On the Future of Computer Science in South Africa: A Survey amongst Students at University

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ABSTRACT

The number of those computer science students, who intend to become academics (scientists or researchers) in their future career, is currently very low, and so is the 'popularity' of the mathematical courses in the CS curriculum. Most CS students of nowadays seem to behold the university as an industrial job training facility rather than a home of science. This situation leads to concerns about the future of academic computer *science* in a late-modern society which is ever more depending on the 'production' of scientific knowledge. This short-paper presents and interprets the results of a recent survey amongst university students in this context, and suggests that those problems may be tackled in the future by means of differently designed curricula for differently motivated students with different prospective careers.

ACM Categories and Subject Descriptors

K.0 [Computing Milieux], K.7 [The Computing Profession]: K.7.1 *Occupations*.

General Terms

Human Factors.

Keywords

Survey amongst students, future of academic computer science, differently designed curricula for differently inclined students.

1. MOTIVATIONS

"Don't blame me for the fact that competent programming, as I view it as an intellectual possibility, will be too difficult for 'the average programmer': you must not fall into the trap of rejecting a surgical technique because it is beyond the capabilities of the barber in his shop around the corner" – Edsger Dijkstra, **1975**.

"The required techniques of effective reasoning are pretty formal, but as long as programming is done by people that don't master them, the software crisis will remain with us and will be considered an incurable disease. And you know what incurable diseases do: they invite quacks and charlatans in, who in this case take the form of software engineering gurus"

– Edsger Dijkstra, **2000**.

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"It is not the task of the university to offer what society asks for, but to give what society needs" – Edsger Dijkstra, **2000**.

Repeatedly I have noticed throughout the years that students in my courses respond to unexpected difficulties or challenges with resistance rather than with curiosity, for example in a recent 3rd-year course about formal semantics [14]. Similar experiences have also been made in the USA where *"students influenced by the difficult job market also question why they need to take subjects that are not directly related to what they will do when they leave college"* [11]. For most of my students nowadays the classical function of a university as a 'house of science' (or a 'republic of scholars'), in contrast to a vocational college or trade school, seems to have become irrelevant. The background of this current international trend was recently illuminated [12]. Specifically for the discipline of CS this phenomenon was predicted already more than thirty years ago: *"Some of the graduates of the recommended program will continue academic work in computer science (...), but most will seek employment upon graduation"* [2] though there was no indication in that document about how small the number "some" would be. The fact that also science itself is a proper profession –as it was explained by Max Weber to the Bavarian students in an invited lecture [13] which the students themselves had organised– seems to have been forgotten by many students of nowadays, for whom 'employment' is per-default associated with the commercial industry. Elsewhere I have already described the measurable effects of those trends with regard to the numbers of academics (scientists and teachers) and the difficulty of staff-recruiting in academic departments of CS and related disciplines [6]. Motivated by those observations and problems I have conducted a survey –see below– the main purpose of which was to determine the proportion of students who would still be willing (against the trend) to serve as the next generation of academics at university. Computing being a technical subject with highly-paid career opportunities outside academia, I have already expected beforehand that only a small number of answers would indicate any inclination towards an academic career. This local and subject-specific situation, however, might possibly differ from the situation in other faculties, such as the humanities, or from the situation in other countries in which the academic salaries might possibly look more attractive when compared against available (or non-available) options outside university.

Within the general theme of SACLA'2015, namely: *"renewing ICT teaching and learning"*, this short-paper contributes to the following called-for **topics**:[*]

- **Renewing curricula**,
- **Renewing teaching-management**.

[*] https://sites.google.com/site/sacla2015/

2. DESIGN OF THE SURVEY

Without revealing the epistemic interests 'behind' the survey, I merely asked the students to voluntarily do a small questionnaire about their future career plans; (permission by the faculty's ethics committee was obtained for this purpose). A sufficiently large cohort of students participated [5]. Copies of the questionnaire paper were handed out at almost the same time in three groups of CS students: one in study-year 2 (undergraduate curriculum), one in study-year 3 (undergraduate curriculum), and one in study-year 4 (the 'honours' curriculum in the South African academic system). Doing the same survey almost simultaneously in groups of different study-years (2, 3, 4) aimed at finding out whether the students' academic age significantly influenced their prospective professional inclination. First-year students were *ex*cluded from this survey under the presumption that very young students would still be too 'disoriented' about their future careers.

To prevent selection-bias the survey was taken in courses that are compulsory for *all* students at the local CS department, such that I would not accidentally 'filter out' the more industrially or the more scientifically oriented students by visiting an elective course. Visiting compulsory courses also ensured the needed number of answers for the sake of reliability. To avoid suggestive-question-biases which are typical for surveys with pre-formulated answer-options, the questions were asked in an 'open' style. The paper itself was structured in the following form:

- **About yourself** (please underline): I am: ♀ *female* / ♂ *male* (including the option not to underline anything),
- **In which profession** OR job OR role OR other activity do you 'see' yourself *immediately after* your degree? (please describe): .....
- **In which profession** OR job OR role OR other activity do you 'see' yourself *several years after* your degree? (please describe): .....

The purpose of the first question was to determine if the students' academic-scientific inclination (if any) had perhaps shifted from the (traditionally) male into the female domain.

For the sake of authenticity the students were given merely *five minutes time* to scribble their answers, such that they would not distort their own 'spontaneous intuition' by spending too much time with rational reflection and re-considerations of the matter during the survey.

3. DATA AND RESULTS

3.1 Raw Data

All answers were gathered at *university* –not: vocational college– in the middle of the South African academic year. Due to shortage of page-space available for this report, the details of the students' anonymous answers have been published 'online' [5], whereby I have slightly compressed longer sentences to their main nouns for the sake of brevity; (for example: a written sentence such as *"I would like to become a software engineer"* is represented in the data sheet [5] by the brief term 'software engineering'). With all the raw data thus provided, the readers of this report can critically re-interpret my findings or discover more subtle trends in the data.

3.2 Analysis and Interpretation of the Data

For the purpose of this short-paper I did not need to look into the all the details of the many possible IT-related career paths, short-term or long-term, which the students have mentioned in their answers [5]. The career paths envisaged by those students are not particularly 'visionary' or 'revolutionary'; they fit well into the usual social norms and conventions of nowadays. Thereby –no surprise– the answers given by the older students were typically somewhat more 'realistic' than the answers provided by the younger students: those were still somewhat more 'tentative' or 'colourful' in parts. Also not surprising in this field of study is the often-expressed desire to eventually leave the technical details of IT-labour behind, in order to become an administrator, manager, director, or employer at a higher level of authority: see Nagl's post-graduation career survey in Germany for comparison [8].

As far as the main problem *–can we effectively produce the next generation of academics in CS?–* of this case study is concerned, it was necessary to watch out particularly for those students who, in their answers:

- aim for the MSc or the PhD degree (even without explicitly mentioning an academic career), or
- aim specifically and explicitly for a profession as academics, lecturers or researchers, (thereby self-understandingly implying the higher degrees).

Moreover, by design of this survey one can distinguish between:

- *short-term* academic ambitions (only for immediately after completion of the BSc degree), and
- *long-term* academic ambitions (envisaged for several years after completion of the BSc degree).

If additionally the students' academic ages (study-year) and ♀/♂ are taken into account, there are many attribute combinations with regard to which the collected raw data sheets can be classified.

As it could have been expected on the basis of [2], the proportion of students without any scientific ambitions was 'overwhelming'. Those students, who wrote that they are planning to study towards MSc or PhD degrees –even if they intend to do so only to competitively increase their own 'market value' for the purpose of climbing up the 'corporate ladder' in the commercial realm– can perhaps still be regarded as 'potential' or 'possible' academics, particularly during times of economic recession when places in the commercial industry are harder to reach. Some of those students might later change their minds and could still become members of the academic community as per second option. Most interesting are, of course, the few students who have clearly indicated already at their young age that they feel 'called' to enter the academic realm. On the basis of the above-mentioned criteria, the following pictures clearly emerged:

A male/female-comparison across all age groups –ignoring those students who did not indicate their ♀/♂ attributes– shows that the commercial-industrial inclination of male and female students is equally strong (Figure 1). However one can also see that within the minority of explicitly academically inclined students the proportion of female students is at least twice as strong as that of their male study-colleagues. It might thus seem that the future of academic CS could be predominantly female; however one must also take into account that the figure shows *percentages* (%). In absolute numbers the cohort of self-attributed male students (110) was still considerably larger than the cohort of self-attributed female students (33) in this survey, i.e.: male CS academics will probably continue to out-number their female colleagues for many years to come. The next picture (Figure 2) shows that, in this survey, there were only small (statistically insignificant)

differences in the academic inclinations of all students across all age groups (2nd, 3rd, 4th study-year). In all groups one can find an almost equally strong desire to go into the commercial industry after graduation, i.e.: in all age groups the minority of scientifically inclined students is almost equally tiny.

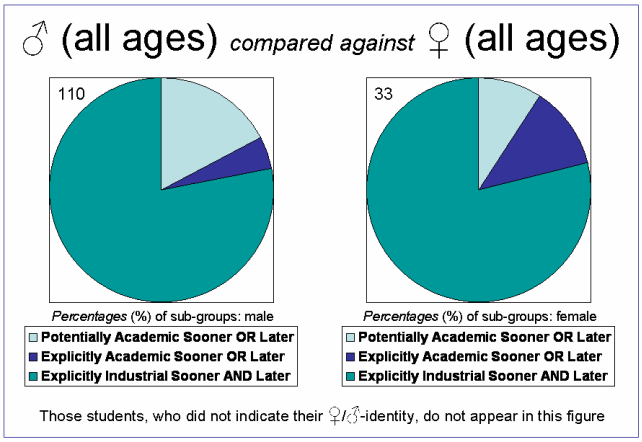

Figure 1. Academic inclination: ♂ versus ♀

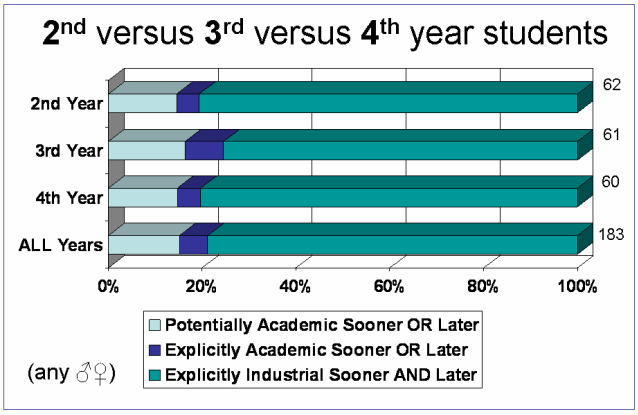

Figure 2. Academic inclination per age groups.

3.3 Independent Corroboration by Other Sources of Information

From a methodological point of view I still had to ask critically whether my findings were sufficiently 'representative', or whether they were merely accidental. To this end I looked for additional *independent* support in the following way:

For 4th-year ('honours') students the local CS department offers a variety of *elective* courses which students are not forced to take. The 'popularity' of different voluntary courses is therefore a good indicator of the students' practical-industrial versus theoretical-academic inclinations. Thereby I *hypothetically correlate* students' inclinations towards mathematical courses with their inclinations towards science in general (as it is also the case in physics and the classical engineering disciplines with their largely mathematical contents). The resulting picture (**Figure 3**) shows that particularly the *mathematical* courses were rather *un*-popular, whereas the less mathematical courses were disproportionately 'overcrowded'.[†]

[†] For data protection reasons I cannot provide the enrollment details of the individual courses, which I have therefore clustered together into those two broad categories of above, "mathematical" and "industrial".

This picture seems to coincide well with the notorious *'crisis of mathematics'* in South African pre-university schools [7], which seems to procreate itself also amongst university students. The enrolment numbers, on which the picture (Figure 3) is based, were taken from the *previous* academic year, *not* from the academic year in which the questionnaire survey was carried out. Thus, at the time of my survey, those students were no longer 'in the system', such that the popularity of those elective modules *independently* corroborates the answers which the later students provided to my future-career survey questions. All in all, the findings seem to indicate that the majority of students considers their university mainly as a provider of practical-industrial skills, whereby the opinion that "mathematics is not necessary for a good IT job" seems to be predominant.

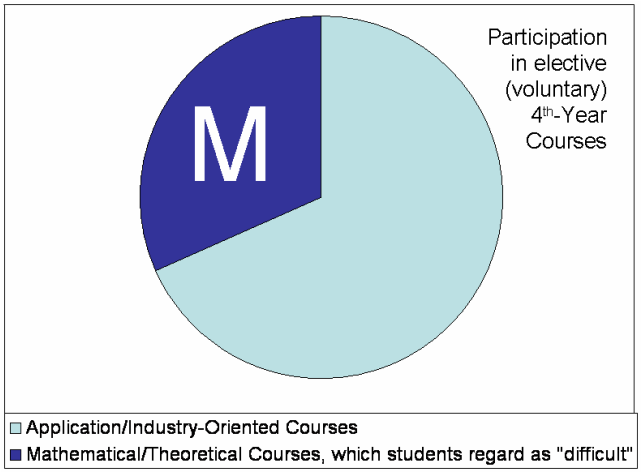

Figure 3. Popularity of elective courses at 'Honours' level.

By the way, this wide-spread anti-mathematical attitude is not only problematic with regard to the future of *academic* CS: it *also* prevents the *industrial* practice of software 'engineering' from 'catching up' with the traditional engineering disciplines and their long-established quality standards [3]. Indeed, the *commercial disadvantage of a shortage of scientificness* in the computing discipline was noticed even by industrialists like Auerbach [1].

4. SUMMARY AND OUTLOOK

All in all my survey indicates clearly that very many local students behold their university as little more than a job-training-centre for the provision of industrially 'useful skills'. The beauty of science, for its own sake, does not seem to play any role in the personal value-systems of those students any more. Moreover: similar to what Peter Seybold had written about the USA [11], also in South Africa many students are financial debtors immediately after having obtained their BSc degrees. Several students had, indeed, added such remarks about their personal financial situations as un-asked footnotes at the bottom of their questionnaire papers; however I did not reproduce those remarks in the published data sheet [5] because they did not fall into the epistemic scope of my survey. For many of those students employment in industry seems to be the most viable option for off-working the burden of their study loans as quickly as possible. Also the public social prestige of wealthy businessmen might possibly be effective as an incentive, particularly for first-generation-students who are newly arising out of hitherto non-academic families. Anyway, whatever the deeper reasons of the described phenomena, at least the following *two questions* arise immediately from the data:

- Does the low percentage of scientifically inclined students in nowadays lecture halls pose any threat against the future continuation of academic computer *science* for its own sake**?**
- Does the strong industrial-practical focus of current CS curricula, which were designed for the benefits of the large majority of industrially inclined students, do *injustice* to the few –nevertheless important– students who nurture more theoretical-scientific career plans for which they would need differently designed curricula**?**

"Related to this is the normative debate about the future of the university. Should we continue to transform our universities into hierarchical corporate organizations fostering an entrepreneurial ethos...? Or should we seek to recover an academic ethos according to which the social legitimacy of science does not derive from its short-term exploitation for private gain...?", asked Hans Radder in a recent book on the modes of contemporary science [10]. In a related discourse also other authors observed an *"increasing emphasis on vocationalism in higher education and instrumentalism in research"* [9]. With the survey reported in this short-paper I have not only demonstrated the *congruence* of local and subject-specific academic issues with the global academic issues that are internationally discussed [9] [10] [12]; I have also highlighted the *problems* which could possibly arise locally for (or rather: against) the development of academic computer *science* in such a social context.

As a solution to the identified problem I can only propose the design and introduction of new, additional, separate, specifically science-and-theory-oriented curricula for preparing –from their very first day at university– a small group of particularly inclined students immediately for their MSc and PhD degrees (and subsequent academic careers) without designated 'exit point' prior to the MSc, whilst the majority of commercially inclined students would still continue to go through their industry-oriented curricula (Figure 4). In such a way one could also avoid the social conflicts mentioned in Section 1, in which particular groups of students rebel against supposedly 'unneeded' curricular topics. Similar suggestions were already published more than ten years ago, and were likewise motivated by the growing need to *defuse* the theory-versus-practice-*tensions* arising from the traditional manners of teaching of CS at universities [4].

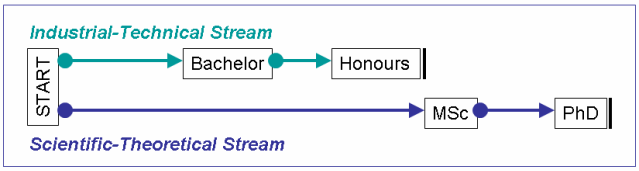

Figure 4. A 'science-first' curriculum for 'theoretical' students.

As far as *future work* is concerned the following three next phases seam to be reasonable and feasible:

- Establish an international special interest group (SIG) for *enhancing the scientification* (and theoretical formalisation) of the traditional CS curricula for especially gifted students,
- *Develop* such a curriculum within the above-mentioned SIG,
- Convince at least one university (anywhere in the world: preferably a small university characterised by organisational 'agility' and flexibility) to run a *five-year pilot study* such as to gain experiences with the novel arrangements,
- *Feed the experiences from the pilot-study back* into the SIG.

5. ACKNOWLEDGMENTS

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