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Imagining STEM higher education futures: advancing human well-being

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Abstract The paper explores a conceptual approach to the question of what it means to provide a university education that addresses equity, and encourages the formation of STEM graduates oriented to public-good values and with commitments to making professional contributions to society which will advance human well-being. It considers and rejects resource-based and utilitarian approaches to well-being and opts for Amartya Sen and Martha Nussbaum's capabilities approach which involves developing graduates' capabilities and functionings to be and do in ways which they have reason to value. The capabilities approach argues for educational and social development as the expansion of such freedoms. The approach is sensitive also to diversity through the focus on the choice of a plurality of functionings and a wide informational basis for policy, practice and social justice evaluations. It allows an analysis of how different individuals can convert available resources into functionings through attending to conversion factors: personal (internal) conversion factors, social conversion factors and environmental (external) conversion factors. All make a difference to how an individual converts her resources into functionings and makes advantage and disadvantage visible. There is a further education-specific issue, that of selecting core valuable capabilities because not any form of science and engineering education will do. Educators need to deliberate and agree which capabilities and corresponding functionings are valuable and so should be supported in policy and practice. In a capabilities-friendly education, education would aim to secure and distribute valuable education capabilities to diverse students (women and men, black and white, rural and urban and so on) paying attention to the social arrangements in education (pedagogies, institutional culture and education policy) and to conversion factors and barriers that might impede the development of opportunities and valued outcomes.

Keywords Human capabilities · Education and society · Student diversity

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Introduction

Higher education, including science and technology, is central to development agendas globally (World Bank 2002; UNESCO 2009). In this global agenda, notwithstanding the tremendous equity gains in the expansion of access to higher education,[1] it is economic growth and human capital that is prioritized over equity within countries and across countries, with concerns about rising inequalities emerging primarily from threats to growth (OECD 2012).

This global agenda plays out in particular, but not necessarily unique, ways in different geographical regions. Higher education in South Africa serves as the context for the argument in this paper. It is indisputable that South Africa needs economic growth and social development, and it needs this both to be inclusive and to generate jobs and employment to secure people's lives and livelihoods. The National Development Plan envisages universities as 'key to developing a nation' and economic development, central for 'knowledge capital' in the form of human capital, scarce skills, and knowledge for growth and employability, but only thirdly for wider benefits of social mobility and equity (NPC 2011, p. 262). Higher education numbers have grown significantly. By 2011, there were 899,120 students at the 23 universities in South Africa, up from 495,356 in 1994 (DHET 2011, p. 37), and by 2010, 80 % of students were black, 67 % African and 57 % male (ibid., p. 37). These are important equity gains, at least in terms of enrolment figures. Much more problematic are completion and graduation rates—which are poor; and the distribution of students across fields of study and subsequent employment—which is uneven across race, gender and university (Bhorat and Mayet 2010). It is also the case that 84 % of the population do not access higher education (Singh 2011). Turning to broader challenges, South Africa is one of the most unequal countries in the world, a country in which currently 10 % of the population earns 58 % of national income, and the poorest 10 % just 0.5 % (Keeton 2012), a country where inequality has recently been described by the World Bank as a 'corrosive reality' (Isa 2012, p. 1).

This is the situation facing higher education institutions. What does it then mean for a science and engineering student or graduate professional to take responsibility for contributing to changes to make South African society more just?' This 'think piece' proposes that educationally valuable 'human capabilities' (Nussbaum 2000; Sen 1999) and plural functionings can take us forward in examining equitable educational futures for STEM in higher education in a context of persistent and growing inequalities in South Africa and elsewhere. It requires that we ask whether university students or aspirant students have greater available opportunities than they had in the past, and asking are their capabilities equal or unequal along educationally and socially valuable dimensions. Specifically what would science and engineering education that took human development values of equity, empowerment, participation and sustainability (Boni and Walker 2013) seriously look like? What would students have reason to value doing and being now and as future persons, informed and shaped by their education and experiences at university?

[1] The numbers of the age cohort worldwide enrolled in tertiary (which can however include further and not only higher education) grew between 2000 and 2007 from 98,303,537 to 150,656,459 students (UNESCO, 2009: 205) although the proportion varies from country to country and the least dramatic gains are in low income countries where participation has only increased from 5 to 7 %. Sub-Saharan Africa has the lowest participation in the world, but, even here, absolute numbers increased from 2,342,358 students to 4,139,797 (Unterhalter and Carpentier 2010).

The prior questions for higher education ought, then, to be: How does higher education and STEM contribute to building a decent society which values creating capabilities for all its citizens and not just those who have the privilege of a science and engineering university degree with excellent employment opportunities (Bhorat and Mayet 2010)? How do STEM science and engineering graduates use their knowledge, skills and effective power as professionals to make good lives for themselves while also contributing to sustainable human development as a public good (Walker and Mclean 2013)? How are science and engineering graduates being educated in universities to be the 'enlightened, responsible and constructively critical citizens' envisaged by South Africa's 1997 White Paper (DOE 1997, p. 1–3)?

To be sure, historically what, how and for what purposes universities teach arises out of and is always realized within socio-historical contexts. For the most part of their history, far from being progressive, universities have legitimized dominant social and political values. Nevertheless, we can draw on other 'ideas' of the university (Newman 1852): the critical and emancipatory power of knowledge and reason; the usefulness of knowledge for society; and, potential for equality, critical citizens and democracy. Universities can disrupt hierarchies, opening out significant opportunities and achievements for marginalized or under-represented groups and individuals, and can instill altruistic values and outcomes as a contribution to more justice in society. While higher education has a reproductive role in reproducing existing social hierarchies of social class, gender, race and language, it also has this potentially transformative role. Moreover, research on social change suggests that if (professional) elites are sufficiently socially aware, they can play a significant role in transformative development, not only through quality public services, but also by broadening civic participation and consolidating democratic reforms (De Swaan et al. 2000).

Human capabilities approach and equitable futures

Consider Ntebo, a black student studying engineering. She has the financial resources (commodities) and the grades (schooling outcomes) to come to university. On the surface, she appears to have well-being and good opportunities which have enabled her to access higher education. But now she is struggling because she feels that she does not belong to the University or in the programme, which seem far removed from her upbringing in a poor urban township. She feels alienated. She feels she cannot ask questions of her lecturers or turn to other students for help, or say that she does not understand or try out her own ideas in dialogue.

What theoretical approach would help us to explain Ntebo's situation and the inequalities she faces? Do we give her more money and resources? Do we ask how satisfied she is? Or do we ask what she can be and do?

This think piece proposes the last approach—capabilities—for science and engineering education aligned with 'thick' public-good educational processes. The approach was conceptualized by Nobel Laureate Amartya Sen (1979) in his Tanner lectures as an alternative to other ways of thinking about human well-being. In the capabilities approach to human development, the focus is not only on income and other resources (computers, libraries, university buildings and infrastructure, for example) as ends in themselves. Sen rejects GDP or average income in a country as the single measure of human well-being because resources are the means but not the ends of development and further, do not tell us

who has how much.[2] A focus on GDP can give a high ranking to countries, even if they are unequal in all sorts of other ways. South Africa, for example, is classed as a 'middle income' country. The GDP or average income of South Africa, the resources that the University has, or even the average allocation per student does not tell us much about distribution to each student or their meaningful participation and success in higher education. Nor does a focus on higher education for economic growth and human capital—however important—tell us much about the hopes of Ntebo's family, of her struggles for higher level skills and knowledge, how these and other things are important in her life, or what the circumstances are that have affected her access to and participation in higher education. So a resourcist approach, even if it was egalitarian in giving each person an equal amount would still not tell us about Ntebo's ability to convert her bundle of resources into actual achievements. While decent income is tremendously important (we have students in our universities who do not get enough to eat, who are housed in sub-standard accommodation, who struggle to get by), it is not a proxy for *all* aspects of human development in higher education, or the plural good things that make up a flourishing life. Once sufficient resources are in place have we done enough to implement science and engineering education which is equitable and transformative?

Nor do we only ask how about people's perceived welfare, that is how satisfied people are with their lives (and then aggregate satisfaction across the nation). Although we would certainly want to know the answer to this question, it is not the only question we need to ask, and we would want also to know how satisfaction is distributed. The difficulty here is that people adapt to bad as well as good circumstances. Generally in adapting to the bad they ask and expect less, or if better off people are very satisfied and some very poor people are not, the overall satisfaction calculus will not tell us this. For example, Ntebo decides not to try hard in her course because she thinks will fail and rather aims for a low passing grade, because, she says that she knew that if got 50 % she would be happy. She ends up setting a low goal for her success, but she adapts her preferences (Nussbaum 2000) so as to be satisfied with this reduced goal. If we were to ask if she were satisfied with her study achievements, she would then say she was indeed 'happy'. Have we then done enough for the well-being of Ntebo and other students?

To evaluate well-being, Sen (1979) rather proposed capabilities as the metric of justice. The approach asks us to consider what people value being and doing, and to work to increase their freedom to be in those ways or to do those things in terms of living lives they regard as good. As Nussbaum explains:

> We ask not only about the person's satisfaction with what she does, but about what she does, and what she is in a position to do (what her opportunities and liberties are). And we ask not just about the resources that are sitting around, but about how those do or do not go to work, enabling [a university student] to function in a fully human way. (Nussbaum 2000, p. 71)

Functioning achievements (beings and doings) indicate what a person manages to do or to be in comparison with others. Thus, the functioning may be critical thinking, and the real opportunity for critical thinking is the corresponding capability. Education allows the

[2] This is captured in Nussbaum and Sen's (1993, p. 1) quote from Charles Dickens' *Hard Times,* referring here to Mr Gradgrind's school: 'And he said, 'Now this schoolroom is a nation. And in this nation, there is fifty million of money. Isn't this a prosperous nation? Girl Number twenty, isn't this a prosperous nation, and aren't you in a thriving state?' 'What did you say?' asked Louisa. 'Miss Louisa, I said I didn't know. I thought I couldn't know whether it was a prosperous nation or not, unless I knew who had got the Money and whether any of it was mine. But that had nothing to do with it. It was not in the figures at all', said Sissy wiping her eyes.

functioning to be exercised, so that the capability is effectively possible (Robeyns 2011). Having the freedom to choose functionings from an individual's capabilities set is also intrinsically valuable. But we do not look only at a single functioning (e.g. thinking critically) and then say that a student has well-being. Capabilities are the freedoms each person has to choose and exercise a *combination* of ways of beings and doings they have reason to value. The opportunity overall to choose a good life is then constituted of many different functionings. A student or graduate with a wide capability set of values, knowledge and skills is empowered to do more with their life, to have more well-being. As educators, we would ask: What combinations of well-being functionings are open to our students? For example, to study engineering, to think critically, to read with understanding, to develop good academic arguments, to assist peers in their learning, to have access to work-based experiences, to develop career networks, to move about campus freely and safely, to have good friendships with diverse students and so on.

The ultimate ends of interpersonal comparisons—how Ntebo is doing compared to other students—are a person's capabilities, not her resources or the satisfaction she may claim with regard to aspects of her life. Our question then is: What capabilities does this person have, in comparison with others? Our answer would reveal what is going well or badly in students' lives, and any significant interpersonal variations. We can then turn to educational and social arrangements and social norms, and the fairness of the conditions for students to participate in higher education in order to understand what needs to change. If we agree collectively that critical thinking is important for all students, then justice and transformation would require addressing the shortfall if at all possible whereby some students are able to develop as good critical thinkers and others are not. It would not be helpful to offer money to compensate the students doing badly; even if in the short term this looks attractive it would be to undermine seriously our educational goals. Nor could we just go on what students say as many may adapt to low achievement and yet say they are happy, as Ntebo does.

The capabilities approach is sensitive also to diversity through the focus on a plurality of functionings and a wide informational basis for social justice evaluations (Sen 2009). It allows an analysis of how different individuals can convert available resources into functionings through attending to conversion factors: personal (internal) conversion factors, social conversion factors and environmental (external) conversion factors (Sen 1999). All make a difference to how an individual converts her resources into functionings. For example, in South Africa, a working-class university student from an overcrowded school accepted into engineering may need more resources in the form of bursaries, academic support and access to networks which generate employment possibilities, than a student from a middle-class and good-quality schooling background, with connections through family and friends to science and engineering professions. However, conversion factors need to be understood not only one by one in each person's life but relationally—one person's conversion factors will be affected by and affect others and high-quality higher education might also operate as a significant social and environmental conversion factor. In a capabilities-friendly education, education would aim to secure and distribute valuable education capabilities to diverse students (women and men, black and white, rural and urban and so on) paying attention to the social arrangements in education (pedagogies, institutional culture and education policy) and to conversion factors and barriers that might impede the development of opportunities and valued outcomes.

A capabilities-friendly science and engineering education in universities would be instrumentally, intrinsically and socially valuable. It would ask what students need to know and do instrumentally in order to deal innovatively and confidently with rapid

technological change and the exploding access to information and to get a decent, career-building job. But it would also be concerned with how education and knowledge are intrinsically valuable (a love of mathematics or physics or solving engineering problems), and also socially important in enabling an understanding of the lives of others and a concern to develop people's 'basic' capabilities though professional contributions (for example, scientific research to eradicate malaria, simple technologies for water supply in a community, developing inexpensive and sustainable power sources, contributions to sophisticated well-constructed infrastructure projects or technologies which benefit the lives of all, as well as fair employment practices, treating workers with respect and so on). In all this, it is important, as Nussbaum (2010) argues, that science and engineering education is for rich human lives, rather than obtuse but technically proficient and knowledgeable professionals with limited affiliation to the lives of others or concerns for building an inclusive democracy.

Both Sen and Nussbaum argue that the focus of public policy should be to develop capabilities, leaving it up to people to decide on how to lead their lives (that is, which functionings to realize). However, this does not work well in the space of education where the relationship between capabilities and functionings is rather important. Functionings are achieved living, and having the functioning (for example, of critical thinking) in turn strengthens the underlying capability so that both functionings and capabilities matter, the former in terms of actual achieved living and the latter in terms of freedoms to achieve (Sen 1999). Nussbaum (2000) explains that to develop a capability (for example, for lifelong learning), we might need to promote a relevant capability 'by requiring the functioning that nourishes it' (ibid. p. 91). She suggests that 'the more crucial a function is to attaining and maintaining other capabilities, the more entitled we may be to promote actual functioning in some cases, within limits set by an appropriate respect for citizen's choices' (ibid. p. 92).

Thus, with regard to public-good professionalism (Walker and McLean 2013), we suggest that it is crucial for neophyte professionals to *practice* being public-good professionals, and for university educators to evaluate public-good functionings in order that students might develop and enhance their capabilities through the course of their higher education. It is to functionings that we turn to assess how students are developing and what kind of graduates they might potentially be; an absence of a functioning can indicate an absence of valued capabilities. Moreover, observed functionings are proxies for assessing whether or not the underlying capabilities have been formed and are being sustained. For example, an academic literacy course in a foundation year enables a student to proceed to the first year of the degree. But unless teaching and learning works to sustain those academic literacy gains this is not a secure functioning and may even become a 'corrosive disadvantage' (Wolff and De-Shalit 2007).

There is a further education-specific issue, that of selecting core valuable capabilities because not any form of science and engineering education will do. Educators need to deliberate and agree which capabilities and corresponding functionings are valuable, and so should be supported in policy and practice. Sen and Nussbaum disagree on the matter of capabilities lists, but the disagreement turns on the place of a canonical list of universal capabilities. In Nussbaum's (2000 and 2011) approach, the philosopher formulates, justifies and defends the conception of the good life and a central list of human capabilities, all of which Nussbaum judges as important and incommensurable. To remove any of the central capabilities would be to make a life 'not worthy of human dignity' (2011, p. 31). All democratic nations should therefore specify minimum thresholds of each of these capabilities for everyone. Sen's (2009) capability approach is deliberately incomplete. He

accepts that there are some basic capabilities which could be agreed by everyone, for example, those captured in the Human Development Index. But he argues that to specify a single list of capabilities is to change the approach into a theory, whereas he intends it to operate as a general framework for making normative assessments about quality of life. Therefore, he does not stipulate basic human capabilities, nor how different capabilities should be combined into an overall indicator of quality of life. For him, a 'workable solution' is possible without complete social unanimity being achieved. For Sen (1999), the process of public discussion is crucial, with people (and not just governments) as co-creators of development and change.

My approach steers a middle way between one list and no list to argue for workable agreements around core valuable higher education capabilities which could draw on the lists of others and on empirical investigations. An open-ended approach may not work well if it comes up against erroneous common sense understandings of disadvantage, for example, people might not understand that gender equity is not settled even though the overall majority of undergraduates are now women. In our application to professional education, Monica McLean and I (Walker and McLean 2013) bring together elements of public reasoning, the idea of a partial ranking—some professional capabilities which can be agreed are valuable for a comparative assessment of justice—and an ideal value of human dignity, which morally guides the right thing to do in concrete professional situations. We suggest that in thinking about professional education (and here we include engineering education as one of our case studies), it is not possible to support just any freely chosen capability and functioning, for example, to be able to patronize poor communities, or for white professionals to treat black unskilled workers in a racist way, or to be professionally indifferent to suffering. Professional capabilities ought to be worthwhile and to capture worthwhile functionings for public service. We think there is a need for capability dimensions both to give some content to professional education, to work out what public-good professional education might look like, and to then consider how practice and reality accords with the ideal; we need some yardstick to judge whether things were more or less just and fair and indeed, effective. We have therefore developed a list of eight professional capabilities extrapolated from empirical functionings which were seen to be of value to various stakeholders: informed vision; affiliation (solidarity); resilience; social and collective struggle; emotional reflexivity; integrity; assurance and confidence; knowledge and skills. Science and engineering educators would similarly need to consider what the core capabilities are for a science and engineering graduate, and the underlying educational ideal which informed any selection.

While philosophically capabilities would appear to support an individual maximizing calculus (what each person has reason to value being and doing for their own good life), in our work on public-good professionalism, a concern for and obligations to others and the foundational value of human dignity directs this maximizing calculus to take into account the improvement of the well-being of others as a means to my own well-being. What I have reason to value as significant to my own good life then includes advancing the well-being of others. Science and engineering education could play a role in shaping such ethically worthwhile and non-instrumental personal calculations. Students should learn to deliberate about the possibilities for a life well lived, and develop insight and self-awareness about lives of significance and responsibility. For example, STEM students and graduates could reflect and deliberate on the reasons and values upholding their professional agency, on their freedom and power to act in society, but also their freedom and power to question and reassess prevailing norms and values (Dreze and Sen 2002). They could learn that being advantaged generates obligations to others because 'capability is a kind of power, and it

would be a mistake to see capability only as a concept of human advantage, not also as a concept in human obligation' (Sen 2008, p. 336). If someone has the power to make a change that he or she can see will reduce injustice in the world, then there is a strong social argument for doing just that (ibid.).

To be sure, what is at stake is not any educational future for science and engineering, but a direction of travel which is towards 'redressable injustices' (Sen 2009, p. vii). Concerns for equity in higher education and society and decent lives would direct students, graduates, researchers and university teachers as bearers of knowledge (basic, 'blue skies' and applied), technology and information to economic and social development which promotes human capabilities and well-being for all. How science and engineering in higher education actually does this, with what effects, would need to be evaluated empirically according to a capabilities metric to understand how well students were doing in the space of educational arrangements and graduate identity formation.

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