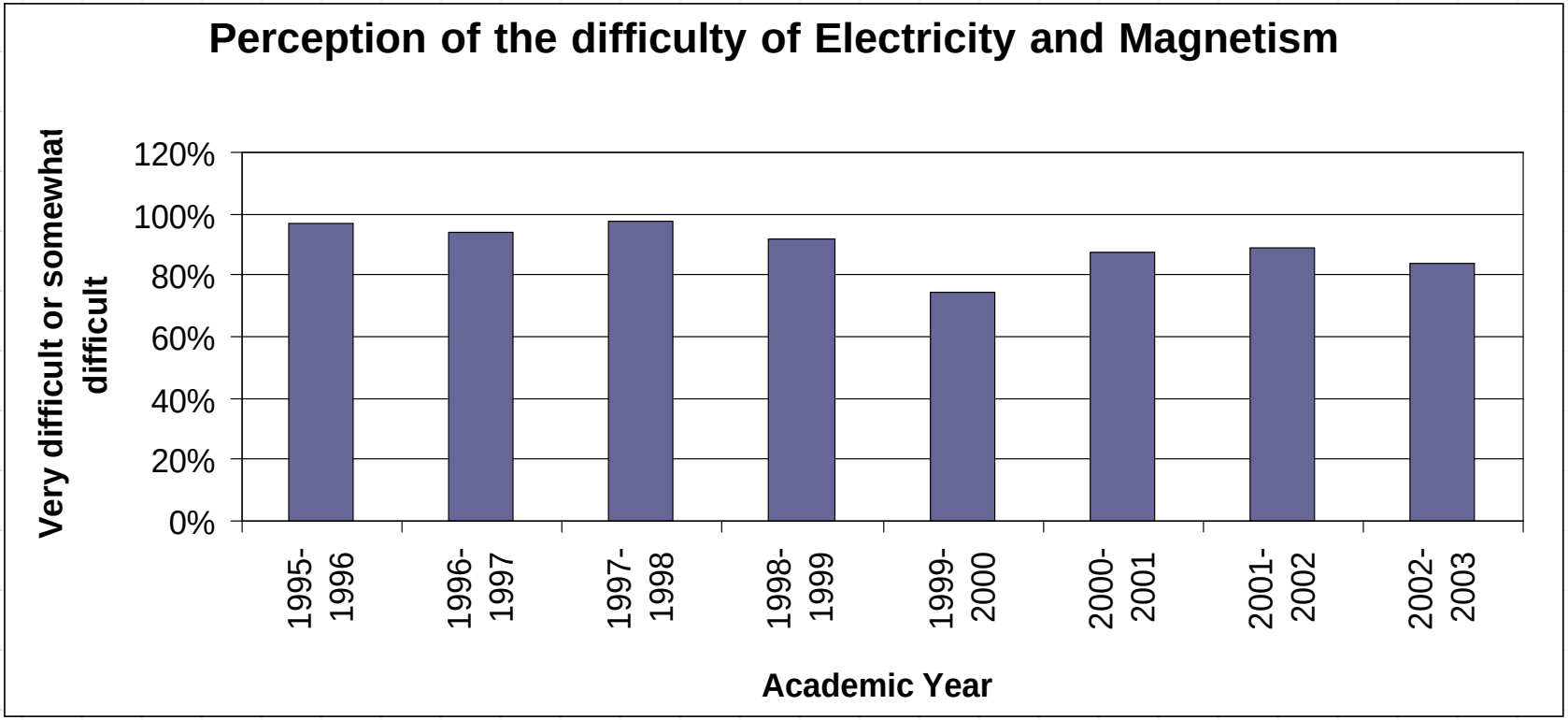


Student and lecturer workload

Student workload	Hours	Lecturer workload	Hours
Attending lectures	120	Lectures (3 groups)	360
Laboratory	15	Laboratory (15 groups)	225
Self study (including seminars)	130	Prep-time	510
		Tutorials	360
Re-sit exam	20	Exams	360
		Other academic training activities	150
Total	285	Total	1965

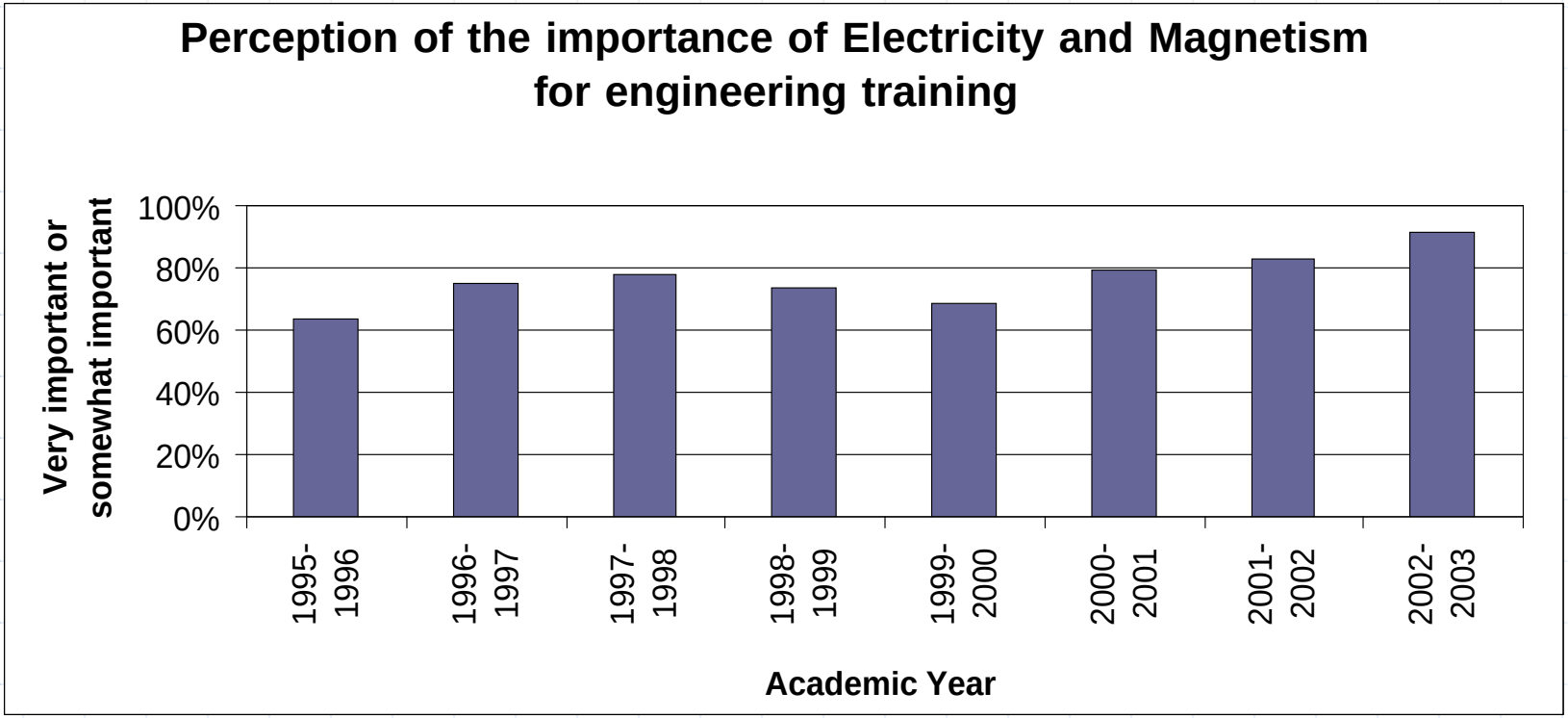
Survey results : Achieved goals ✓

- Students find the concepts of Electromagnetism a little easier although they still consider them rather difficult to learn.



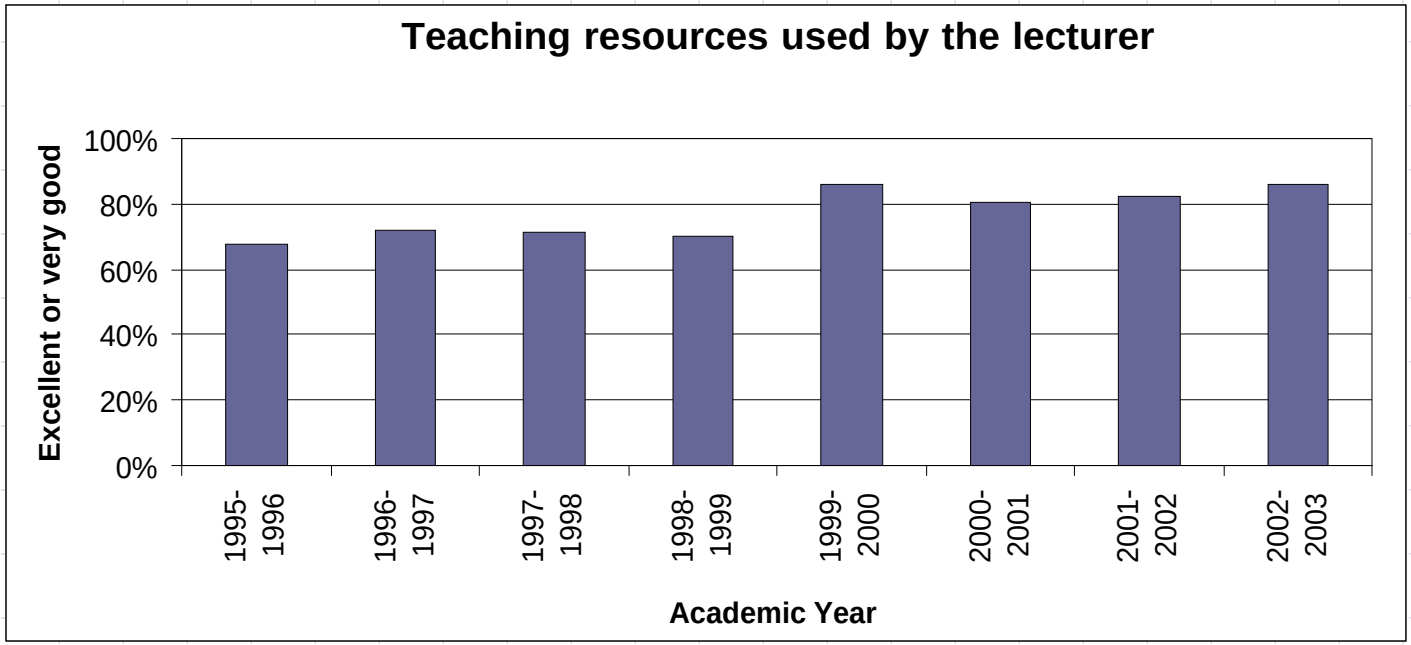
Survey results : Achieved goals ✓

- Students consider Electromagnetism very important for their training



Survey results : Achieved goals ✓

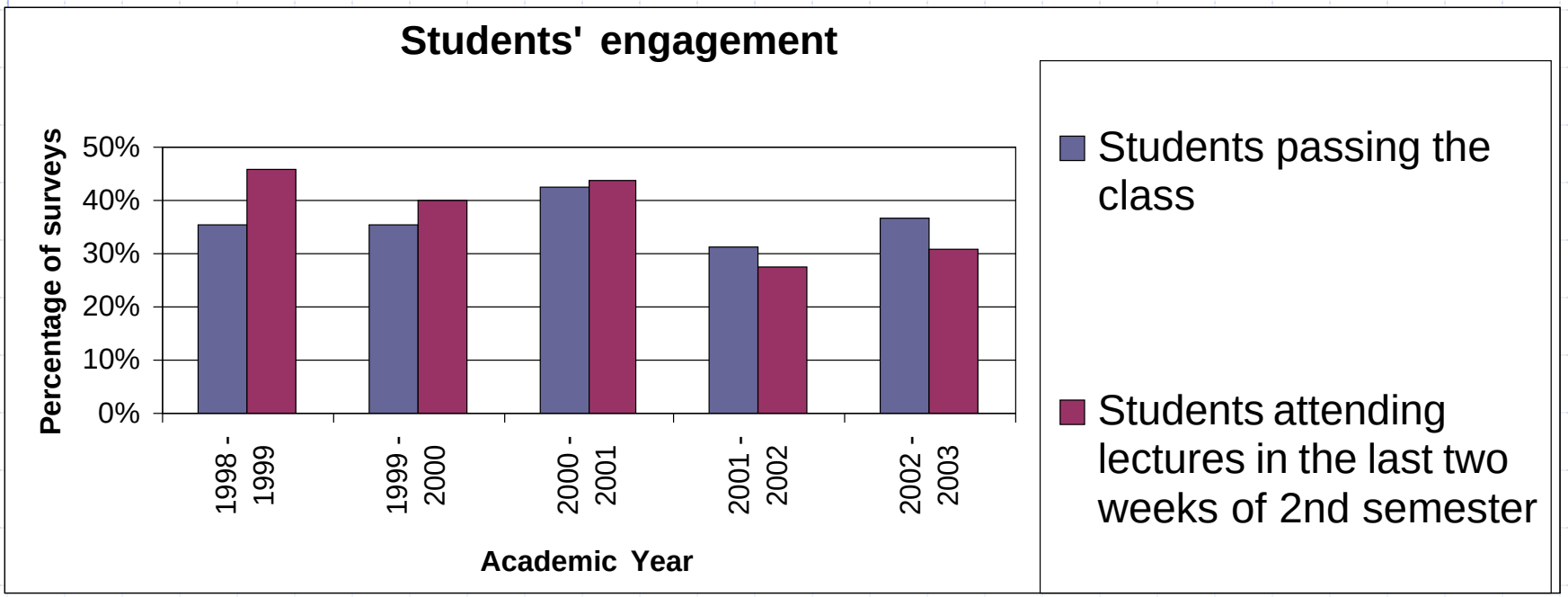
- Students think that the teaching resources have been improved and they are satisfied with the actual level of teaching resources



- Laboratory sessions dedicated only to electromagnetic phenomena have also been very well accepted.

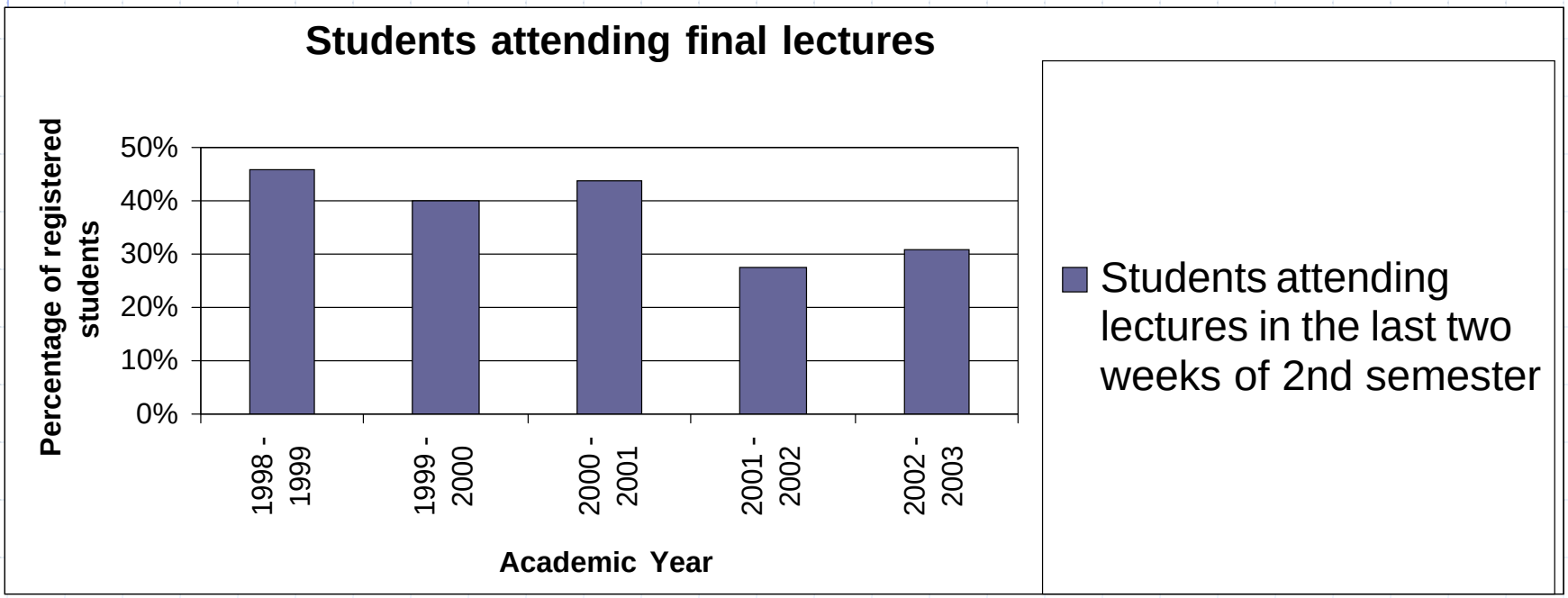
Survey Results: Failures x

- The engagement of the students is still very low as well as the academic results.



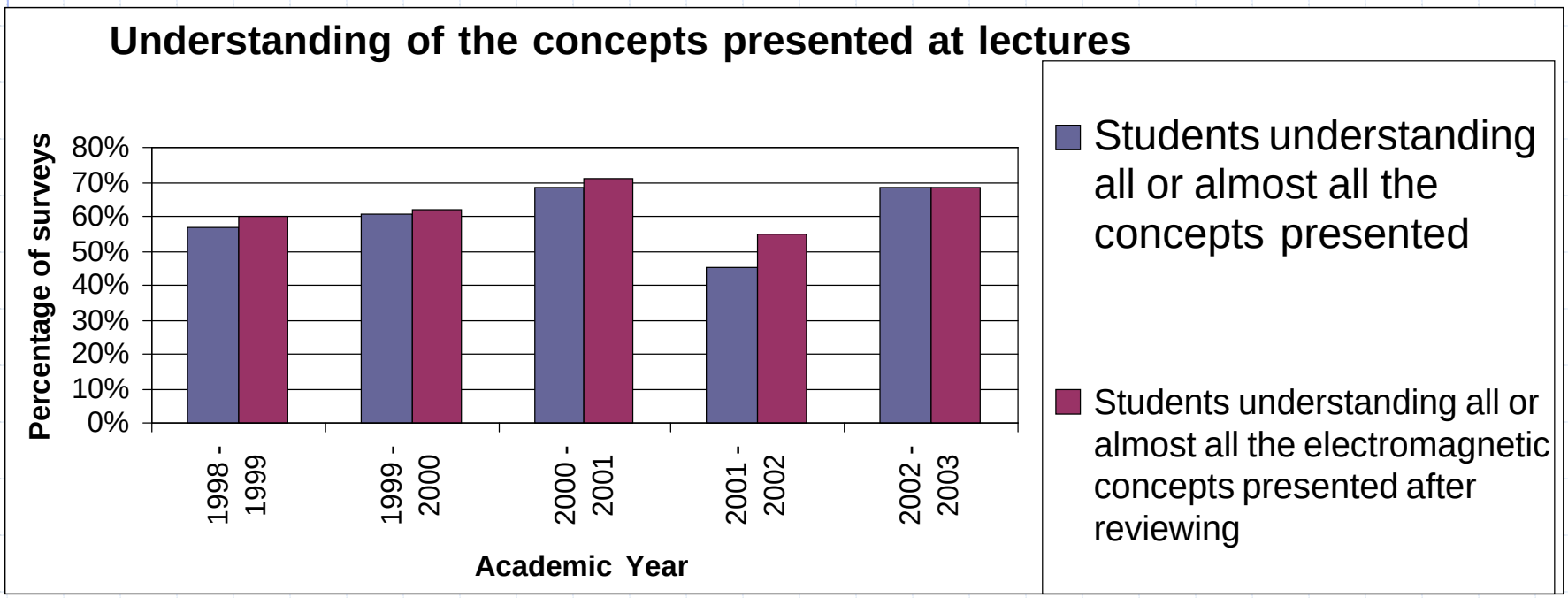
Survey Results: Failures x

- Attendance at second semester is still quite low and has not been increased at all



Survey Results: Failures x

- Students' benefits from conventional lectures have been improved. Nevertheless, higher level could be attained.



- The number of students engaged in voluntary work is extremely low, as it does not reach up to 5% of the registered students

Evaluation x

- Continuous evaluation strongly demanded by the students, not yet implemented due to the high number of students.
  - 3 hour examination at the end of each semester + 3 re-sit exams.
- Importance of laboratory work should be increased (10% of the final mark).
- Voluntary work doesn't appeal to students (10% extra points).
- Academic success is still low (table XII).

Conclusions:

Present situation

- The actual standard required is appropriate for freshmen.
- The low requirements to enrol and to continue in a course, together with the low cost of tuition and fees, can explain the relaxed approach of the students to the subject.

Future improvements

- A compulsory enhancement should be to get the students more involved in the learning process in order to increase their comprehension of the subject.

Conclusions:
Future improvements

- More motivation and better results are required; this might be achieved if students could have closer contact with professional practice.
- More supervised laboratory seminars are needed.
- Additional examinations organised by the faculties should test the initial level of knowledge of freshmen.
- In case the freshmen do not reach the required level, they should undergo an introductory course organised by the faculty.