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Case for action

The following newspaper headlines indicate the situation at our department in 1999 and 2000:

> *Computing flagship in distress*
> Computerworld, January 1999 [86]
>
> *Computing studies havoced by cut-down virus*
> Universitetsavisen, March 2000 [17]
>
> *Brain drain in the computing department*
> Universitetsavisen, March 2000 [18]
>
> *Computing students disappear*
> Computerworld, June 2000 [51].

Briefly, we were in deep trouble until the press found other crises to write about. And our department could revert to normal operations again.

The case for action says why *the company must reengineer.*

–Michael Hammer and James Champy [32, p. 154]

Business context

Customers, competition, and change are *the* three forces which are important to organizations in the marketplace today. These forces have always existed, but have changed and are very different from what they were in the past [32, pp. 20–27]. Competition is international and it intensifies. New competitors do not play by the established rules and are not constrained by their past. They write their own rules while our department is locked up in ancient rules and assumptions. Change occurs constantly and when organizations least expect it. Technology changes the nature of competition in unexpected directions.

Our competitors are no longer the other computing departments in Denmark. The rules of competition are being rewritten by actors who do not respect borders, time, and place. Our new competitors have a global presence and are our primary suppliers of knowledge in our education:

publishers. The Internet enables publishers—in collaboration with some of our international competitors—to offer services which were earlier exclusive to university departments. Tomorrow, students can acquire video lectures on demand whenever they want, from where they want, and as many times they want. Publishers already provide additional teaching material and services in combination with textbooks, and it is a matter of time before publishers provide complete packages for courses in computing, including globally recognized exams.

Some primary schools in Denmark have opted for a different way of teaching by establishing individual learning environments for pupils [4]. These schools no longer provide mass education, but understand the valuable differences of their pupils and provide teaching based on individual preferences. The primary schools are slowly undergoing changes and, in the long run, these changes will affect our department. These pupils will some day become our students fueled with high expectations to teaching which matches their individual needs.

The IT University of Copenhagen established in 1999 attracts a lot of students away from our department, as prognosticated in [86].

The formation of the IT University was spurred by an interest in the Danish government to increase activities within IT in eastern Denmark which has gone far below the activity at the universities in western Denmark. During the years 1992–1996, the growth in research activities in western Denmark has led to 16% increase in the number of jobs in the IT industry compared to 4% increase in eastern Denmark [81]. Danish politicians simply do not have confidence in that the universities in eastern Denmark will give higher priority to IT.

The Confederation of Danish Industries (DI) supported the establishment of the IT University in order to fulfill the increasing demand for educated employees in the IT industry [27]. According to DI, the IT University should provide a versatile education, which combines computing and commercial skills and knowledge, and reeducation for people already working in the industry. Moreover, the IT industry demands masters with an interdisciplinary education in preference to the masters from the existing universities. DI does not write off the existing institutes of IT education in Copenhagen, but proposes that they are strengthened as these institutes must lead the way within IT.

Computing is a vibrant field and has become the defining technology of our age [40, pp. 9–10]. Technical and cul-

tural changes influence the nature of educational processes. New technologies, such as the web, enable distance education and the Internet enables sharing of curricular resources among educational institutions. Furthermore, computing has received greater acceptance as an academic discipline with the entry of computer technology into the cultural and economic mainstream. We have gone from explaining what we do to finding ways to meet the ever increasing demand.

It is imperative that the computing curriculum is attuned to the changes in our society. In 2001, the Joint Task Force on Computing Curricula, assigned by the IEEE Computer Society and the Association for Computing Machinery, published the report *Computing curricula 2001—computer science* [40] which provides a set of recommendations for undergraduate programs in computing. Computing departments abroad have adopted this curriculum or some of its earlier versions.

Business problems

The educational mission of our department is to produce bachelors and masters in computing *and* to offer a subsidiary subject in computing [78]. Our core business is that we *select* an amount of students who want to *study* computing which *takes* either three or five years and *results* in a degree with the desired outcome of *taking up* a job in either the public or private sector. Our students as well as our department hold a stake in the outcome of their education. In order to understand our shared performance, we consider the following measures:

- annual output of bachelors and masters,
- actual study time of bachelors and masters,
- throughput of courses, and
- employment rate of just graduated.

Since 1980 the annual intake has been between 88 and 268 students, but about 200 students between 1991 and 2004 (*see* FIGURE 1). Among the intake during the years 1992–1999, the output of bachelors was 114 before August 2000. The average number of bachelors per admission year from 1992 to 1995 was 26. About 12% of the intake during the years 1992–1995 have received their bachelor's degree. Our target should be that 95% of the selected intake leave our department with a degree.

The prescribed study time of bachelors is three years. Of the 114 bachelors in our student records graduated during the years 1992–1999, the average actual study time of

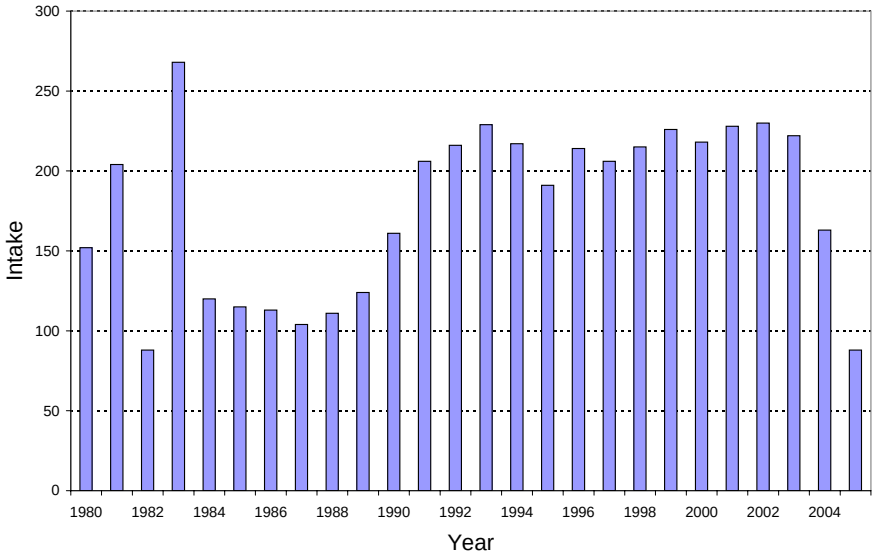

FIGURE 1. The annual intake (as of October the first) of students with computing as their main subject from 1980 to 2005. **Source:** Ministry of Science, Technology and Innovation; University of Copenhagen; [19, p. 28]; and [78, app. 3]

bachelors was 4.2 years or 1.2 years above prescribed time. In total, 17 undergraduate students took their bachelor's degree within the prescribed time during the years 1992–1996. None of the intake from 1997 had graduated as of August 2000 within the prescribed time. Our target should be that 90% of the selected intake make it within the prescribed time.

Our output of masters was 42 per year during the years 1990–2004 (*see* FIGURE 2). Compare this number to the total intake of undergraduates (*see* FIGURE 1). Our target for the output of masters should be 95% of the annual intake of graduates. This reflects closely the anticipation of the respondents in the survey conducted by the Faculty of Science in 1996 [2]: about 90% pursued a master's degree.

The prescribed study time of masters is five years. During the years 1985–1999, the average actual study time of masters was 8.8 years with a high standard deviation [3, p. 30] and was the highest compared to mathematics, physics, and chemistry at our faculty. In comparison, the average actual study time among all computing departments in Denmark was 6.7 years. During the years 1971–1985, the average actual study time of all masters in computing in Denmark was 8.5 years. Hence, while our com-

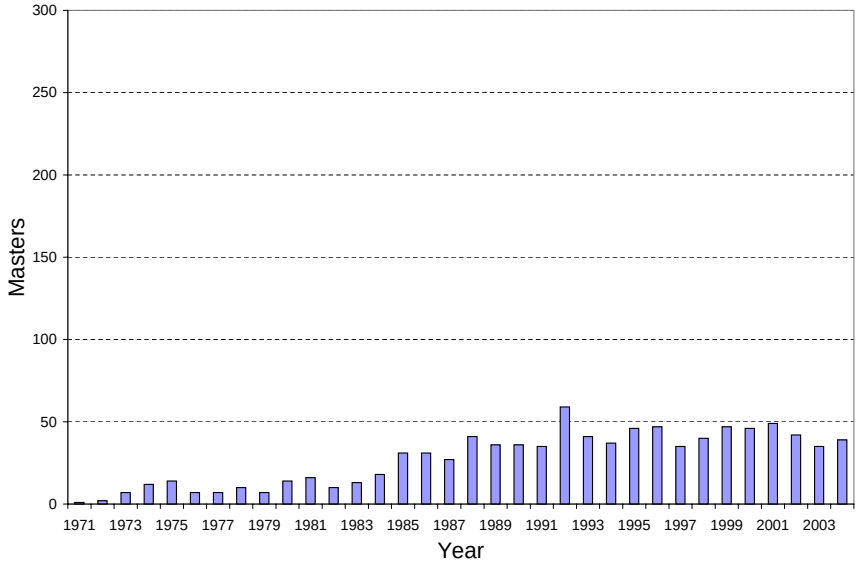

FIGURE 2. The output of masters per calendar year from 1971 to 2004. **Source:** Department of Computing and [3]

petitors managed to bring down the average actual study time with about two years, we have gone up. According to our student records, by the years of admission 1992 to 1995, only 7 students managed to get their master's degree within four to five years.

Roughly one third of the intake never attended the first-year exam and have likely dropped out within their first year (*see* FIGURE 3). For example, of the students among the intake in 1998, 49% have never attended an exam. In 1997, the course team which provided the first-year course was replaced by another team of teachers; the content of the course was changed as well. After these changes the throughput of the first-year course dropped as can be seen from the figure. Because of the other targets, our target for the throughput of courses—after a new form of selection—should be 100%.

dropout [47, p. 12]**:** *a person who has moved to another study program,* or *has discontinued his or her studies*

In our survey, 77% of the respondents at second and subsequent years were occupied within information technology in the private or public sector besides their studies at our department. We take this as evidence that our bachelors and masters are doing well. Our target for the employment rate of just graduated, who will not continue their studies, is 100%.

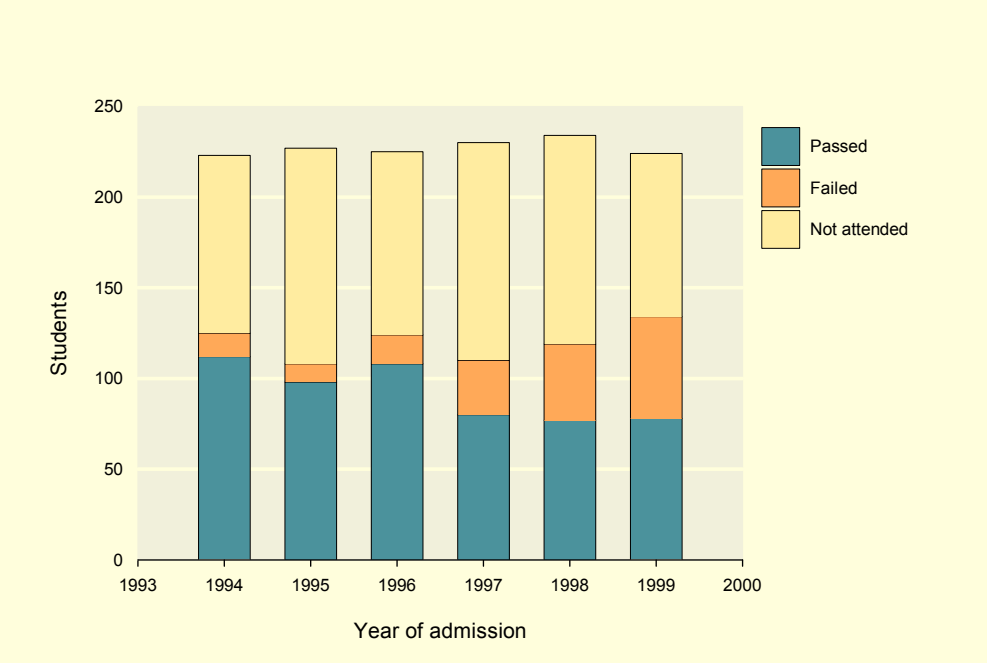

FIGURE 3. Throughput of our first-year course from 1994 to 1999. **Source:** Faculty of Science

To sum up, a high dropout rate and long actual study times are a problem for our department—and for our students. The dropout rate is highest within the faculty and highest among all computing departments in Denmark [86].

The Students' Representative Council at the University of Aarhus has developed a theoretical model to explain dropping out [47]. The model is based on international and national models, and research on dropping out in both colleges and institutes of higher education. The model is characterized by as being simple and generic. It is not the intention to capture all aspects of reality with this model. The purpose of the model is to provide insight into the factors conductive to the decision to leave school before graduating. The model focuses on the first year of study which is justified by two reasons:

1. Statistics from the Danish Ministry of Education document that 56% of dropping out from Danish educational institutions for higher education occurs within the first year of study and 79% occurs within the first three years of study. International research supports the results from the Danish Ministry of Education [47, pp. 12–13].
2. International research confirms that the transition from high school to higher education is demanding (*see* [47,

Key factors influencing dropping out

The six key factors that influence dropping out are:

1. **Intellectual** and **personal resources** influence the chance of completing the course of study. The resources define demographic variables (age, sex, ethnic background, standard of living, relocation prior to study), educational prerequisites (admission grade, previous education, duration from graduation of previous education until enlisted at higher education), private economy (income, financial situation, job situation), family (marital status, children), social contacts (family, friends outside education, time spent with friends, loneliness), knowledge of education prior to start (quality of information about the study life and requirements), and motivation (intrinsic and extrinsic motivation).
2. The **social environment** is a variable that determines the well-being of a student in a social context. The social environment defines contact to peer students (friendship) and teachers (informal contact), social activities (student parties, associations, politics), and physical artifacts conductive to social interaction (canteen, recreational facilities).
3. **Professional environment** is a variable that determines the well-being of a student in a professional context. The professional environment defines the contents (interest and professional expectations), workload, exam and teaching formats (preferences for specific formats, professional and pedagogical competences of teachers), and physical teaching facilities (auditorium, library, computer facilities).
4. **Expectations** prior to admission not fulfilled during the first period of study. Dropping out may indicate whether the actual contents of the education, social environment and/or professional environment meet the expectations of students.
5. **Integration** as a combination of personal contacts, commitment, and a sense of belonging to the higher education.
6. **Negative experience** from exams can influence the decision to drop out. The negative influence is increased if the student was used to high grades in the previous education, but receive lower grades at the higher education.

Source: [47, pp. 28–31]

ch. 3] and the references mentioned therein).

The model assumes that any student at an institute of higher education is attributed with intellectual and personal resources. These resources influence expectations to the social and professional environment. Also, the resources influence experience with exams negatively. The resources, the expectations to the social and professional environment, and negative experiences with exams influence the social and professional integration among students, and satisfaction with the education (*see* BOX *Key factors influencing dropping out*).

A high dropout rate is just the symptom of the problems our department has had for the last three decades and probably will have for years to come. Job opportunities in the industry for students and their inadequate qualifications

are blamed for the high dropout rate [86]. The foregoing six factors are generic, but the Swedish National Agency for Higher Education found that the following eight factors are conducive to dropping out among computing students in Sweden [84, p. 23]:

- Wrong choice of subject.
- Mismatch between expectations and reality. Their expectations do not match the actual contents and the study efforts required. Some students expect an education in the use of computers within economics and science.
- Inadequate prerequisites in mathematics.
- Difficulties with programming. Some students find that programming exercises require more prerequisites than indicated prior to admission.
- Demand of qualified workers in the IT industry.
- Government study grants are stopped due to high income.
- Students cannot complete their subsidiary subject.
- Pedagogical skills of teachers are inadequate.
- The education is used as supplementary training by people working in the industry. Hence, students take a course once in a while.

The same factors are valid in our department too.

We cannot change the intellectual and personal resources of our students. We cannot and should not give high grades to students in order to prevent negative experiences from an exam being the reason to drop out. We can facilitate a social environment and an integration among the students at our department. We can provide as much information to our students prior to admission and in this way enable them to decide whether our department can meet their expectations or not. Our core business is the *professional environment* and this factor makes up *our* stake in dropping out, and it is the one *we* can change. We should ensure that we live up to our part.

Marketplace demands

Customers demand that they are treated individually. The power in the provider-customer relationship has shifted in favour of the customer. Products and services must be designed for the particular demands of customers. The market for mass-produced goods and services simply no longer

exists—in fact it never did. And higher education is no exception.

In our survey, as many as 95% of the respondents found that the projects are a professional challenge; 52% definitely agreed and 43% predominantly agreed on this statement. As many as 91% of the respondents found that the projects are a practical challenge. That is, we have to keep project orientation, which means individual supervision. Also, according to our survey, the students want to choose the required subsidiary subject freely, if this requirement cannot be withdrawn altogether. In the marketplace there is a need for greater diversity and choice, and we have to be able to meet these demands.

Diagnostics

In a newspaper article [86] our department was characterized as a flagship in distress. The article listed several obstacles which make corrective actions difficult:

1. Ph.D. scholarships are limited due to a tough financial situation and continued budget cuts. In addition, as there are few openings as assistant professors, students are not likely to apply for Ph.D. scholarships—as it is evident there is no job waiting for them down the line.
2. Faculty policy requires the department to operate with a large intake despite the fact that many students are not qualified to study computing at all. Moreover, there is general reluctance to let talented students skip their fifth year and begin immediately on the Ph.D. education.
3. Since funding for research projects is cut, the best teachers and researchers go over to institutions where fundraising is easier.
4. The department has some of the best and worst researchers in the country. Unproductive workers were hired in the early days of the department because of a great demand for computing experts in the industry. It was necessary to expand the department fast and for vacant positions there were not always well-qualified applicants. However, the positions are permanent; it is almost impossible to get rid of unproductive workers.
5. The student-teacher ratio is high which means that more resources are to be spend on teaching than on research.

6. The department is less involved in lobby activities directed at the national bodies which fund research and advise politicians in these matters.
7. The department has a variety of active research areas, but it does not renew itself.
8. Our competitors run smear campaigns against our department.

Most of this is true, but where is our own initiative.

We cannot meet our measures of performance due to one simple reason: we have not understood the fundamental requirements of our students—their learning preferences. The outcome of formal education depends so much on understanding student differences in motivation, interests, learning styles, and aptitudes [48, p. 33]. Knowing the learning preferences of students can yield dramatic improvements in the effectiveness of learning [48, p. 5].

We cannot solve our problems through conventional thinking and improve what has long existed. The university has earlier asked us to downsize as a mean of solving financial problems. However, downsizing means fewer people doing the same work and is not an option for us.

Our goal is to achieve dramatic improvements in our key business processes with respect to our measures of performance. This is achieved through reengineering our department—starting all over again—with the insight of the future developments in the marketplace and fundamental understanding of our students. This will lead to new jobs—and simply another way of doing things.

Costs of inaction

In each dropout case there are three losers: the student, educational institution, and society. For the student, the process of withdrawing may be a painful experience marked by low confidence, disappointment, and depression—or it may be a positive step taken with confidence and conviction [13]. Dropping out has as an emotional cost [47, p. 13].

For the educational institution, resources, in terms of time and money, are wasted once the student drops out. Danish universities receive funding based on the amount of credits the students obtain and additional funding per bachelor's or master's degree. The income to cover costs of teaching diminishes.

For the society, dropouts incur a significant cost. The Danish Ministry of Finance quantifies the cost to be the equivalent of an increase in the workforce of 40 000–50 000

people. Moreover, people with a lower education are known to spend eight years less on the labour market [47, p. 27].

If we do not adapt our way of doing business to changes in the marketplace, others will take our business away from us. Publishers will slowly acquire many of the competencies our department has today and deliver teaching through further development in technology. However, we can turn this threat into our advantage.

A merger with the IT University of Copenhagen is an obvious solution and that is likely to be the next major event in the history of our department; it only requires that we do nothing at all.

Vision statement

> **We offer the leading computing education in Denmark.**

Our aspiration is to be the leader in the country as to the schooling of computing experts. Being attuned to the individual needs of our students combined with timely supervision is our task.

> **Nine of ten students finish their education on time.**

We should design and give an education which ensures that nine of ten students complete their studies on time. That is, our education does not produce dropouts.

> **Our computing education is imperative to the future success of our students.**

We should ensure that the best jobs in the industry are filled by masters and bachelors from our department.

> **A job at our department is a challenge as much as an opportunity.**

We should strive to be innovative and effective in everything we do. We should attract and retain the best people by making our department a challenging place to work.

Our name

We must change our way of doing business and we must change our name.

> **Our future name is 'the School of Computing'.**

We do not have a name in Danish for one simple reason: our business is international.

the school must appeal differently to students whose motivations are intellectual, to those whose motives are professional, to those whose motives are social, to those who are conventional, and to those 'not elsewhere classified'.

–Herbert A. Simon [73, p. 267]