

Interrogating our assumptions about the relationships between engineering education research, educational reform and social change

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Introduction

It may seem self-evident that education research is conducted for the purpose of informing education reform. Most of us came into engineering education research because we thought some aspect of the way we educate engineers needed to be improved. We most probably could not imagine another reason for doing it.



In the early days of engineering education research, many people who were drawn to this emerging field were university lecturers, and their motivation for doing this research came from their experiences (and frustrations) in the classroom¹. Increasingly, especially with the establishment of Ph.D. programs in the field, those coming to this research area do not necessarily have teaching experience but they still want to improve engineering education, in this case because of their experiences as students.

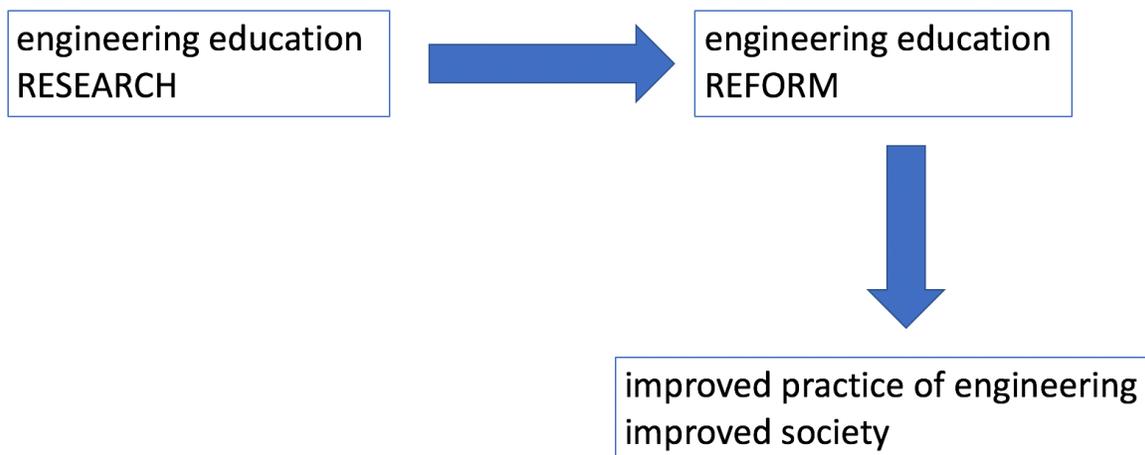
Improving education is also a central part of many of our debates about the societies we live in and the way we would like them to be. Americans are especially noted for having what have been termed 'evangelical expectations for education': achieving social change through education is more palatable than other means for those who are invested in a fundamental

¹ Borrego, M., & Bernhard, J. (2011). The emergence of engineering education research as an internationally connected field of inquiry. *Journal of Engineering Education*, 100(1), 14–47.

belief in the possibility of individual self-improvement and societal development². But South Africans too – I cannot tell you how many times I have seen the invocation of Mandela’s famous quote that ‘Education is the most powerful weapon which you can use to change the world’³. It’s a nice thought but I am not sure it is true, and in this talk I will review the empirical evidence for interrogating this statement.

So, in short, it seems to me that most of us in this community hold to these core assumptions:

1. That the reason we do (engineering) education research is to improve education (the assumption is that our research can deliver prescriptions for what should be done to improve it)
2. That improved (engineering) education systems can benefit the practice of engineering in ways that will also effect positive social and economic change



In this talk I would like us to take a close look at these assumptions, drawing on idea popular in sociology to “make the familiar strange”⁴. If you go to the internet you can find a gazillion first year sociology essays in response to the question of what does this term mean! I want to pause briefly to think what this might mean in the context of education, where I think it is particularly difficult because we all have such long inductions into the commonsenseness of education and how it is structured. Even when we are railing against the status quo and arguing for change, we do this, I think, mostly from a sense of familiarity. What does it really mean to step back and ask – why are things as they are? I can say that from my first experiences of going to study in another country I found myself having to ask these questions daily, and in my present position at Virginia Tech this continues maybe even with increased intensity.

² Lagemann, E. C. (2000). *An Elusive Science: The Troubling History of Education Research*: University of Chicago Press. p. xi

³ Speech, Madison Park High School, Boston, 23 June 1990

⁴ Mills, C. W. (2000). *The sociological imagination*: Oxford University Press.

I am therefore interested in the work these assumptions around education research and education reform do in constructing our field, but I am also interested in the way they might keep blinkers on us and in fact constrain our ability to do really good research.

This line of questioning that I want to explore in this talk was opened up for me on my first day in the M.Ed. in Science Education program at the University of Leeds in 1993. One of our first lecturers said: “If you think doing this masters degree will make you a better teacher you are very mistaken”. I will admit that initially this was rather a disturbing thing to hear. I was also a reformer and I had chosen to do a masters in education, rather than the more sensible thing of continuing in a technical discipline, because I thought education mattered more than anything and that I could learn to do it better. But I am grateful to those brilliant education scholars who understood that in order to become an education researcher, you needed to be able to bracket off your identity as a teacher and a reformer, in order to step back and ask interesting questions and seek out the less obvious answers, to “make the familiar strange”.

1. Purposes of Engineering Education Research (EER) as shown in its research literature

I have been working in this field for a good number of years now, and I have not only heard the arguments for the purposes of engineering education research; I have made them myself. But to firm this up these impressions I did a browse through the most recent articles available in our two flagship journals, the Journal of Engineering Education (JEE) and the European Journal of Engineering Education (EJEE). This is not an extensive bibliometric analysis by any manner of means – I will leave that to others if the direction seems productive – but merely an illustrative qualitative analysis. What I was looking for in these articles was evidence of the motivations we give for doing our research. Usually these statements are made in the introductory section of the article but are often revisited in its conclusions.

In working through these articles I found three basic kinds of warrant for doing the research. These are:

1. Engineering (science) courses are conceptually challenging. Therefore we need to do research on students’ conceptual knowledge in order to develop (and evaluate) better methods of teaching in order to facilitate this learning.
2. There are skills that engineers need that are not developed in the curriculum. Therefore we need to develop (and evaluate) course innovations that aim to build these skills.
3. The population of engineers does not represent the population at large. This is because of the negative experiences under-represented students have both in K-12 STEM experiences and, if they choose to do it, in the engineering degree. Therefore we need to research the experiences of under-represented students in order to develop (and evaluate) interventions to improve the institutional environment.

Thus, in summary, these three kinds of purposes can be summarized as directed towards these three aspects of educational reform

1. Pedagogical development
2. Curriculum development

3. Institutional development

The latter two purposes orient themselves directly towards impacting on the profession – Curriculum development is aimed towards producing engineers with better skills, and Institutional development is aimed towards producing a more diverse community of engineers. Pedagogical development sometimes is invoked towards producing engineers with stronger conceptual knowledge but sometimes it seems this is self-evident and doesn't need stated, the engineering curriculum and its outcomes are taken as given and not assumed to be in need of change.

My preliminary analysis suggests that pedagogical development as a purpose is more prevalent in EJEE articles, and institutional development (focused towards broadening participation) more in JEE. Both journals include work focused towards curriculum development. Again, this could be a line for more extensive research if we feel it is important – the whole backdrop to this talk is that we need to think about what empirical legwork is important to do and what is maybe less important to do.

It also appears that the US researchers work more consistently to a very recognizable and more elaborated way of laying out this argument at the start of the paper – factual assertions, linked by close logical connections, building to the motivation for the research. It has been suggested⁵ that this relates to the genre required for proposals to the National Science Foundation (NSF). Here for example are the first two sentences of an abstract:

With increasing demand for improved medical equipment and healthcare, next-generation biomedical engineers need strong design skills. Equipping biomedical engineering students with tools for idea generation and development can increase student design success.⁶

Whatever the details in terms of the different categories of purpose outlined here (pedagogical / curriculum / institution) or the degree of elaboration in the text, across both journals we see that research articles in this field are focused on **changing** education at these various levels, i.e. influencing education reform.

In the introduction I outlined two aspects of the assumptions we make about change, firstly about changing education, and secondly that changed education will produce changes in society. Here I have shown three ways in which we deliver our arguments about changing education. With regard to this second assumption, that changed education can improve society, I find in our journal articles that this tends to be more implicit, but it can be noted

⁵ Personal communication, Aditya Johri

⁶ Lee, J. W., Ostrowski, A., Daly, S. R., Huang-Saad, A., & Seifert, C. M. (2018). Idea generation in biomedical engineering courses using Design Heuristics. *European Journal of Engineering Education*, 1-19.

explicitly in national reports and policy statements on EE and EER⁷. Here, as one might assume, the economic arguments are salient, but the broadening participation agenda which is especially prevalent in the USA does orient itself towards social development and inclusion.

I now turn to a broader historical and sociological literature that can offer insights on the relations between education reform movements, educational change, and social change.

2. Historical and sociological evidence on the relations between educational reform movements, educational change, and social change

To start our process of making the familiar strange, it will help to look at the well documented history of educational reform movements and educational change. This literature spans both schooling and higher education, and here I draw particularly on two key overview texts that mainly reference the US and UK contexts.

The overall finding is pretty straightforward. In short, education systems do change, often quite substantially (contrary to the argument that they don't) but they don't always change in the directions that the reformers would like. In general, education change seems to be caused more by changes in the external social and economic environment, than the prescriptions of those within the system such as teachers and scholars with a reform bent. Let's have a look at this in some more detail.

Setting out on an historical overview of education in the USA, Rury, in his book, Education and Social Change⁸, notes:

Is relying on educational institutions to address larger social problems a strategy ultimately doomed to failure or disappointment? The answer to this question is a persistent puzzle in American history, for people in this country have placed uncommon faith in the power of education to improve society. (p. 1)

Surveying the early 20th century, he notes how the dramatic expansion of secondary schooling certainly had a significant impact on the economy, with the provision of workers with higher levels of education. But at the same time, this was the era of the progressives like Dewey, and their vision that education would foster a more democratic and humane sense of community was arguably not achieved, as the American high school developed as an institution that certainly fostered youth culture but incorporated different sub communities depending on (what Americans prefer not to call) social class. In the post-war period, issues of inequality and social justice rose to the fore especially during the civil rights era, and many felt that education reform would help achieve this. In fact, this was the period where significant federal funds

⁷ Case, J. M. (2013). *Researching student learning in higher education: A social realist approach*. London: Routledge, see chapter 8.

⁸ Rury, J. L. (2012). *Education and Social Change: Contours in the History of American Schooling* (4th Edition ed.). New York: Routledge.

started flowing to schooling, to attempt to alleviate these social inequalities. Despite these unprecedented levels of funding, no significant progress was made in terms of relative school outcomes. Studies started to show the unpalatable finding that family background was a greater causal determinant of school outcomes than anything that happened in the school, at least at a macro level⁹.

This is education's 'inconvenient truth' and why social policy focused solely on education as a change agent is doomed to fail – for a whole range of reasons, individual students respond differently to education environments, and even when these environments are improved, there will be differential outcomes. Advancing social equality is most probably more effectively done through measures in the areas of labour and tax reform, child welfare, public housing etc. The sociologist Basil Bernstein famously (and controversially) said: 'education cannot compensate for society'¹⁰.

Very similar overall findings are seen in the context of the UK, surveyed in a similarly titled book, *Education and Society*, by the sociologist Rob Moore¹¹. Moore kicks off his investigation with the observation that in education, 'the kinds of things expected to make differences often do not' (p. 2). He also makes the important point that education often holds together contradictory purposes; in more elaborated form this argument has been made by Manuel Castells¹².

To understand those changes that we **have** seen in education and education outcomes in the post war period, Moore argues we cannot find explanations only within education, we need to locate this in an understanding of broader dramatic changes in society over this period, in the nature of work, in family structures, in role of women, around multiculturalism. Looking at social class, over this period, despite this being a major focus for reform and the impetus for significant interventions especially in schooling, there has been no change in relative outcomes, although there has been an upward change in absolute outcomes. On the other hand, this period has seen what is often termed a 'gender revolution' in terms of women's participation in and outcomes in education – but here the reform efforts were at best fragmentary. These changes are certainly more due to changes in broader society than anything else. In terms of ethnicity, it completely depends on which group one is talking about; some have seen huge relative changes in educational participation and outcomes, and others have not. Overall, Moore reflects that the degree of social mobility in modern societies is so great as to negate the Marxist reproduction thesis, but also not enough to support the liberal open meritocratic ideal.

⁹ Coleman, J. S. (1994). *Foundations of social theory*. Harvard University Press: Cambridge, MA.

¹⁰ Bernstein, B. (1972). *A critique of the concept of compensatory education*.

¹¹ Moore, R. (2004). *Education and society: issues and explanations in the sociology of education*. Cambridge, UK: Polity Press.

¹² Muller, J., & Cloete, N. (2017). *Castells in Africa: Universities and development*. African Minds, see Chapter 3.

In terms of national comparisons, Moore raises further questions about causality:

It might be that richer societies have more developed education systems because they are richer, rather than their being richer because they have more developed education systems (p. 36)

Therefore, as education scholars, it is high time that we need to wean ourselves of some very simplistic ways of thinking about the relationship between education and society, and especially about educational change and social change. This is hard because it goes against some deeply ingrained views in our contemporary society. As mentioned earlier, education tends to take a central place in our debates on social change. Moore notes that a reason why education is such a primary focus for reform is that 'it is amenable to change in a way say that structure of the labor market, family relations is not' (p. 6). Education thus gets treated as 'the principle means of creating a more equal society' (p. 7).

In the introduction I already cited Condliffe Lagemann's reference to the 'evangelical expectations' that Americans hold for education. It is worth noting what she goes on to say. She notes a tension between, on the one hand, these expectations, and on the other hand 'popular disdain for education and educationists, on the other'

She goes on:

"This tension has fueled an impulse to extend education to more and more people and to rely on it for an ever-increasing range and variety of social purposes, while also encouraging a reluctance to bear the costs of supporting education at truly adequate levels'.¹³

Importantly, she notes how education is located in 'larger constellations of social values and views that have often found their clearest manifestations in debates about education....' (p. xiii)

While we might miss the comfort of these views, and particularly in how we can use them to justify our place in the world as education researchers, Moore points out how they seriously limit our thinking for the true capacity of education to stimulate individual change. He makes a subtle but important argument:

"... if the *instrumental* capacity of the education system to realize certain kinds of economic and social policy objectives is weaker than has often been thought, then there is less justification for restricting the flexibility of schools in realizing intrinsically *educational* objectives." (p. 118)...
"The final implications of these sociological accounts might well be that the best reasons for doing things in education are educational reasons, and that educators are best employed pursuing these intrinsic aims rather than being harnessed to external objectives".

Think for a moment of what this might mean for engineering education. To even find its intrinsic educational aims. It is a radical thought.

¹³ Lagemann, E. C. (2000). *An Elusive Science: The Troubling History of Education Research*: University of Chicago Press, p.3

3. The promise and possibilities of educational research to support evidence-based practice

Here we need to return to think further about our initial assumption, shown at the outset of this talk to be key to how we argue for the purposes of our research, that we might be able to deliver well on prescriptions for reform. Here the literature on evidence-based research in education is worth reviewing.

The notion of 'evidence-based' practice, originating in medicine, has been attractive to educational policymakers for some decades now. It is also a basis on which many of us like to argue for the value of funding and supporting education research.

But there are a few niggly considerations here.

Firstly, any of you with real teaching experience should be inclined to think a bit critically about an article that writes in favor of intervention because student grades increased. Unless you have a very large sample and a standardized test (unlikely in most higher education contexts) this argument really doesn't fly on a number of scores – the variation in student background year to year, the potential relationship between teaching and exam scores when the teacher is the one both teaching and setting the exam, and so on. You should also be inclined to be a little cautious when claims for the value of an intervention are made on the basis of course evaluation questions with simple numeric ratings that are akin to customer satisfaction surveys. (If you review or edit papers in our field you will know that many authors still present the evidence for researching interventions on this basis).

For those researchers who do claim to be able to measure the impact of an educational interventions there is still a problem, as outlined by John Hattie and colleagues found after doing 800 meta-analyses of some 50 000 research studies on teaching and learning:

“The most important discovery from the research was that almost any intervention can claim to “work.” Almost every intervention had an effect size above zero which simply means that the intervention had some positive effect on achievement. However, if every intervention has some effect on achievement, then all we need to do is implement more of what we already do – so all we need is more money, more resources, more teachers, and all of our problems will be solved. However, this will not solve the problems in education. Instead, we need to be more discriminating.”

Thus there is also a robust debate amongst education scholars of what constitutes 'evidence' in education, and how this might link to practice. In my view a really useful way of thinking about evidence-based practice in education comes from the Dutch education scholar, Gert Biesta¹⁴ in a 2007 overview article.

¹⁴ Biesta, G. (2007). Why “what works” won't work: Evidence-based practice and the democratic deficit in educational research. *Educational Theory*, 57(1), 1-22.

Two key issues he highlights are the following. Firstly, much of the thinking around evidence-based practice tends to focus on questions of efficiency or so-called effectiveness, not taking into account that what is a desirable outcome is not necessarily a simple matter, easily agreed on. This is going to be a significant challenge for us if we manage to wean ourselves off instrumental views on the purposes of engineering education.

“evidence-based education seems to favor a technocratic model in which it is assumed that the only relevant research questions are questions about the effectiveness of educational means and techniques, forgetting, among other things, that what counts as “effective” crucially depends on judgments about what is educationally desirable”. (p. 5)

A second key point is that education is not medicine. Evidence-based practice rests on a certain notion of how causality works in the profession. It is based on an idea that a professional does something – an intervention – which brings about certain outcomes. This is a key part of how we conceptualize the engineering profession. However, in education, while teachers certainly direct their actions towards particular outcomes, the causality is not straightforwardly linear. As Biesta notes:

... the most important argument against the idea that education is a causal process lies in the fact that education is not a process of physical interaction but a process of symbolic or symbolically mediated interaction. If teaching is to have any effect on learning, it is because of the fact that students interpret and try to make sense of what they are being taught. It is only through processes of (mutual) interpretation that education is possible. (p. 8)

Now Biesta does not say that we should not be trying to base our practice on evidence – not at all – but he argues that we need to do this in a rather sophisticated manner. Because all of our educational deliberations ultimately rest on questions of value and educational desirability, we need to be able to interpret evidence with care. I would add that because of the significance of context in education, there are always going to be issues around what is termed ‘transferability’ of the research. For higher education this is an even more pressing matter than school education, given the highly specialized nature of advanced disciplinary knowledge, and the multitude of forms of higher education structures even within a single national setting. Biesta again expresses it clearly:

... research cannot supply us with rules for action but only with hypotheses for intelligent problem solving. (p. 20)

4. Conclusion:

Could we loosen the bonds between engineering education research and reform?

To have interrogated two key assumptions about the work that we do might indeed be unsettling, and so at this point in the talk I want to start to build things up. What might it look like to do education research that is not so tightly tethered to a reform agenda, that is modest not only about the capacity of education to effect social change, but also about the capacity of education research to deliver the prescriptions for education change. (These are the two core assumptions I outlined at the outset of this talk)

I do think this would involve a paradigm shift in the true sense of the word. It would involve critiquing of our notions of linear onwards and upwards development, so core to our enlightenment sense of ourselves, but maybe also limiting. It involves a serious departure from a positivist stance, which most of us said we had already left behind, but which I think continues to shine through in the arguments we make about our work, especially when we are trying to convince colleagues and funders who operate in a sci/tech way of seeing the world. Here we should include ourselves, steeped in our own socialization to engineering and its commitment to economic and social development through technological advancement.

What does it mean to really take on an interpretivist stance, a focus on ‘verstehen’: ‘understanding people and ourselves’? What is really going on in the education systems we research? What forms do they take and why? What is changing and what is not changing? What are the forces that promote change and what forces limit it? I think a really interesting way to stimulate these questions is to look outside your own country into another system. You will find a lot of things that you find taken for granted are not so in this other place. How does the logic of education work in this other country? What does it mean to be a student? What does it mean to be an engineering student? What does it mean to be an engineering lecturer? And so on. You can also cross time. What aspects of our current system are intrinsically bound up in life in the second decade of the twenty-first century? Of course, we think about technology but you can also go back just one generation and see very different social norms on student life, on relationships between students and lecturers, and so on. Sometimes I think our focus on what we call ‘active learning’ is really just about an attunement to changed social norms in the hierarchies between young and older adults – just look at the changed workplace, at relationships between parents and children, and so on.

What does it mean to move from being a ‘true believer’ to a position that is somewhat agnostic on these matters? Does this lead us to nihilistic despair? Is this to give up, or is it actually to work on the blind spots, to become more modest, and ultimately more able to really make a significant contribution through the new insights that our research delivers?

To further inform this position I find value in the work of higher education scholar Graham Webb, in his 90s critique of the then common sense on the topic of staff/faculty development¹⁵. He suggests that rather than all marching lockstep to a common beat, our research should

¹⁵ Webb, G. (1996). *Understanding staff development*. London: Society for Research into Higher Education & Open University Press.

be a 'site for contestation' – but in a hermeneutic spirit that is kind to the other. We should interrogate closely how we view the world and how we legitimate what we do. He says we should watch for 'an exaggerated confidence in a particular opinion' (p. 65). He notes with surprise that there has not been more work critical of the prevailing discourses at that point in staff development, and I wonder if we could say the same about engineering education.

I also want to note here a further significant risk of being too focused on education reform, is that we fail to account for aspects of our current system that actually work well. The problem with this is that it leaves us completely unguarded when there are assaults on education from external parties with external agendas, be they financial, political or whatever. Here two recent developments come to mind. In 2013, a highly influential report emerged, whose title proclaimed An avalanche is coming: Higher education and the revolution ahead¹⁶. It was extraordinary to see how many university leaders were taken in by the view that in just a few years face to face higher education would cease to exist as everyone moved to MOOCs. Some years on we can see that breathless argument for what it was. In 2015-16 in South Africa, the #FeesMustFall student movement protested tuition fees, but also at a broader level raised critiques around the experience of higher education. The validity of these critiques notwithstanding, it was notable how some academics and even university leaders seemed to buckle in the face of the argument that the South African university was so irredeemably racist that it should cease to function, and thus in some cases the doors of learning were shut¹⁷.

In conclusion then, I do think education, and engineering education in particular, plays an important role in society. But it cannot be the major impetus for resolving core social problems. We should not measure it to this yardstick. We should rather aim to recover the intrinsic educational reasons for why we do what we do and not be ashamed to argue for the legitimacy of our work on this basis. In doing research let's start from a position of curiosity long before we make strident arguments that we will be able to move quickly to develop practical solutions for education problems. Let's rather look to the long term and aim for generating knowledge that can be the basis for 'intelligent problem solving' in our classrooms, our degree programs, and our institutions. To do this we need to make the familiar strange. This might well be aided by work that looks beyond our own immediate contexts of time and place. We might find this a compelling intellectual journey.

¹⁶ Barber, M., Donnelly, K., Rizvi, S., & Summers, L. (2013). An avalanche is coming: Higher education and the revolution ahead. *The Institute of Public Policy Research*.

¹⁷ Case, J. M. (2017). Public higher education in peril? A view from down south. *CGHE working paper*. Retrieved from <http://www.researchcghe.org/publications/public-higher-education-in-peril-a-view-from-down-south/>