[1]Who shall we put on the postage stamps?

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Abstract

We review the nature of disciplines within the modern university, and the place of Computer Science as an example. Noting the emergence of "notables" in traditional disciplines, we consider the advantages and disadvantages of such pantheons, and who might occupy that of Computer Science. A survey from among the CS community is conducted and summarised, and some remarks presented on the possible uses of the conclusions.

Disciplines

When our country's national Post Office approaches senior Computer Scientists and teachers of Computer Science with a proposal for a series of postage stamps featuring our most influential contributors, who will we choose? Within a discipline, who deserves recognition, and who gets it?

The modern university is usually aligned along disciplinary boundaries, and this has led to studies that characterise the similarities and differences between them. The purpose of such studies is manifold, but includes the establishment of "context within which theories and concepts make sense" (Clark 2003).

In most institutions, the Faculty divides – engineering, science, art etc. – are clear and widely understood, but finer grained and more informative taxonomies exist. Becher and Trowler observe that "a very significant consensus on what counts as a discipline and what does not" exists within universities (Becher and Trowler 2001). This is not to suggest that university political boundaries define the disciplines: rather, they align themselves on the boundaries defined by a wider community of scholars, within which exists a body of knowledge and associated organisational theories and methods.

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The discipline is defined by a combination of social and epistemological characteristics.

Various mechanisms for classifying disciplines have been used. Observation of how researchers operate permits a clustering of like with like (Snow 1964, Pantin 1968), while Biglan has considered the perceptions of practicing academics themselves (Biglan 1973a, Biglan 1973b). He generates two dimensions of "measurement" for disciplines – hard-soft and pure-applied. The former determines the extent to which academics will concur that there is an agreed body of theory within the discipline, while the latter determines the extent to which the discipline is seen as being concerned with practical problems. Figure 1 (after (Biglan 1973a) and (Clark, 2003)) illustrates the accepted placement of some representative disciplines.

These studies of definition are not idle:

> *To talk about academic disciplines, professions. or even manual trades as communities or cultures will perhaps seem strange. Yet communities of practitioners are connected by more than their ostensible tasks. They are bound by intricate, socially constructed webs of belief, which are essential to understanding what they do.* (Brown et al., 1989)

An important part of education is the communication of the culture of the discipline, not just its content. As teachers, we hope that our graduates not only have the necessary knowledge base to operate in their discipline, but also the wherewithal and understanding to assume membership of its surrounding culture: Clark writes that practitioners

> *are socialized into their particular fields as students … they enter different cultural houses, there to share beliefs about theory, methodology, techniques, and problems.* (Clark 1983)

and Brown notes

> *… students are too often asked to use the tools of a discipline without being able to adopt its culture … Too often the practices of contemporary schooling deny students the chance to engage the relevant domain culture, because that culture is not in evidence. … This is not to suggest that all students of math or history must be expected to become mathematicians or historians, but to claim that in order to learn these*

subjects … students need much more than abstract concepts and self-contained examples. (Brown et al. 1989)

There is thus much more to the education of our undergraduates than their learning of disciplinary content. When they leave university, and move on to be fully accepted as part of the community, graduates should (eventually, if not immediately) be familiar with the debates in which others engage, and be able to think as a member of that community (Gibbs 1999; Langer 1994). Ackoff considers these issues and notes forcefully that

> *The world is not organised the way universities … are, by disciplines. Disciplinary categories reveal nothing about the nature of the problems placed in them, but they do tell us something about the nature of those who place them there.* (Ackoff 1994)

These are issues to which we should address ourselves in our provisions for student learning.

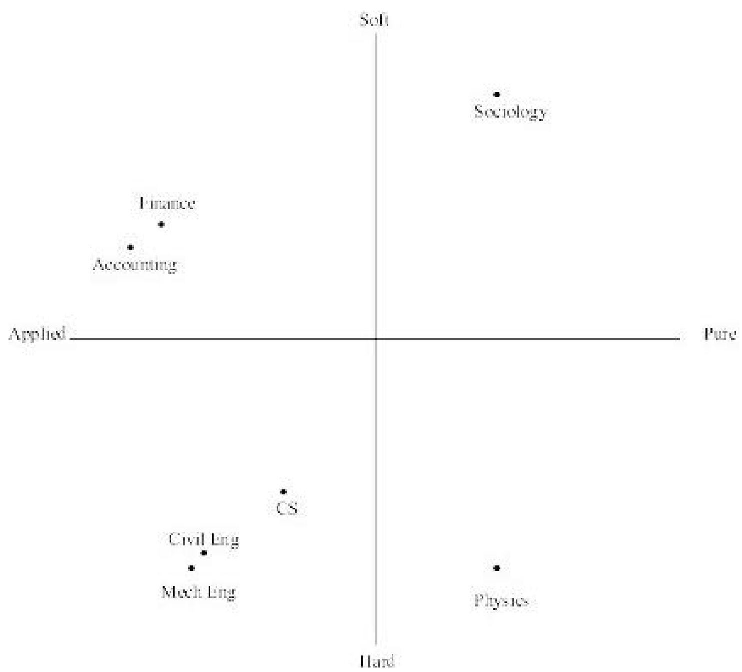

Figure 1: *Selected disciplines located on the Biglan dimensions (after (Biglan 1973, Clark 2003)).*

Computer Science as a discipline

Although the study of the nature of academic disciplines is relatively recent, little attention has been given within it to the nature of Computer Science (CS), although a good quantity of soul-searching literature does exist. Clark (Clark 2003) gives a good bibliography; see in particular (Abrahams 1987, Loui 1995, McGuffee 2000, Plaice 1995, Wulf 1995).

The low coverage is partly due to the short history of CS itself;

> *In its early years, computing had to struggle for legitimacy in many institutions. …[T]he battle has largely been won. … There is no longer any need to defend the inclusion of computing education within the academy. The problem today is to find ways to meet the demand.*
> (ACM 2001)

although considering that the crystallization of "accepted" disciplines is also relatively recent, the youth argument holds less water with each passing decade.

Considering Biglan's classification, CS was considered to be "hard" and "applied", but less extreme in its characteristics than many disciplines (see Figure 1). Becher (Becher and Trowler 2001) builds on these conclusions to describe epistemological and cultural similarities between disciplines, noting that CS is pragmatic, concerned with the creation of products, entrepreneurial, and infused with professional values which are shaped, inter alia, by academics.

This picture of CS suggests its predominant similarities are to traditional engineering disciplines and there is good evidence in the literature (Clark 2003) to support this view. On the other hand, strong cases have been made for it being a traditional science (for example, (Holcombe 2000, Tichy 1998)), while the extreme purist view is that CS is mathematics and applied logic (Dijkstra 1989).

There are as many arguments to be made as there are possible classifications. These include the possibility that CS is a fundamentally new, and therefore different, form of discipline that cannot be classified in any existing way (Weiss 1987). Clark discusses the various conclusions, and reasons, for the divergence of view, in detail (Clark 2003), and goes on to note that Becher's demonstrations of commonality of social organisation and epistemology are apposite, and that teachers of CS should be clear in their own minds at least about where the subject lies in order to be clear about what students should be learning.

Persons and personality

> *The office of the physicist often has pictures on the walls of such greats as Einstein and Oppenheimer; the sociologist prefers to pay homage to Weber and Durkheim.* (Clark 1983)

Whose pictures are on the walls of the Computer Scientist's office? Whose should be? Does it matter?

In discussing the characteristics of disciplines, various authors note observable features such as vocabulary and ornamental artefacts by which we may be recognised or judged (Becher and Trowler 2001, Clark 1983). Mathematicians will use words such as "elegant", and historians "masterly", in very specific ways; chemists will have molecular models on their desks. We might ask what words (beyond jargon) and ornaments characterise CS. At a recent State funeral in the UK, it was observed that "people want and need their idols", and there is evidence that disciplinary communities are not an exception. Clark notes (above) a choice of portraits, and further observes that the academic world often performs "as a secular form of religion", implicitly with its Gods. Becher notes that disciplinary characteristics (sometimes surprisingly) outweigh national loyalties, suggesting some global agreement on who the Gods might be.

The metaphor should not be overstretched, but hagiographies can be found without difficulty in many disciplines. Becher notes that "disciplinary ideology would include … a careful choice of folk heroes" (Becher and Trowler 2001) and notes the value of "legends" beyond their role as symbols. On physics, we read "the big names are inevitably more prestigious" (Becher 1990). On philosophy, "We need to think that … the mighty mistaken dead look down from heaven at our recent successes, and are happy to find that their mistakes have been corrected" (Rorty 1984). In presenting a cornerstone of CS history [Leo], we read "Maurice Wilkes is one of the heroes of our nation and one of the most uncelebrated" (Caminer 2001). Eliot writes "Someone said, *The dead writers are remote from us because we know so much more than they* *did*. Precisely, and *they* are *that* which we know." (Eliot 1920) – the existence of the "mighty mistaken [sic] dead" inspires and motivates us. Whatever our view may be of pantheons, they appear to exist and are one mark of the discipline's existence.

These idols should be handled with care. Considering the historiography of philosophy, Rorty considers that the study of the history of science is self-evidently respectable. We would not expect to "fall in" with our predecessors, but would be pleased to engage with them on equal terms, and please them with our successes: " … we have, in these areas, clear stories of progress to tell". However, he proceeds to decry (specifically within philosophy) doxography – the practice of telling the story of philosophy via the contributions of a succession of philosophers. Discussing geography, Taylor writes "Every discipline has books purporting to show their particular evolutionary development" and goes on to discuss the manipulation of the roles of "accepted giants of the past" (and the introduction of new ones) in support of various interpretations (Taylor 1976). Criticising Whig historiography, Graham pursues this point in considering histories of science:

> *the reconstruction of scientific development which focuses on the "great men" and on the linear and accumulative sequence of discoveries represents a distorted picture of which not only the epistemological implications and assumptions could be drawn into question but which also coincided all too neatly with an idealized picture of the scientific enterprise*. (Graham et al. 1983)

These are points that it is easy and proper to accept, but in doing so it is interesting to note evidence from physics that an elite does exist within research activity (Cole and Cole 1973). Analysing the "Ortega hypothesis" that significant scientific advances come as a result of large numbers of small, less significant ones, they present evidence that this is not so. Importantly, they proceed to make the point that while major research advances can be attributed to relatively few, the contributions of the many to teaching and other disciplinary activity are in no way less important in their indirect contribution to scientific progress. It has been noted some time ago (Reif 1961) that the pursuit, and use, of "prestige" is a side effect of the way science is conducted. This has clear undesirable effects, and is not to be welcomed, but is inevitable in the light of the way the current "system" operates – professional advancement is difficult to separate from reputation, and the senior reaches of a discipline are influenced by those with the best reputation, howsoever obtained.

There is no requirement for the Gods of the disciplines (particularly in the youthful CS) to be deceased, and indeed while professionally active they can be deeply influential leaders – perhaps the award of the Nobel Prize is the best example of this, although there exists a host of other prizes and awards that are "determinants of prestige" (Garfield 1983). Becher and Trowler write "the stars of a particular discipline occupy the main gate-keeping roles" (Becher and Trowler 2001), while Kekäle notes "respected researchers may act as strong role models … within a disciplinary community" (Kekäle 1999). Well over a hundred years ago, Lavoisier established a reputation that meant that "all those concerned described the chemistry of the nineteenth century as an extension of the Lavoisian enterprise" (Graham et al. 1983). Harvard attracted a group of leading philosophers at the turn of the twentieth century that dominated and directed American philosophy (Clark 1983). Fermi, having acquired "baronial power", came to dominate Italian physics and used his influence to lift it to the first rank (Clark 1983). Durkheim, having established a reputation, acquired the Minister of Education as a patron and effectively fathered the discipline of sociology by a combination of "adroit administrative manoeuvring and intellectual brilliance" (Adam and Fitzgerald 2000). On the other hand, in discussing physicists, Becher notes negative possibilities with the ability of "leading personalities" to distort and retard disciplinary belief (Becher 1990).

Of course, and especially in science, leadership and influence can be used to direct resources. For example, a Nobel prize cannot help but raise the profile and esteem of the winner, and in the prevailing university system resource would be likely to follow. Fermi used his reputation to establish resource to guide his direction of Italian physics, and more recently physicists note "there is a need for good impression management with those who award research monies" (Becher 1990). The influence of esteem in winning resource is not discipline independent, with a suggestion that hard-pure disciplines (according to Biglan's characterisation) are more prone to favouring a small elite (Becher and Trowler 2001). This can be a self-reinforcing effect:

The more eminent a scientist becomes the more visible he [sic] appears to his colleagues and the greater the credit he receives for his research contributions. (Mulkay 1977)

Graham notes that histories are an exercise in legitimation for their intended audience

Legitimations are directed to those who support [science], in a very general sense the lay public, and more specifically governments, foundation and other sponsors. … Legitimations of this sort typically assume the format of popularised accounts of heroic achievements. (Graham 1983)

He goes on to note that this mode of delivery of history, which can "create" heroes, is useful in addressing the lay public who might lack the knowledge to form a more informed scientific opinion.

The effects among the lay and non-specialist public should not be underestimated. We have noted that high profile researchers can act as role models within a discipline, but their role outside may be far reaching. Galleries of "notables" are often used to raise the profile of disciplines in adverse circumstances. Noting "in the physical sciences almost half of American students are taught by teachers without a major or minor in that field" an approach of delivering biographies of notable women has been used to increase the recruitment of women to engineering (Harckiewicz et al. 2001). In describing a motivation to succeed at mathematics, in difficult social and political circumstances, Kaczynski writes

First of all, we were fascinated by the challenges of solving problems and by the legends of famous conjectures; we tried to follow the examples of educational and scientific idols. (Kaczynski 2000)

Thus the existence of idols accessible outside the discipline can be influential.

Eponymy perhaps represents one of the greater accolades that may be awarded (Garfield 1983), and an obvious route into the wider public consciousness; it is more evident among the hard, pure disciplines (Becher and Trowler 2001). The existence of Einstein's Relativity and Fermat's Last Theorem must surely be known to millions who would scarcely be able to recite more than the names. The instances of eponymic misattribution are many, and there are likewise many instances of disciplinary notables going unattributed in this way, and of eponyms derived from [otherwise] scarcely known individuals. Eponymy can be frowned upon by "hard" scientists because of its lack of descriptive power (Henwood and Rival 1979), however

> *Eponymity, not anonymity is the standard of recognition in science. … [eponymy is] the most enduring and perhaps most prestigious kind of recognition institutionalised in science.* (Merton 1957)

It is dangerous, perhaps, to name something as abstract as a theorem, concept or paradigm until there is some certainty about its long-term influence, and it is unusual (although not unknown) to do so in the lifetime of those so honoured. There is not, though, a formal mechanism for this, and the use of a name for a discipline specific concept must be seen as true recognition of the importance of some contribution.

It is no surprise that eponymy, as used and recognised by the general public, is scarce in the youthful CS. An initial (far from authoritative) catalogue (Boyle 2003) has been constructed which provides some early observations. The Turing Test and the Von Neumann Architecture are perhaps the best known, but we might be surprised to find them known far outside the CS community. A host of other examples exists, but for most, if not all, we are in waters populated by those with at least undergraduate exposure to the discipline. Interestingly, some of the better-known examples are scurrilous, facetious, or not "Laws" in any scientific sense – Moore's Law and Stigler's Law are good examples.

Other pantheons

Anecdotally, it can be instructive across the modern disciplines to ask the question "*Who are the famous physicists/mathematicians/sociologists …*". There is not unanimity, and one would not expect it, but there is usually clear opinion from which broad conclusions emerge. Physicists are in little doubt about the importance of Einstein, and economists will award Keynes a mention (whether approving or not). In many disciplines, meaningful answers can be extracted from apprentices as young as school pupils. This is usually (but not always) associated with eponymy – thus Boyle, Fermat and Newton might well be proposed by 15-year olds, but so too might we expect Russell and Mendeleev to be known as influential by many apprentice philosophers or chemists.

Significant literature exists for other disciplines; often this is informal or journalistic, in particular a number of WWW pages of varying seriousness. A short list of these has been compiled (Boyle 2003); some of these pages have specific pedagogical aim (Ridener 1998) while others are for entertainment only, with no suggestion of completeness. Physicists can see galleries of Gods of their science who have appeared on banknotes (Redish 2001) and a different one for those on postage stamps (Reinhardt 2003) (prompting the title of this paper).

Economics provides "Great economists before Keynes" and "Great economists since Keynes" (Blaug 1986a, Blaug 1986b), each of which is a simple list of 100 great economists, each of whom is given a one-page biography. Keynes unarguably bestrides the discipline, and one might similarly expect to see catalogues of the great political theorists before and after Marx, and maybe physicists before and after Einstein, but it would be hard to agree on a single signpost for CS.

Does it matter?

What is the relevance of these observations? Most CS university students will get some form of history lesson, quite probably informally from greying professors explaining what it was like for them to be students of computing, although this is unlikely to allude much to the personalities. We suggest, however, that the encultured computer scientist (as opposed to the simply qualified) is able to do more than list hardware generations, and to characterise the history of programming languages, and will be able to expound to some extent on how, when and why things occurred, including some knowledge of the major players in the development. Here, the interest is not so much the identities of these people, but whether they might be agreed to exist, and for what reasons. We shall note that some CS hagiographies can be found, but do their subjects wield "baronial power" as Fermi did? Do they control or direct resource? Are our Gods role models or mentors, representing us to the general public?

A springboard for the considerations of this paper was the informal observation that few graduates were able to attach recognition to more than a very few of the CS pantheon, and often knew very little about the ones they could name. Eponymy plays its role (as among schoolchildren), and Turing, Von Neumann and Dijkstra were known to be "names", but we contend that it behoves the educators among us to provide our students firstly with a little more than the name, and secondly to extend the list from which they can recognise something.

A survey

Various lists of "Famous Computer Scientists" can be found; usually these are narrow and specific in their choice, or exist as light-hearted forewords or padding. "The Universal Computer" (Davis 2000) presents a very particular history of computing via similarly particular biographies; "Heroes.com" (Proddow 2000) documents the "heroes of the dot com era" (and was published before it became clear that they may have been false Gods). "Out of their minds" (Sasha and Lazere 1995) provides anecdotal biographies of 15 computer scientists whose reasons for selection are not quite clear. Schneider, for no very clear reason, prefaces a book on Visual Basic with potted biographies of his own choice (Schneider 1999). Gürer addresses the shortage of publicity given to the role of women in CS (Gürer 1995, Gürer 2002), and identifies some Goddesses.

In an effort to reduce the effects of preconception and prejudice, a survey has been conducted to seek academic practitioners' views on who the personalities of the computing discipline are. As a systematic and scientific exercise in data collection this is flawed in many ways, but nevertheless provides usable preliminary conclusions on what people think. The value of addressing the community to elicit broad disciplinary views has already been noted (Becher 1990, Becher and Trowler 2001, Biglan 1973). Similarly in physics (Cole and Cole 1973) it has been observed that recognition is correlated with academic "acquaintance", usually via publication of influential articles, making enquiry of active practitioners a reasonable approach. Shortly we will consider a very similar approach recently to his one pursued in physics (Durrani 1999).

Data collection

A short questionnaire was devised that aimed specifically at what teachers felt their students ought to know (in contrast to asking their own opinions). The key question was

To which 8 people in the discipline do you consider all Computing (and similar) graduates should be able to attach a two-sentence biography?

Properly interpreted, this question would tell us who university teachers considered to be the guiding lights of the discipline from the point of view of the students' enculturation. It remains probable, however, that many responders will simply have listed their own favourites, and given little thought to the point of the question. Perhaps, however, this is as it should be – the personalities are truly emerging from the community and folklore of the community's active practitioners.

The questionnaire also asked simple questions about the background and age of the responder, in the suspicion that these parameters might influence the pattern of answers.

Questionnaires were distributed at three computing conferences of differing profile; ITICSE-01 and LTSN-ICS 2001 are conferences of teachers of university computing (drawn from the international and UK communities respectively), while BMVC 2001 attracts an international (but predominantly European) audience of computer vision researchers. Additionally, a web page was created (Boyle 2003) to solicit the same information, and advertised widely through international contacts (and through them, further).

There is no suggestion that this methodology is either rigorous or complete, and the results must be viewed in this knowledge. The exercise is not, of course, complete, and the database of responses continues to grow; there may come a point when the weight of response permits more concrete comment to be made, but the subject matter of the discussion will always remain one of opinion.

Response pattern

The results presented here are based on 118 responses; this number is not clearly not large (although Durrani used a sample of comparable size for useful results (Durrani 1999)). Respondents came from twenty different countries (on four continents), but were dominated by the UK and the US (partly reflecting the shape of the discipline). The great majority were prepared to reveal in which decade they received their computing education, although whether this was formal (i.e., a qualification) was not asked: 20% learned computing in the 1960s, 37% in the 1970s, 37% in the 1980s and the remainder more recently – opinions might differ on whether these data represent the age distribution of the CS academic profession.

Opinions

The questionnaire permitted (and encouraged) respondents to rank their replies; the web mechanism enforced a ranking while most who used the paper form did not indicate an explicit order. Considering results with and without account being taken of rankings has little effect (and no qualitative effect), so we overlook it here.

	Overall	UK	North America
Turing	20	20	21
Von Neumann	15.5	13	19
Knuth	12.5	11.5	13
Dijkstra	11.5	7.5	13
Babbage	10	12.5	7
Hopper	7.5	7.5	9
Gates	7	8	5
Wirth	6	6	5
Berners-Lee	6	8.5	5
Lovelace	4.5	4.5	4

Table1: Percentage of poll of the top 10 choices; overall, UK and North American respondents.

Table 1 summarises the top of the poll, and Figure 2 illustrates the distribution of vote frequencies. The pattern is immediately obvious – one or two formative members of the discipline dominate opinion, while a number of other illustrious contributors follow them. The distribution, coupled with the size of sample, does not permit firmer conclusions than that Turing and Von Neumann can be agreed as important, another dozen or so are influential, and then there is a number of others who attract the support of a small number of individuals; following the top ten come, in order, Hoare, McCarthy, Codd, Jobs, Minsky, Backus, Zuse, Brooks, Kaye, Sutherland, Boole … Details may be seen on the WWW (Boyle 2003).. This pattern is very similar indeed to that observed in a poll of physicists, which was dominated by Einstein and Newton (Durrani 1999).

Echoing Becher’s remarks on disciplines transcending nationality, it is difficult to argue significant difference between global, UK, or North American opinion; Babbage and Berners-Lee score in the UK seemingly at the expense of Von Neumann and Dijkstra, but such conclusions are dangerous to depend on; the numbers are low, but maybe nationality shows some influence here. An orthogonal examination of the data from the viewpoint of age (or rather, date of education) suggests some generational influences: 80’s children are disposed towards Gates and Hoare, while

60's children like Hopper, but not, strangely, Knuth, whose better known contributions began some time ago.

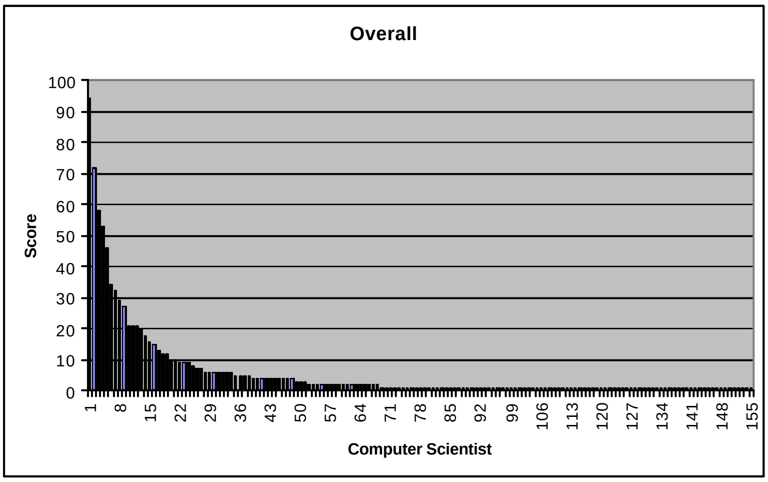

Figure 2: *Distribution of ranked opinions; axis is number of those voting for an individual. Over 50% of opinion is concentrated in the first 10 individuals, and 70% in the first 20.*

In total, 160 "names" were offered; notable among the also-rans were Shannon, Aristotle, Archimedes, and the Arabs ("for inventing zero").

Discussion

At this stage, these data are little more than an amusement and provocation. As we have noted, the survey was not based on scientific technique or sampling (although we hypothesise that the outcomes would be similar, had it been), and the numbers are low. There is also evidence that the question was interpreted very differently by different people, and often inaccurately. Nevertheless what we present corresponds with Durrani's work on physics, and there is food for thought in what we see, especially in the written opinions that many chose to add to their responses.

Many respondents chose to say they thought the exercise was "interesting" and were keen to see a summary of results, suggesting a nerve had been touched. Many also noted how hard they found it (an observation witnessed in several cases); respondents frequently found the first two or three easy, then wrestled hard with the remainder for a number of reasons. Several noted that CS is young;

> A: *I wonder how accurately we can do this given the youth of CS.*
>
> B: *CS wasn't thinking about its history when I was being taught.*
>
> C: *It is too early to identify computer scientists who are contemporaries: we do not know the full impact of their contribution,*

> *and a number of "famous" scientists pander more to the funding agencies and their agenda than the discipline. It is unlikely that there will be "famous" scientists from our own times that will be of the calibre of my Famous 8, whose contributions stand out as landmarks.*

C here is (perhaps unwittingly) making the point of Graham noted earlier that high profile might be more to do with resource than science, or at least used to attract resource.

Observations on the nature of the discipline emerge;

> D: *Leaders of corporations have probably had more influence than technical pioneers. Their focus groups have probably had more influence than anyone.*
>
> E: *People come in pairs or teams. Places can be more famous (Xerox Parc).*
>
> F: *The subject has areas that determine the answers.*

Many responses highlighted famous corporate leaders (some, such as D, exclusively so), and many chose to group individuals ("The original Unix team"). In many cases it was clear from the selection that the respondent was speaking for a specific area of activity such as AI, or graphics etc.

One respondent was critical of the whole exercise;

> G: *This is completely pointless and in fact dangerous – computing is about ideas, not people. What happens when one of the "heroes" turns out to have been a terrible person, or have stolen their ideas or whatever? The historical aspects of computing may be interesting, but history is not a procession of great people. As a Physics graduate I would be hard pressed to name 4 – and one of those would have said "If I have seen far, it is because I have stood on the shoulders of giants".*

Although there is evidence that physicists usual can summon the names of their Gods, these remarks are fair and echo those of Graham and Rorty noted earlier. History is, indeed, not a procession of people, and computing (along with many hard disciplines) has its fair share of controversy over whether notable developments have been correctly attributed. Nevertheless, the exercise of asking does not create the names, and we have the evidence that, to some extent anyway, they exist.

Conclusions

Knowing who we might nominate for Computer Scientists on a series of postage stamps maybe does not teach us much; even those who did not nominate Turing and Von Neumann would be unlikely to dissent from their appearance, and it seems unlikely that anybody would lose much sleep over none of their nominated eight being chosen. However, if we can agree that the emergence of "names" is inevitable and is, more contentiously, one of the credentials of a discipline, there is some interest in the names that have floated to the top of the list.

More than half of the top ten are deceased, so maybe CS is not so young after all. Why do Babbage and Lovelace both appear? It is hard to argue that CS would have developed much differently if they had not existed at all; perhaps they make a good story and are truly part of our mythology, both deserving a place. Of the others, it is quite clear that some, at least, exercise formidable influence on the development of computing in its broadest sense – arguments may be held over whether they will influence it in the strictly academic sense.

Two women in the top ten represents a better female representation than is seen in many CS classrooms, although if we descend the list there are precious few more to be found.

The appearance of Gates is interesting; respondents seemed to be firmly in favour or opposed to him, with little middle ground. Proponents will point to his (or rather, Microsoft's) influence, while detractors will state forcefully that he has "done" nothing himself of note. Respondent D above draws attention to the influence in CS of the [possibly] non-technical.

Hindsight often suggests better approaches; when the survey was well underway, similar work on physics (Durrani 1999) came to light. As regards the pantheon, we see a similar pattern, with respondents predominantly showing enthusiasm and a very small number taking offence: "Your questions will lead to incoherent answers", noted a Nobel laureate. More interestingly, Durrani went on to ask, inter alia,

- What have been the three most important discoveries in physics?
- What is the biggest unsolved problem in your field?

- What is the biggest unsolved problem in the rest of physics?
- If you were starting your research career in physics again, which areas would you go into?

These are questions it may yet be interesting to ask within the CS community; a very small anecdotal sample has already yielded provocative and interesting views[2]. Certainly these topics pick out where practitioners think the real contributions have been, and in which direction we are heading (or should be).

Another study of physics notes;

> *Qualities of personality are more important than the layman might suppose. … Intellectual style counts for at least as much as professional ability. The great men [sic] of physics, who are not necessarily identical with the great physicists, have personal and moral qualities which are more important than mere skills and techniques.* (Becher 90)

– going on to note the value of "ruthlessness", "stamina" and persuasion. So perhaps those who attract attention and fame are not necessarily strictly the greatest within the discipline, but serve a role within and without it as advocates, leaders and resource winners. This observation would fit well with theories (e.g., Belbin's (Belbin 1981)) suggesting success depends upon a suitable range of skills being melded together, rather than on an array of prima donnas.

The potential influence of individuals has been noted; likewise groups of disciplinary notables "free of the slow processes of democratic deliberation" (Clark 1983) can effect changes in disciplinary direction. Perhaps this can be observed within CS in the UK with the recent identification of "Grand Challenges" (UKCRC 2003), which may be interpreted as an attempt to identify the best direction for the discipline's research.

Concluding, we can agree wholeheartedly with Graham et al. and respondent G above. History is not a procession of "greats", and the last thing university education needs is an undergraduate course on "who did what". Rather, teachers might seek to weave into the existing curricula enough anecdotal history to establish covertly in the

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[2] "Unsolved problems? Just two – software reliability and usability": Ian Utting, UKC, personal communication.

minds of students that bit of our culture which will establish whose pictures will appear on the postage stamps. An obituary for Dijkstra included the observation

> *Ultimately his success can be measured not simply in the recognition of his own work but in the standing of the discipline as a whole*. (Times 2002)

– the writer noting accurately the contribution to the discipline transcending the details of his work. The obituary concluded with Dijkstra's own observation;

> *I mean, if ten years from now, when you are doing something quick and dirty, you suddenly visualise that I am looking over your shoulders and say to yourself "Dijkstra would not have liked this" – well, that would be enough immortality for me.*

For all of us, probably.

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