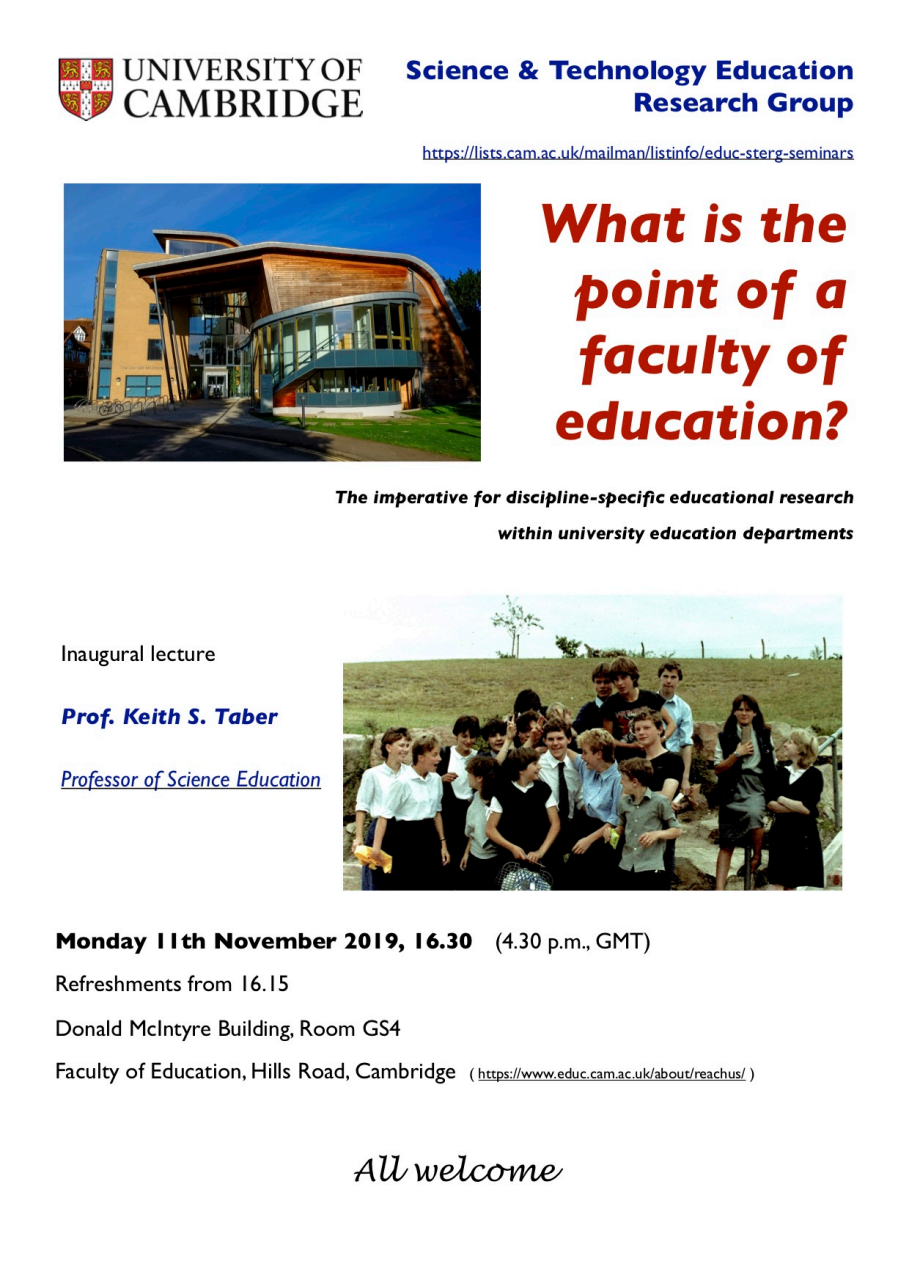
Taber, K. S. (2019) ***What is the point of a faculty of education?: The imperative for discipline-specific educational research within university education departments***. Inaugural professorial lecture. Faculty of Education, University of Cambridge.



A video recording of the lecture can be accessed via

https://science-education-research.com/academic-standards/what-is-the-point-of-a-faculty-of-education/

The full slide show and text of the talk as given can be found here

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The text in *this document* includes some material slightly truncated in the lecture as presented due to time pressures.

What *is* the point of a faculty of education?

The imperative for discipline-specific educational research within university education departments.

Abstract:

This lecture poses the question of what the purpose and value of an education faculty or department[1] might be in the modern university. In particular, it asks what the so-called 'USP' (unique selling point) of such an institution is, and highlights the potential for a large eclectic department (such as the one I have been working in) to be seen as redundant in the context of a wider university. It seeks, then, to respond to this enquiry through identifying the particular expertise provided by an education faculty, in relation to the 'proper' specification of the content of educational scholarship. From this position, an argument is made that an education faculty that wishes to remain viable at time of severe pressure on university resources should, as an imperative, prioritise core work around those areas of scholarship, teaching, research, and public engagement that only this particular kind of institution can offer. This is not, by any means, an argument for building a homogenous silo of education scholars looking to see educational work as somehow encapsulated and disconnected from other disciplines and shunning cross-disciplinary, inter-disciplinary or trans-disciplinary ventures - far from it - but rather an argument that a faculty which looks too much like the university writ large within one department opens itself up to being seen as potentially redundant and dispersible without losing anything essentially particular. Indeed, it is argued that the kind of work which society desperately needs education faculty to undertake is in a very real sense at the borders of educational studies and other disciplinary areas.

Introduction

This is my twentieth year working in the Faculty of Education at Cambridge, an institution which deserves that common epithet of being 'a very broad church'. In my time in the Faculty, I have worked alongside, and sometimes with, sociologists, counsellors, economists, psychologists, philosophers, historians, geographers, design specialists, drama specialists, playwrights, literary theorists, neuroscientists, mathematicians, composers, biologists, chemists and physicists - and I imagine I have missed quite a few specialisms as well. That has been a wonderful privilege. I doubt there is any other faculty in the university with such a diverse spread of specialisms all working together and teaching the same students. That offers an immense richness, and we could even argue that the Faculty of Education is a microcosm of

[1] The terms faculty and department may have somewhat different connotations in different universities, so what is a faculty of education in one context may be much the same as a department of education in another, even if technically a department is a lower level entity in the organisational structure. So, the terms are largely used synonymously here. Faculty is also a term commonly used to refer to the body of academic faculty members, as well as the wider more inclusive institution. For most of my time as a member of the Faculty of Education at Cambridge it was considered by the University to be a one-department faculty, comprising the University's Department of Education, so there was only a formal difference between the meaning of the terms.

the University writ large (Figure 1). I do not wish to complain about this at all, as it has meant that my time here has certainly been an education - for me at least.

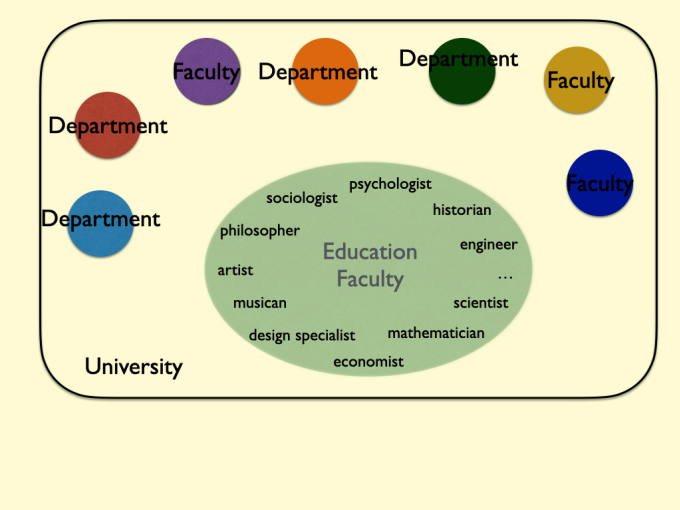

Figure 1. Might an education faculty/department appear to be a microcosm of the University write large?

Teaching in the academy

I should also note that working here in the faculty, I have been privileged to work alongside a good many skilled and enthusiastic teachers. Surely that would be true in any university department - or at least, surely it should be?

There are many committed and enthusiastic teachers across the university, but the difference in a faculty of education is the large number of people who committed to *being teachers first*, before moving to work in higher education; the large number of people who trained as teachers as a vocation, rather than as a pragmatic way to meet the requirements (whether welcome or not) of a lectureship. That is, the faculty includes a large cohort of people who we know wanted to teach, because that is in fact what they chose to do, even when faced with classes of people who had not demonstrated themselves to be highly academic, highly motivated, and very capable of being successful learners. These people felt a vocation to undertake the serious work of supporting the development of young minds (Figure 2).

Figure 2. Supporting the development of young minds

Now I do not want to make too much of this, and my intention is not to somehow suggest that a faculty of education is in some way *better than* other faculties because of this (even if we might hope and expect this preponderance of career teachers might be reflected in faculty teaching), but rather to point out that when colleagues have been selected to teach in this esteemed place, this particular group of people were at least in part selected because *they know a lot about teaching*. This is important for my argument because of the nature of academic specialisms.

Let me, by contrast consider another non-education university department. In fact I'll take my own undergraduate experiences as a model for an example. I invite audience members to consider how much of what I say reflects their experiences as an undergraduate student - I expect that might depend on when and where they studied, as well as the discipline concerned.

The lecturers who taught me were all research specialists. My degree was in chemistry and the chemistry department was staffed by lecturers who each had, I would assume, a decent broad general knowledge of chemistry, but were mostly valued for a specialist research interest. If I had been unsure whether oxygen was an element or a compound, or what a reflux condenser was used for, then (leaving aside, that in such a case I really should probably not have been admitted to read for the degree) I imagine that I could ask any of the lecturing staff for help. But, if I had difficulties with any of the actual undergraduate curriculum, I would need to be more selective. So, for example, I remember someone taught us about electrochemistry; and someone else taught us about heterocyclic organic compounds; and another lecturer taught about inorganic complexes, and another about photochemistry, and so forth. If I had been stuck on the electrochemistry, I would not have thought it sensible to go and see the person who taught heterocyclic chemistry - and had I done so, I would not have been surprised to have been rebuffed.

I would not have expected a response along the lines that 'it is not my job to teach you that, I have no credits for that as part of my faculty workload' (for as a student I had much more naive notions of how an academic community might organise its work) but probably more along the lines that I would be better off seeking specialist advice as that topic was 'not my area'. If you will excuse a chemical joke, then if you have a particular question about the actinides, then there is no point asking someone who does research on the lanthanides: it is not just historians who can justifiably claim an enquiry is out of their period.

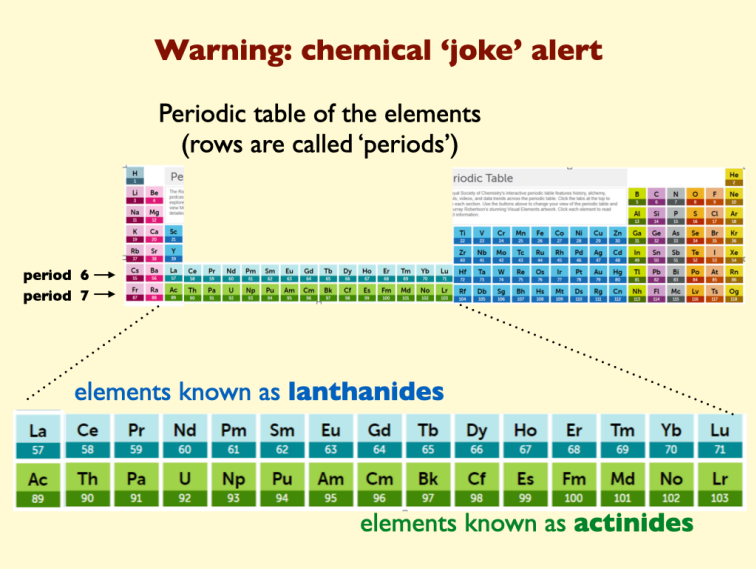

Figure 3. An expert might reasonably decline responding to a question that was 'not her period'

This is how research intensive universities work - if the audience will excuse an anachronistic Baconian metaphor - we might say that Universities select disciplinary specialists who are hopefully moving forward the boundaries of their subject by having a focused point of attack, not taking random pot shots across the border.

I am old enough to have attended university before it was widely recognised that it was a good idea to provide lecturers with some systematic input on how to teach. At that time, going to University still seemed a pretty neat idea for a young mind, rather than a default position, to the extent that my parents had no real conception of what a university was or why I might want to defer earning a living in order to go to one. That I had been talking about going to university to study science since I started at my secondary education at the local comprehensive seemed to have been taken as little more than the whimsey reflected in my earlier misguided career aspirations at primary school. My mother still sometimes reminds me that I wanted to be prime minister, but gratefully does not seem to recall the phase when I was going to be an interstellar preacher.

At that time there was an assumption that if you got in to university you should be able to learn from someone coming into a lecture theatre and writing on a chalkboard for 50 minutes. Within a department University academics had their research, had their research students, and between them had to cover the teaching. Some of my university lecturers certainly had some pedagogic skills, and some seemed to genuinely enjoy teaching - indeed some *even* liked interacting with undergraduates: but there was also a sense these attributes should be considered as bonuses - something over and above what we could feel entitled to.

The old adage of a lecture being a means to transfer information from the lecturer's notes to the student's notes (perhaps without passing through the mind of either) certainly often applied. The lecturer copied from his notes that some quantity or other was 'approximately not equal to zero', and I wrote this down desperately hoping it would make more sense to me later when I reviewed my notes.[2]

I am aware it may not have been exclusively like this everywhere in the University. One day I went to a seminar on Rousseau where everyone sat around the table and had a conversation with a lecturer who did not write anything on a chalkboard; but I was an interloper and such modern techniques had certainly not yet reached 'science city'. Science education seemed to be based on reproducing lecture notes in exams, and so accordingly there were a lot of lectures.

I had a friend reading history who only had one lecture to attend each week, but was also expected to write an essay every week. We chemists were advised it would be a good idea to write at least one essay *a year*, ***if*** we wished to, and that we could even hand them in for someone to - presumably - read them. It was not a strong commitment to creative writing. Of course we did get to write lab. reports, and as my tutor said to me at the start of the course, this could help increase our overall marks: "*I've never known anyone who's marks were not pulled up by the practical component*" he reassuringly told me.

A year later we had both learned something. "*Well,*" he told me "*that the first time I've ever known anyone who's aggregate marks were not pulled up by the practical component*". My main problem was that my lab. reports reported *what had happened* in my lab sessions, where clearly what was actually required was reproduction of the lab. reports that had got top marks in previous years (which as I recall were available in a spirit of generosity without charge from their authors - authors who in the spirit of scholarly tradition had presumably drawn upon previous sources themselves). So, whereas I thought we were learning to do science, and expected to give honest reports (as becomes a former aspiring interstellar preacher), the process was more about acquiring *something akin to even more lecture notes* telling us what should have happened. I had failed to recognise the actual creative writing component of the course.

I recall the Monday morning physical chemistry lecture course during my first year where lecture notes were provided as hand outs at the start of the class, and many chemistry students only stayed long enough to pick up the hand-out, whilst the numbers were made up by people not meant to be in the class, but who had been visiting loved ones over the weekend, or were from other disciplines (perhaps they should have gone to learn about Rousseau?) and who wanted to check out whether the Prof. really was as eccentric as was claimed.

He had a disarming habit of copying notes on to the board for a few minutes, then very slowly moving halfway up the steps to the back of the tiered lecture theatre to carefully read what he had written from a distance. He would then

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[2] It did not. I understood ***equal*** *to zero*, I understood ***not*** *equal to zero*, I understood ***approximately*** *equal to zero* - but to this day have not got my head around what counts as '*approximately not equal to zero*'.

slowly shake his head for several seconds as though faced with the work of an especially incompetent student, before returning to the front and the task of copying his notes onto the board. He seldom communicated with the class though other modalities, although I do recall him once suggesting to the room that "you will remember this from your second year" and then carrying on with no apparent concern regarding the response "we are first years".

It was noticeable that even if lecturers asked whether the class had followed a point, or had any questions, they usually did not seem to have thought through what they would do in the unexpected scenario that the class *had not* followed the argument or *did have* a substantive question.

Indeed, I recall a subsidiary [3] maths class where the lecturer regularly stopped to ask the class, or at least rows two and three, that is those students who seemed to fall within her field of vision, whether they were following. Unfortunately this lecturer, who was clearly a highly intelligent mathematician, did not really have a vast array of teaching strategies. After writing up a few lines of symbols on the board the lecturer would turn to the class. [4] The conversation would usually follow the pattern.

> "Do you see? Do you see?"
> [quiet acquiescence]
> continuation of the lecture

But occasionally someone on row 2 or 3 broke ranks, and a new pattern of dialogic interaction developed:

> "Do you see? Do you see?"
> "No, I am sorry, I do not follow."
> [pause]
> "Well, it's on the board. It's on the board.
> [pause]
> Do you see?"

This seems to be a variation on the well-know classroom interaction triad: I-R-E, that we could label IRE(R,R). That is

- Invitation by the teacher to comment
- Response by the student
- Evasion of the response by the teacher

(•Return to the previous activity,

- Regardless)

Needless to say, this approach only taught us that there was little point in questioning the train of symbols on the board as they were considered to be self-evident and the most help we were going to get was to be pointed towards the board, which at least, sometimes unlike the symbols, was self-evident to us.

It became clear to me from tutorials that this particular lecturer was genuinely keen on helping students learn, and would seem to have wanted to find ways to explain abstract concepts (concepts that had become second nature to her), to those of us less enlightened - but just as I had no idea how to make sense of some of the maths I met, she seemed to have no idea how to teach the mathematically challenged - beyond presenting that which seemed to her to clearly make sense.

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[3] In the English university system it is common for students to specialise in their major, but take one or more 'subsid' subjects early in their course. I read chemistry, but in the first year also attended maths and physics 'subsids'.

[4] At this time the notes were physically written on a board in real time, so for most of the session the lecturers had their backs to the class to face the board. Luckily mp3 players and mobile phones and other such distractions had not yet been invented. (Yes, for any youngsters readers - this is 'within living memory'!)

Something that school teachers discover very early in their preparation is that while a clear and logical presentation of carefully sequenced and explained material that is designed to build on expected prerequisite knowledge is certainly necessary when teaching most classes, it is by no means sufficient. The well-prepared, logical, carefully sequenced, well-pitched (or levelled as teachers are suppose to say today!), and skilfully explained lesson that has been planned is based on an *assumed* model (whether made explicit or not) of what the learners are ready and able to make good sense of: and as models are necessarily imperfect, and classes present diverse sets of learners, is only ever a starting point for the lesson itself (see Figure 4).

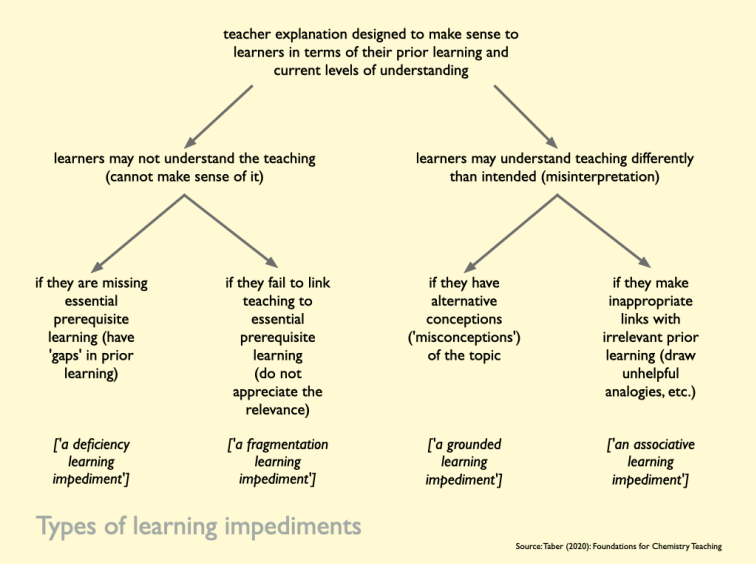

Figure 4. Ways in which learners' thinking may not match the model of learners' thinking in the teacher's mind [5]

Whereas the lecture can be written in advance (a feature I have taken full advantage of today), like a score for a musical composition, teaching a class has to treat the prepared script as the basis for improvisation where the performance has to build on the contributions of others in the ensemble.

In a very real sense most of the lecturers I sat in front of in my undergraduate education, watching them from behind as they represented their specialist knowledge by inscribing on the boards, *were* lecturers, but did not seem to be *teachers* in any deeper sense. They may have been excellent teachers of their research students working in small group settings, but giving lecture courses to a hundred or so people at a time was enacted as a process of transferring information, not engaging in knowledge development. [6]

The academy and its social contract

My intention here is not to be critical, and perhaps such a thing would not happen today, and certainly not here at Cambridge - but simply to point out something that *will* seem to be self-evident to most people in this faculty: *that one does not become a good teacher simply by being appointed to a job that has a title such as lecturer or professor*. That is, teaching has to be learned like most other worthwhile activities.

Of course we are all teachers to some extent in the informal life-world of everyday interactions, and some people do seem 'naturals' in the sense of seeming to intuit some of the basic attitudes and skills supporting effective teaching.

[5] Figure based on Figure 3.1 in Taber, K. S. (2020). *Foundations for Teaching Chemistry: Chemical knowledge for teaching*. Abingdon, Oxon.: Routledge.

[6] See Taber, K. S. (2019). *The Nature of the Chemical Concept: Constructing chemical knowledge in teaching and learning*. Cambridge: Royal Society of Chemistry.

Learning from each other is a normal human activity, and is largely responsible for the way culture develops iteratively over time. But learning in informal settings tends to happen in a rather different way from learning in classrooms where one 'expert' is '*plonked*' in front of a large number of novices with whom the expert often has no pre-existing personal relationship, for intermittent timetabled periods separated by long enough periods for what had been presented in the previous class to be no longer especially salient. (In schools, of course, we make sure that there are plenty of interfering experiences in the form of other short inputs on a range of totally different topics from other curriculum subjects between each lesson in a sequence.)

Thus *pedagogy* becomes important. (*More on that theme later.*)

At the end of my first term of chemistry I did suggest to my tutor that I wished to take up some study of philosophy and psychology - but was told that as a chemist the selection of supplementary subsidiary subjects open to me was limited to maths, physics, and biology - although in my case, apparently, not biology. Perhaps, had I formally engaged with a study of Rousseau I would have appreciated that the chemistry department was engaged in a form of social contract.

I think all the undergraduates in my department were aware that the department was *really* interested in research students, and in consequence *somewhat* interested in the one-third of those in the undergraduate cohort that made it through the three years who might potentially make that transition from the 'main group' of chemistry students.

But there was also a societal need for chemists beyond the academy. So, *part* of the purpose of the university chemistry department was to prepare enough chemists to enter the chemical industry and to provide people with subject background to be specialists in public policy, law, and so forth, even school teaching, in exchange for which a fraction would be creamed off - or at least defer entering such careers - to support academic research in the university. [7] The university provided society with the chemists it needed, and in exchange society allowed the university to entice a selection of the best ones to remain in the academy for a few years, or, indeed, sometimes indefinitely.

Indeed, my own impression was that whilst there was something of 'horses for courses' in that particular students would suit academic research, and others industrial positions (whether in research and development or in production or marketing, etc.) there was no necessary assumption that becoming a professional chemist *outside of academia* was inherently something inferior to becoming an academic researcher - just something different. Indeed, collaborations where academic research and studentships were funded by particular industrial partners seemed highly valued.

The university academic as a specialist

Whilst I have been talking about chemistry, I think something similar can be said about many university departments. I imagine that departments of archaeology, architecture and arts history contain teaching officers who are largely archaeologists or architects or arts historians (or whatever, according to department) and the department looks to induct more novices to become archaeologists or architects or arts historians (or whatever); some of whom will move into the academy, whilst others move into practice or careers that may use their specialist education in some other

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[7] I recall being given encouragement by Dr (later Prof.) Frank Palmer when I chose to do one of my third year projects preparing a display for an open day, rather than lab. based work. As part of this I was preparing a poster about a pair of geometrical isomers (molecules with the same formula, but a different arrangement of the atomic cores in space). As I recall now, I was told that one isomer was meant to be a naturally occurring compound in plants, and the other its isomeric form that did not occur in nature. The Prof. of organic chemistry still wanted me to synthesise the pure isomers (that is, *to actually do* some chemistry) which I was finding challenging, whereas I wanted to spend the time available preparing my display (that is, *to communicate* some ideas about chemistry). I recall someone suggesting (and I think this is now accepted) that actually the natural product was a mixture - even if the plant only synthesised one isomer, this had spontaneously converted into a racemate (a mixture of both forms) by the time it was extracted as a natural product, and this spontaneous process might have been the basis of my lab. difficulties.

There was a preparation room behind the main lecture theatres with drawing boards and stencils where I was working when Dr Palmer came in and expressed interest in what I was doing. Rather than suggesting I should be doing some real chemistry, he seemed to actually consider the project might be educationally valuable. He had been rumoured to have been heard saying that for most of the students in the department it was less important they left knowing a lot of chemistry than to be able to work out the interest due on a mortgage. This view may have been shared (if privately) by other staff, but made him seem something of a maverick at the time.

field. (Of course, some may simply seek degree-level employment, but that does not undermine the general principle here *as long as* the demand for chemists, or art historians, that society needs is met.)

Something similar happens in medicine: a medical school prepares future medical doctors, some of whom will do academic research for part or all their careers, whilst most will focus on practice. However, here we find that there is actually a less clear division between academia and professional practice: teaching is provided by many who have clinical posts, and all medical professionals are expected to not only keep apace of the latest research relevant to heir practice, but to contribute case reports and the like when appropriate. Many researchers in medical schools have clinical work which both motivates and informs, and also provides the context (and even if this language would not be used, the material), for their research studies. I will make an obvious point here - if we see the medical model as somewhat diluting the boundary between academic medicine, and medical practice, that certainly does not seem to have devalued medicine in any way as an academic field. (Indeed, arguably, nursing has in recent decades become taken more seriously as an academic area since it has widely adopted a similar professional development model.)

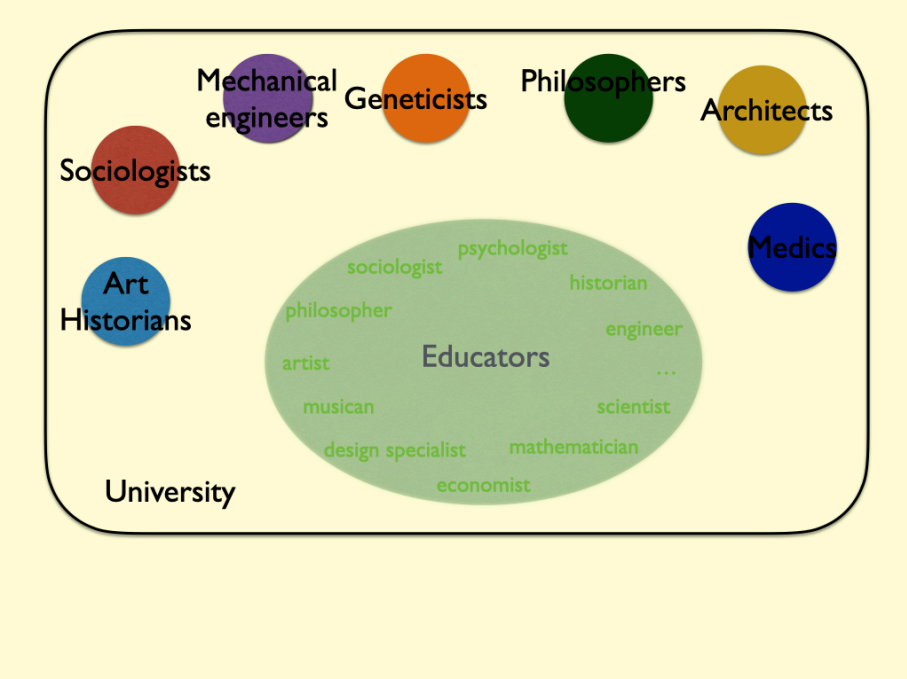

Figure 5. The faculty of…[e.g., education] comprises of…[e.g., educators]

In this regard a department of education may seem somewhat at odds. If the chemistry faculty is made up of academic chemists, and the archaeology faculty made up of academic archaeologists, we might expect the education faculty to be made up of 'academic educators' (See Figure 5). But this is a problematic notion. In a sense all those university chemists and archaeologists and arts historians are also academic educators - they are both academics and educators, they are educators in virtue of being professional academics.

Indeed the term 'academic' would widely be taken to mean someone who is both a scholar, and a teacher. Modifying the term 'academic educator' to 'academic teacher' would not help much in that regard.(And some may see this as another kind of social contract - we support you to be a scholar, and in exchange you agree to give your "not be less than thirty hours' lectures a year" [8]). Every university department is full of academic teachers (see Figure 6), so what is special about the education faculty?

[8] University of Cambridge Special Ordinance C (ix) requires university lecturers and senior lecturers to give at least 30 hours of lectures or equivalent teaching each year (so about what a school teacher has typically undertaken by the end of the 7th or 8th day of the school year). There does not seem to be a specific requirement for readers or for most professors, although the university reserves the right to suggest something. In reality, of course, academics teach *somewhat* more!

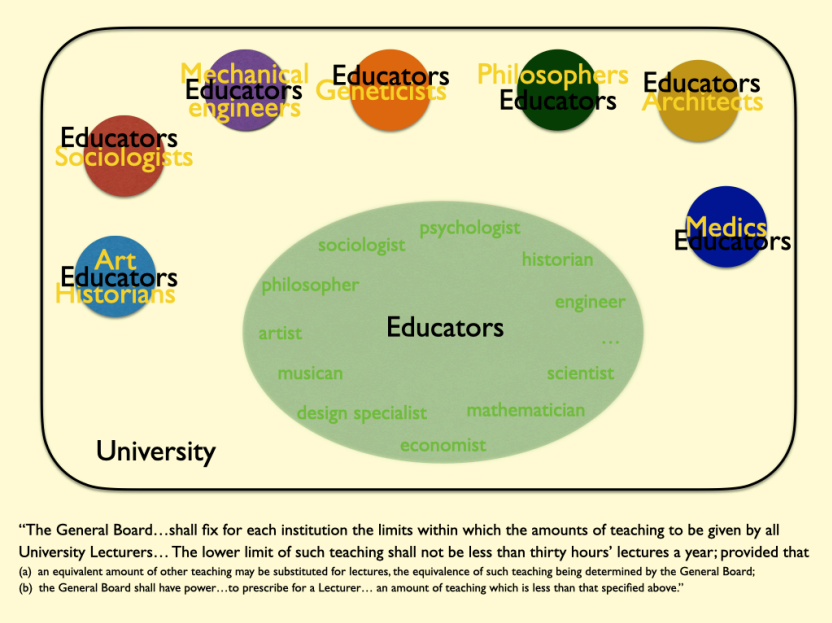

Figure 6: Being educators is not a USP in the University context

Is education a discipline?

I can avoid a problem here by shifting from 'who' to 'what'.

If the chemistry faculty is made up of people who do research and scholarship in the discipline of chemistry, and the archaeology faculty comprises people who do research and scholarship in the discipline of archaeology, and the art history faculty consists of people who do research and scholarship in arts history, we might reasonably expect the education faculty to be made up of people who do research and scholarship in education. That is indeed reasonable, and - I expect - not contentious. So, what I have done here is shift the focus from the faculty, the people, to the discipline: chemistry, archaeology, architecture, arts history, medicine…education?

This raises a genuine question of whether education is actually a discipline. The sociologist (of education!) Basil Bernstein discussed how curriculum subjects or disciplines might be framed in different ways. Some subjects have clear boundaries between them and other subjects, and also between the academic treatment and everyday discourse. [9]

So, chemistry certainly has some overlap with physics: the physical chemists and the chemical physicists will both try to claim thermodynamics as within their domain - but, *generally* it is clear what belongs to chemistry, and what does not. And chemical discourse tends to be clearly distinguished from everyday discourse where (much to the amusement or disgust of the initiated) sugar melts in hot tea, acids are corrosive liquids, and orange juice can be pure. (If some of the audience together do not appreciate that point, this merely indicates how canonical chemistry is divorced from lifeworld discourse.) Thus the metaphor of how students coming to classes can be seen as border-crossers [10] who may be bemused by or misinterpret the language and customs when visiting chemistry-land, or history-land, or economics-

[9] Bernstein (1999) distinguished between the type of ('horizontal') discourse used in everyday situations, which might be reflected in some school subjects such as 'personal and social education', and the ('vertical') discourse of academic disciplines, which took a different form in the social sciences and the natural sciences - the latter being characterised as "a coherent, explicit, and systematically principled structure, hierarchically organised" (p.161). Bernstein, B. (1999). Vertical and Horizontal Discourse: An essay. *British Journal of Sociology of Education*, 20(2), 157-173. doi: 10.1080/01425699995380

[10] "My proposal offers an account of students' lived experiences in a science classroom by considering those experiences in terms of students crossing cultural borders, from the subcultures of their peers and family into the subcultures of science and school science." Aikenhead, 1996: 2. Aikenhead, G. S. (1996). Science Education: Border crossing into the subculture of science. *Studies in Science Education*, 27(1), 1-52.

land and so forth. Teachers are advised to try and ease the transition and make the visitors seem at home - and it is so tempting to make a Brexit [11] reference at that point.

Education struggles here in two regards. (1) We adopt most of our research approaches from other disciplines and (2) we have been conned into thinking that some of the most important phenomena we deal with are straightforward because they feature strongly in everyday, lifeworld, discourse.

Firstly, so much that is explored in educational research could be considered within the domain of other disciplines such as sociology or psychology. Where chemistry has its special techniques of distillation, reflux, gas-liquid chromatography, infra-red spectrometry and all the rest, education uses techniques developed in psychology or anthropology or other social sciences. We use Likert scales, and participant observation, and structured interviews, and document analysis, and Kelly's triads, and so forth - but so do people in many other areas of research. We talk of *habitus* and *cultural capital* and *working memory* and *thick description* and *identity* and *motivation* and *metacognition* and a great many other things that have their origins elsewhere in the academy.

Someone using Fourier transform n.m.r. spectroscopy to analyse their chemical sample is using one of the specialised techniques of chemistry (that is, both the subject matter, and the methodology, are from within the discipline) - but someone using a life-history interview to learn about the career experiences of a retiring teacher cannot claim this is *specifically* an educational technique. If we consider that Kuhn's notion of the disciplinary matrix[12], introduced to clarify part of what he meant by research paradigms (see Figure 7) sets out what it is that is *specific* to working in a particular research tradition, then education seems to do *a lot* of 'borrowing'.

Figure 7: Components of a disciplinary matrix

Everyone is an expert on education, as we've all spent years at school

We in academic education (if we accept such a beast exists) also suffer from that great human faculty - 'theory of mind'. People are mind readers, or at least people tend to think they are. Human social experience largely consists of evaluating what others are thinking, and what they are intending, or suspecting, or hoping, or fearing, and so forth.

[11] The negotiations and political approval for the United Kingdom to leave the European Union - at that point, three years in and nothing clearly decided - had been much in the news at the time of the lecture.

[12] Kuhn, T. S. (1974/1977). Second thoughts on paradigms. In T. S. Kuhn (Ed.), *The Essential Tension: Selected studies in scientific tradition and change* (pp. 293-319). Chicago: University of Chicago Press.

People are generally *pretty good* at this - although the existence of misunderstandings and confidence tricksters shows we are certainly not infallible.

We are also pretty good at effective communication - at understanding each other, at sharing meaning. Again, we are by no means perfect communicators, but in most everyday social contexts, especially ones that are familiar - people function reasonably well. We make purchases from shopkeepers we do not know. We travel on buses driven by people we do not know. We successfully negotiate dental appointments and eye checks, visits to the family doctor, and we can avoid the unwanted attention of market researchers or maverick intergalactic preachers on the street, and we sometimes even manage to pass through doorways apparently designed with discrete infrequent use in mind, but actually employed to allow concurrent ingress and egress for busy buildings. We successfully return dropped property to strangers on the street, and so much more.

So we all, informally, engage in explaining things to others, and indeed in evaluating other's knowledge and understanding of topics in everyday life - in the 'lifeworld', and we have an everyday language for this. We talk about how intelligent someone is, whether they have misunderstood something, what is on their mind…

In education we draw upon this everyday language to discuss our professional concerns (see Figure 8), but this has consequences. In chemistry - or indeed most other fields - there is a professional lexicon which is generally unfamiliar to the uninitiated, and which is formally learned as part of becoming an expert. This is part of what provides the framing that sets the academic field apart from the everyday world where sugar is said to 'melt' in hot tea.

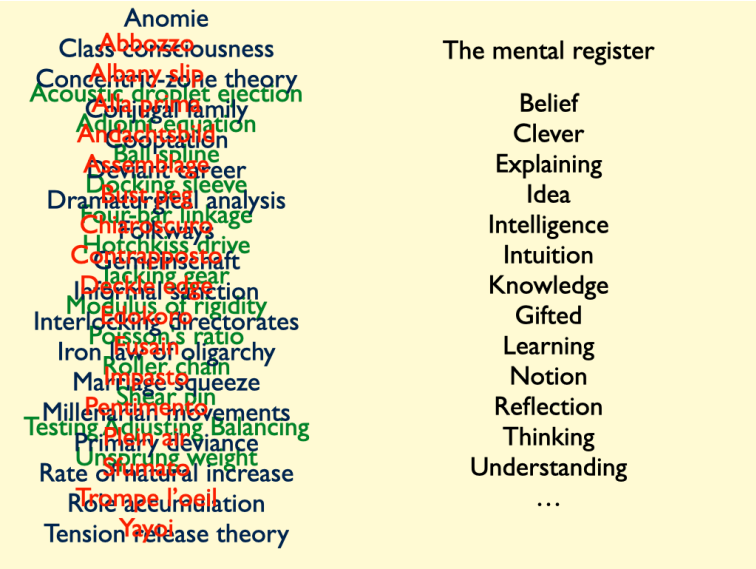

Figure 8: Most fields have specialised language for refined, and carefully defined, abstract concepts, whereas education draws heavily on 'the mental register' of terms that we take for granted in everyday discourse with being formally operationalised.

Yet in teaching, professional discourse often has a surface similarity with everyday discourse as it adopts the 'mental register'[13] of terms that we all use to speak about, and convince - or maybe fool - others (and perhaps ourselves) that we know about such mental features as thinking, understanding, knowing, learning, etcetera.

Now, I am in danger here of seeming to be suggesting that there is *no point* in an Education faculty, as actually what we in such a faculty know about is all covered elsewhere - if not in the common-sense knowledge shared outside the academy, then elsewhere in the university. Clearly, *I do not think that*, but *I think there is a risk of a perception* there that needs to be guarded against.

[13] See Taber, K. S. (2013). *Modelling Learners and Learning in Science Education: Developing representations of concepts, conceptual structure and conceptual change to inform teaching and research*. Dordrecht: Springer.

Dichotomous education faculty

The treatment I am offering suggests a dichotomous model of faculty of teaching staff. Now clearly this is a simplification, but that is fine because I am scientist, and science produces models, and as is well known, "all models are wrong, but some are useful" [14]. This is not a particularly nuanced or sophisticated model, but that is also fine because I am a teacher, and teachers use teaching models that offer a high level of simplification to *introduce* a key idea to students that will act as a starting point for more sophisticated thinking to be developed once that starting point has become familiar and has been consolidated into memory (see Figure 9). I try to follow Bruner here and work with 'honest' simplifications that retain the core essence of what is being represented [15].

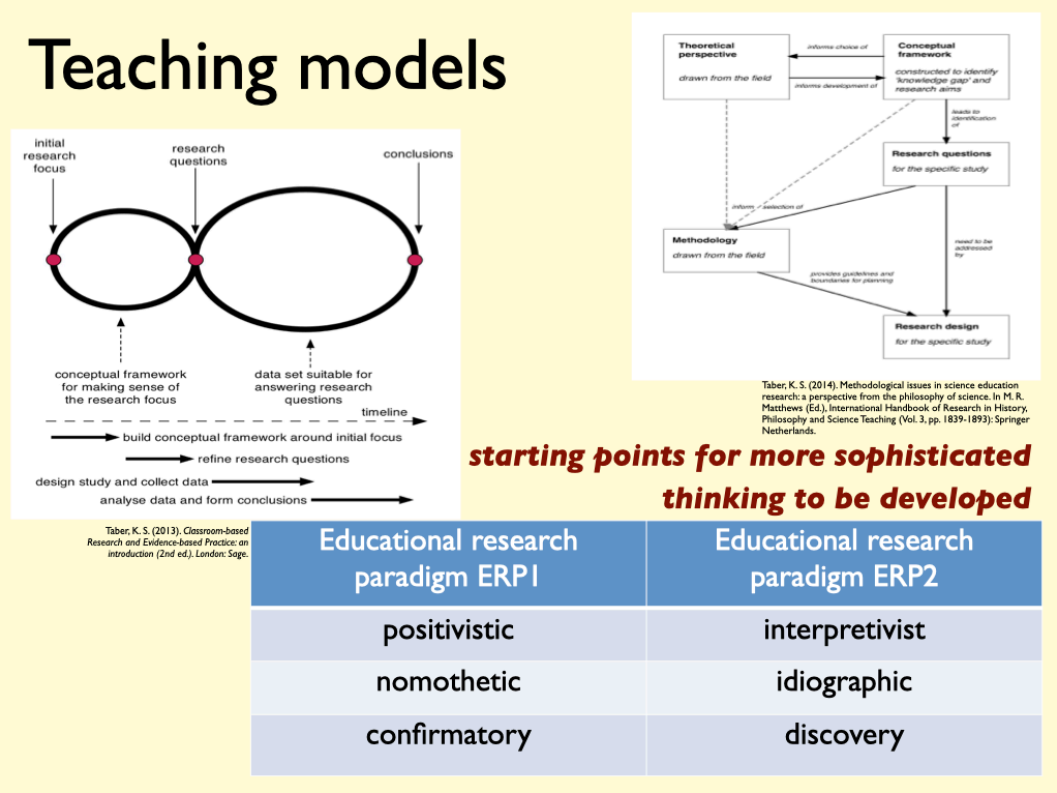

Figure 9: Teaching models are simplifications of complex phenomena or ideas designed for an introductory treatment suitable for later progression to more sophisticated accounts

My suggestion is that *to a first approximation* the faculty of an education department comprises two classes of academic.

One group are grounded in one of the foundational disciplines from which educational studies have developed - philosophy, history, psychology, sociology, etcetera - and have developed personal programmes of research in some aspect of philosophy of education, history of education, psychology of education, sociology of education, etcetera (see Figure 10). In a sense, these people have probably made a 'direct transfer' from one academic department to another. An economist who specialised in educational contexts could work in either an economics department or an education department - they have *dual citizenship* and may cross those borders relatively effortlessly.

[14] Box, G. E. P., & Draper, N. R. (1987). *Empirical model-building and response surfaces*. New York: John Wiley.

[15] Bruner, J. S. (1960). *The Process of Education*. New York: Vintage Books.

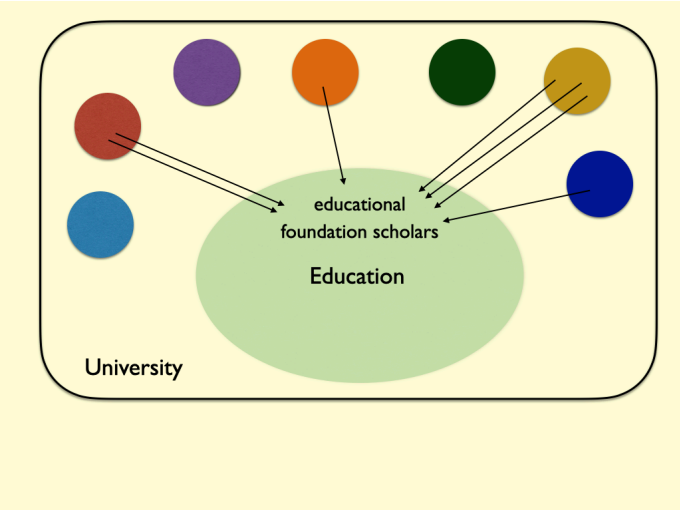

Figure 10. The Education Faculty is comprised of one group of scholars who are scholars in other academic disciplines as applied to educational contexts…

The other group (and please remember, this is a basic model to get across a general point) will likely also have a disciplinary background - part of their professional identity may be to be a mathematician or a historian or a biologist of whatever - but they have not entered the faculty of education by a direct transfer from another university institution, but through a practice-based route (see Figure 11). These people have spent time in professional educational practice - for example, as school or college teachers. So, for example, a curriculum specialist in mathematics has probably spent time in a university mathematics department (or, perhaps, an engineering or physics department in this case) *as a student*, but both the route to the education faculty, and the justification of their employment there, is based on what they have achieved *working within an educational context beyond the academy* since they originally left the university context.

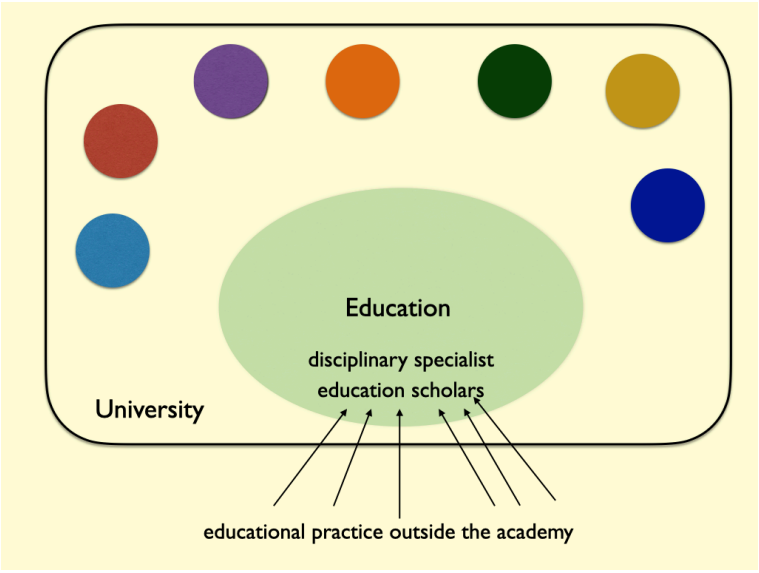

Figure 11…and another group of scholars of varied disciplinary backgrounds who have expertise in the practice of education in various contexts

This would clearly have an important consequence if, in a time of financial pressure and resource limitations, a university decided to consider closing an education faculty (let's call this EdExit) and considered whether it could redeploy staff who did not wish to take early retirement or a redundancy package. Our first group of colleagues could

potentially redeploy back into other departments. They have dual citizenship and so another home to go to. A sociologist of education is still a sociologist. She can teach about aspects of sociology - and indeed has been doing so in the education faculty. She can carry on doing research that will fit in sociology journals. She may not want to move, and the sociology department may not especially want her (given the usual internal politics and intrigues in such institutions), but there is *in principle* a sensible transfer possible if the University sees that as fitting a necessary strategy of consolidation and reorganisation.

What about our specialists in secondary maths teaching, primary literacy, special educational needs, citizenship education, human rights education, and the like? A historian who became a history teacher and has an international reputation in areas of history pedagogy and curriculum analysis and development, but who has published in e*ducation* journals, will not necessarily be looked down upon by a university's history faculty (I would certainly hope not) - but that institution probably does not offer any courses that this specialist is suited to teach on, and likely research into, say, the development of effective history texts for 11-14 year olds, is not seen as fitting into the department research profile (and certainly not the REF submission[16]).

I know that if the university wanted to re-deploy me to another department I would not be too optimistic that the physics department or the chemistry department would be keen to take me - and I would not blame them! Not unless they were looking for someone to do outreach or schools liaison, as I would not be of much use in teaching high level courses. Given my own experiences with the implicit 'creative writing' component of my own undergraduate course, I would not even qualify as a competent lab. demonstrator. I *am* a chartered physicist and I *am* a chartered chemist (and I've even been honoured to receive an award given by a learned scientific society), but that is in recognition of specialist work in science e*ducation*.

Of course, this would not be the case everywhere in the world. In the United States, for example, major University departments of Physics and Chemistry in research intensive universities may have physics education / chemistry education research groups, working under distinguished professors who specialise in educational research WITHIN their discipline. That is not the same in the UK, where science departments do not have education specialists, with, to my knowledge, just a few exceptions.

So the expertise we have here does not relate to scholarship in the disciplines themselves *per se*, but relates to specialisms in disciplinary pedagogic knowledge, and this should be recognised and valued.

I am not sure why, but when it was decided to offer provision to develop teaching expertise for research students and for academics at Cambridge this was done in a completely distinct part of the university, rather than being entrusted to the Faculty of Education or the Institute of Continuing Education. I suspect it may also be significant that although when the University decided to build, and sponsor, *a primary school* (now that anyone can apply to run a school, because of course it is just like any other commercial proposition[17]), it centrally involved the Faculty of Education as a core partner; *yet* when the university entered a partnership to develop a university technical college (UTC) [18] it did

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[16] The vastly expensive and bureaucratic periodic exercise to assess the relative value and impact of the academic output of every university department in the country through setting up committees of brilliant academics who could be doing useful research and instead asking them spend their time rating large numbers of academic outputs that are mostly outside their areas of immediate expertise.

[17] I am being somewhat sarcastic here, but I am old enough to remember when schools were under local democratic control and supported extensively by local government departments that also coordinated provision *across* local schools - rather than being seen as part of some fantastical 'free market'. A cynic might say that political responsibility for supporting teachers and schools to ensure quality has been delegated to economic competition citing 'parental choice' (which usually means the choice of those parents with the most cultural capital) as a means to excuse proper management of the system.

[18] Despite the terminology, this is a secondary school for 14-18 year olds. This type of school is just one of a succession of such categories (others have been city technology colleges, {language, science, etc.} specialist schools, academies, free schools) that have been introduced over time to undermine the comprehensive ideal that students attend their local community school which offers provision for the full range of student aspirations and propensities in parallel with similar schools in surrounding communities. Schools have been encouraged to develop their own USP, to compete for students, and moreover the system encourages schools to form into commercial federations and leads to some schools in effect 'taking over' others like free market businesses. The Cambridge UTC, when launched, needed to attract students who were already attending other local schools.

not think to involve the Faculty of Education *at all* in the planning. Presumably, the University centrally considered the Faculty of Education had no relevant expertise to offer!

The Faculty of Education's USP

But this is just where a faculty of education brings unique specialist expertise (its USP [19]). This is what the Faculty of Education can offer that is not available in the rest of the University. This is where the Faculty of Education offers a wealth of expertise to support an important feature of society. The core foci of education scholarship are *learning and teaching*.[20] Now a faculty of education cannot make an uncontested claim on learning, as the psychology department will understandably have something to say about that (see Figure 12). But nor should we cede this focus wholesale.

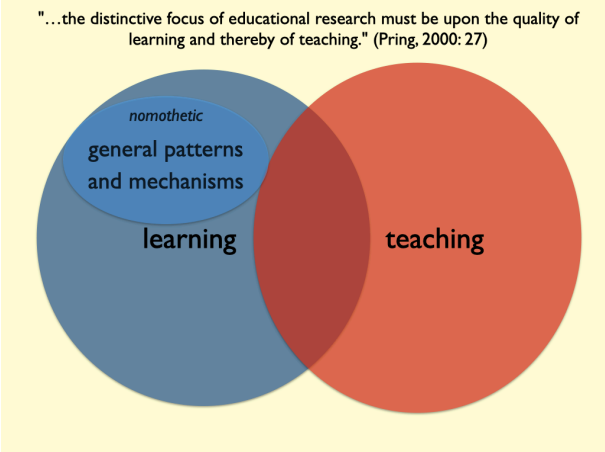

Figure 12. The core foci of education as an academic area

Disciplinary specialist education scholars are interested in applying learning theory to understand the challenges facing learners making sense of the actual target knowledge or skills set out in the curriculum. Generalised theories are only useful to the extent they can be applied in understanding the learning of the actual material that is to be learnt (see Figure 13).

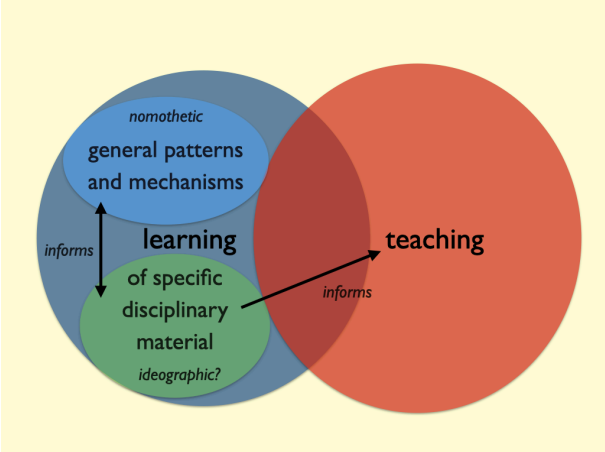

Figure 13. Educational scholarship adopts concepts and theories from psychology and applies them in various curriculum and teaching contexts

[19] 'Unique Selling Point' something that, apparently, any enterprise, needs.

[20] e.g., Pring, R. (2000). *Philosophy of Educational Research*. London: Continuum.

There is a parallel here between two categories of research student studying in the faculty of education. One group are seeking to answer generalised theoretical questions and they usually visit a particular education context to collect data that they hope will offer findings they can abstract from the context to generalise more widely. Those in the other category are collecting data in a context of particular interest to them, primarily to understand, or help change, some aspect of that specific context.

Theory-directed and Context-directed research

(Another teaching model)

Mode of research	Theory-directed	Context-directed
Motivation for research	Limitations of current theoretical knowledge	Scope for improving aspects of the professional context
Priority	Generating abstract generalisations to inform theory	Generating local knowledge to improve work within the professional context
Incidental	Understanding the specific research sites selected for data collection	Possibly generating insights that may be worth testing for wider relevance
Judged by	New contributions to theoretical knowledge	Potential to improve professional context/practice

Taber, K. S. (2013). *Classroom-based research and evidence-based practice: An introduction (2nd ed.). London: Sage.* Taber, 2013: p.128

Figure 14. Two general classes of educational research supported in faculties of education [21]

To an outsider it may seem there is a clear hierarchy here: generalisable theoretical knowledge is surely more valuable than specific context-bound knowledge? But such confidence in generalisation across educational contexts is misplaced. Such contexts are complex with too many variables to identify (let alone characterise) and they are highly diverse. [22] Therefore it is equally important to find out not only 'what generally is' and 'what generally works' but also 'what is here' and 'what works here'. Educational research is often only effectively applied when there is context-directed research to complement theory-directed research.

So a healthy education faculty has a diversity of student research projects, some looking to develop general theories and some seeing how research can make a difference in actual, particular, educational settings. In the same way, I would argue that my two clusters of faculty academics carry out complementary forms of scholarship which are both needed if we are to advance educational knowledge in ways that are actually applicable in practice. This is not a hierarchical or competitive relationship but more yin-yang.

Teaching is the other core theme. Teaching can be understood in different ways (and any students here from my lectures may recall this as an example for discussing the importance of considering ontology when carrying out research - in the sense of making sure you have a clear understanding of the nature of the object of your research at the outset). One understanding of teaching would be the professional work of teachers: the things that teachers are contracted to do, or the things that teachers do as a matter of custom and practice in some educational context. In my

[21] Taber, K. S. (2013). *Classroom-based Research and Evidence-based Practice: An introduction* (2nd ed.). London: Sage.

[22] This is why experimental research into teaching approaches, innovations, resources, etc., is so challenging - most published studies (usually from a single, or very small range of, contexts) have extensive caveats such that even if considered informative in their original contexts, they have very limited generalisability. See Taber, K. S. (2019). *Experimental research into teaching innovations: responding to methodological and ethical challenges. Studies in Science Education*, 55(1), 69-119. doi:10.1080/03057267.2019.1658058

first teaching job this would have included spending my morning and afternoon breaks one day a week monitoring the 'playground' areas and having no time for a break myself, or for setting up my next class. That was not an aspect of teaching I especially liked, but it needed to be done. In my second job it including occasionally having to take turns to monitor students boarding buses home at the end of afternoon school. When I worked in a further education college and had some departmental responsibility this meant doing a check on college rooms on Thursday mornings to make sure scheduled classes were in the assigned rooms and that a lecturer had arrived to teach them.

Another possible definition of teaching, and one I have more attachment to, is the set of deliberate actions carried out to bring about some specified learning. In this definition teaching and learning are closely linked, and clearly this meaning of teaching is at the core of a teacher's work. Teaching in this sense can be in a formal or an informal context, and may concern knowledge, skills, attitudes, values etc. By this definition, learning does not need to take place (if we define teaching as actions that bring about desired learning we inevitably have a more constrained set of actions), but the teacher's actions need to be intended to bring about some particular desired learning. This does not necessarily mean the learning is desired by the learner as well as the teacher - although clearly life is easier for the teacher when this is the case.

Curriculum

This does raise the issue of curriculum. Curriculum is about the identification of what it is useful for someone to learn (and so in teaching, for the teacher to teach). The term is most commonly used in formal educational settings, such as in schools. So, in a school or other formal educational context, there is a curriculum that both acts as a guide for the teachers in terms of what the desirable learning is that they are intending to bring about, but also as a means to both assess student progress and teacher effectiveness. Curriculum brings in mind the timetable of classes, perhaps labelled with subjects - mathematics, history, religious education, physics and so forth.

Yet curriculum would also include those things that may be taught outside of, or at least not entirely within, timetabled lessons: for example, related to values such as fairness, equity, honesty, toleration, empathy, and so forth. Those of us who have worked in schools, especially, will realise that much of our work around the school was concerned with such matters both in terms of being an example and in terms of pastoral work with the children. Indeed, it does not take long after entering work as a school teacher to realise that no matter how enthusiastic and committed one is to one's teaching subject, this has to be secondary to the role of socialising young people in terms of the values that make for a fair, non-violent, and caring society.

In a system with no education faculties, and so no locus for independent scholarship into teaching and learning of curriculum subjects, then it is very hard to see how an effective school curriculum can be set up. Curriculum is a bit like politics in an important respect: it is fine for ideologues to set out a vision for some imaginary utopia, but for a curriculum to deliver rather than just reflect aspirations it needs to be the art of the possible. Governments and learned societies can set out what they would like people to learn - but such goals may end up 'dead in a ditch' if they are not realistic. Classroom teachers would have an idea about that - but they are unlikely to be asked, and in any case there are people who study just such matters drawing on both disciplinary and educational expertise (see Figure 11). My examples are from science education, but clearly the same principles will apply in other areas of the curriculum.

I will assume here that the school curriculum will continue to be largely set out in terms of discrete curriculum subjects which reflect the academic disciplines such as history, physics, mathematics and so forth. That of course should

not be taken for granted, and there are strong reasons to consider that learning that takes place only within apparently discrete subjects has limitations. [23]

In the 21st Century many important developments and enterprises rely on groups of people from different specialisms working together in teams to solve problems or create innovations, and school curriculum that consists entirely of discrete and largely uncoordinated subjects does little to prepare people for this. However, it is also important to bear in mind that those multidisciplinary teams that society relies upon are not groups of generalists, but experts coming from particular specialist backgrounds. So, school needs to find ways to reflect this, by offering taste of the different disciplines AND opportunities to work across subjects.

So one recent trend, or, I suspect, fad, has been STEM in the school curriculum: the idea that the sciences, mathematics, and technology could be seen as part of one school subject: STEM. The danger of seeing STEM as a school subject in its own right is that in time it could be seen that schools need 'STEM' teachers trained in 'STEM' rather than disciplinary expert teachers - whilst I suspect higher education, where STEM seems to have been invented as a marketing ploy for ganging–up to get leverage on politicians, happily carries on with existing discipline–based departments that simply acknowledge STEM as a branding with as much impact on their essential identify as achieving an Investor-In-People plaque or a certificate to acknowledge compliance with fire regulations.

There is a real question then of how one offers a model of STEM in the curriculum which avoids students being in isolated silos, but does not dilute the very specialisms which give STEM is existence. [24] That is a debate that higher education, politicians and practising teachers can contribute to: but which needs to be informed by research and scholarship into the teaching and learning of those subjects in schools.

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[23] I therefore need to make a few comments about this. This could easily be the subject of a lecture series by itself so my purpose here is to simply give a taste of the issue, and to hint that intelligent debate around such matters needs to draw upon research and scholarship into subject teaching.

My teacher preparation (the post-graduate certificate in education) took place before the National Curriculum was introduced and I did a kind of 'joint honours' in the sense that I trained to have two main teaching subjects - chemistry and physics. I was therefore very aware of how material I was teaching in chemistry often drew upon more foundational ideas from physics. There is of course an academic debate about the extent to which subjects can be reduced into another and so, for example, the extent to which chemistry could be reduced to physics. At the risk of jumping to the punchline there, my own take would be that even if all chemical concepts could be reduced to physical concepts, it would be impractical to do so, as the higher level chemical concepts such as acid and oxidation do valuable work at that level.

What is important for learning the canonical chemical concepts is appreciating how chemistry builds upon underlying physical principles. A clear example is how the properties and 'behaviour' of the submicroscopic entities which have a core explanatory role in chemistry - that is molecules, ions, and so forth - can largely be explained in terms of simple electrostatic principles regarding how positive and negative charges interact - a basic bit of physics. What became obvious to me as a teacher and researcher of student learning was that this foundational and obvious application of physics in chemistry was not at all obvious to students. Indeed students often devise their own chemical level explanations that are completely contrary to the laws of physics, and so counter to what they need to think to do well in examinations (e.g., see Taber, K. S. (1998). The sharing-out of nuclear attraction: or 'I can't think about Physics in Chemistry'. *International Journal of Science Education*, 20(8), 1001-1014) .

Another example concerns teaching about the relationship between science and religion. This is something I have given some thought to given a spate of documentaries on major TV channels some years back suggesting that science and religion were essentially enemies and that a scientist must reject religion: a rather dangerous message to convey to young people in a country that needs a supply of scientists and where most people, at least nominally, are religious. This is clearly a complex area given that religious convictions vary a good deal, and that professional scientists take a whole spectrum of positions on the matter. Arguably the matter was addressed explicitly in the religious education curriculum, whilst the nature of science was dealt with in more detail in the science curriculum. Clearly this called for coordination between these departments in schools, which research suggested was not forthcoming. Talking to children understandably showed their own takes on the matter tended to be quite simplistic (e.g., see Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011). Secondary students' responses to perceptions of the relationship between science and religion: stances identified from an interview study. *Science Education*, 95(6), 1000-1025. doi:10.1002/sce.20459).

[24] Taber, K. S. (2018). Knowledge sans frontières? Conceptualising STEM in the curriculum to facilitate creativity and knowledge integration. In K. S. Taber, M. Sumida, & L. McClure (Eds.), *Teaching Gifted Learners in STEM Subjects: Developing talent in science, technology, engineering and mathematics* (pp. 1-19). Abingdon, Oxon: Routledge.

Getting the curriculum wrong

The process of developing curriculum has three important components. [25] The first of these is scoping the subject. So, if we want to represent chemistry or history or mathematics, or design and technology in the curriculum, we first need to know what counts as chemistry or history, etcetera. We probably do not need education faculties *for that*. The university geography department could advise on what is included in or excluded from the discipline of geography.

The second feature is selection. We cannot include all of mathematics in school mathematics, so someone has to decide which maths we will include. University departments will have an interest here as they know what they would like new students to already know, but experts from faculties *of education* may be better placed to advise on what mathematics is likely to be most useful to *most* students (who will not go onto advanced study of maths), as well as how realistic it is to set particular targets for the general student population. [26]

The third feature concerns how disciplinary material is *represented* in the curriculum This is a matter of modelling - of finding *the optimal level of simplification*. This is about simplifying complex abstract ideas enough for students of a particular age and level of study, whilst retaining the essence of the disciplinary idea represented. [27] The curricular model will often not be as complex and nuanced as the disciplinary concept (or learners will not make sense of it) but should not be inconsistent with the canonical version (or what is the point of teaching something that is basically incorrect?)

This is where *the disciplinary experts in the Faculty of Education are essential*. University academics in the source department can set out the canonical account, but this will often make little sense to school children. Developmental psychologists can offer general advice about how demanding an abstract concept is, but are not well placed to appreciate how it can be usefully modelled for school classes within a progression of models of the disciplinary ideas. These different experts could be brought together to co-operate yet *this very nexus of expertise already exists among the curriculum subject experts in the Education Faculty* (see Figure 15). It is those who specialise in studying the teaching and learning of the subject matter who are best placed to support this work.

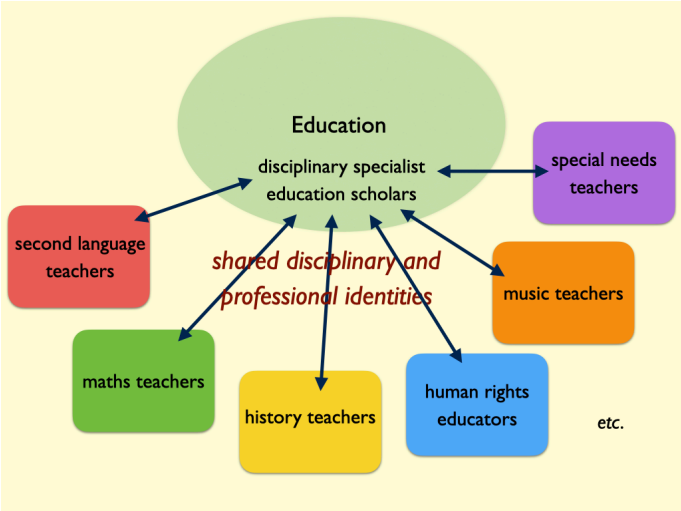

Figure 15. Disciplinary specialists working in education faculties are well-placed to mediate between academic subject communities and subject teachers in schools and colleges (and speak the languages of both)

[25] See, for example, Taber, K. S. (2019). *The Nature of the Chemical Concept: Constructing chemical knowledge in teaching and learning*. Cambridge: Royal Society of Chemistry.

[26] These experts can also advise on what is likely to be viable as subject matter for 7 years olds, and for 10 year olds, and for 14 year olds, and so forth.

[27] Taber, K. S. (2000) Finding the optimum level of simplification: the case of teaching about heat and temperature, *Physics Education*, 35 (5), pp.320-325

I will give one example of what happens when such scholars are not sufficiently included in the process.

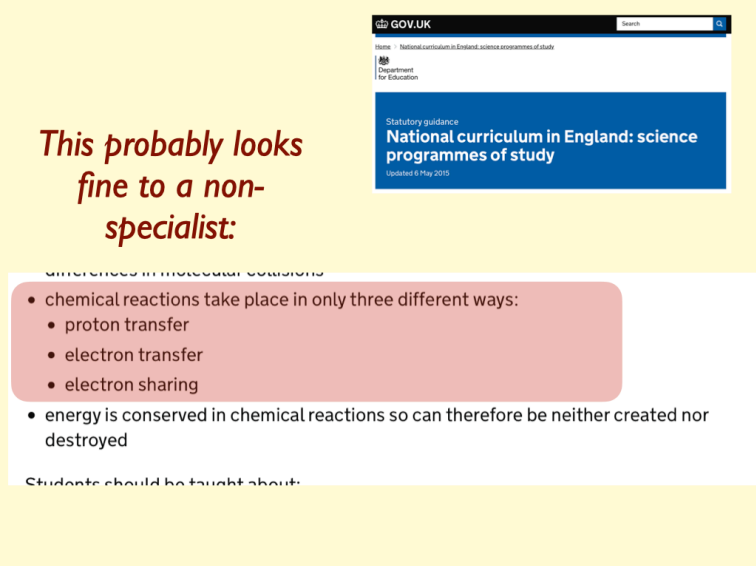

Figure 16. How are 14-16 years olds meant to make sense of precipitation reactions?

This (see Figure 16) is taken from the English National Curriculum (ENC) for Science, that is it is a legal formulation under statutory instrument The same form of words is copied into the requirements that are set out for examining boards, which explains why the same for of words appears in the examination specifications for GCSE science and chemistry of the English exam boards. A search of the web also finds the same form of words on a range of school websites, as part of information presented directly for children and their parents about what needs to be learned.

There are two aspects that are problematic and it will be helpful if I treat them separately. Part of this offers a model of the nature of chemical reaction mechanisms - of how reactions occur at the level of molecules and ions. Now, many of you may be grateful to know, I do not intend to go into detail of this matter here. (I do elsewhere. [28]) However, the formulation here seems to exclude some important classes of chemical reaction.[29]

Now, if I am pleading for the role of disciplinary experts in education faculties I can see I could be challenged on the basis that a chemistry expert, from a department of chemistry, should be able to spot this problem, and it does not need a subject-specialist education scholar. But I am not so sure. All chemical reactions can be understood as involving a shift in the electron density patterns around atomic cores (or kernels) so it might look to the *expert* chemistry academic that this is covered in the ENC definition.

Yet a careful, indeed somewhat hermeneutic, analysis of the ENC shows this cannot be how this curriculum statement is meant to be understood in terms of the level of treatment of other related concepts. I am not saying an academic from a chemistry department *could not* have undertaken such an analysis, but is is much easier for someone who is familiar with the way the subject is modelled in the curriculum, and with the relevant student learning difficulties, and

[28] Taber, K. S. (2020). Conceptual confusion in the chemistry curriculum: exemplifying the problematic nature of representing chemical concepts as target knowledge. *Foundations of Chemistry*, 22, 309–334. doi:https://doi.org/10.1007/s10698-019-09346-3

[29] At least, if chemical reaction is understood in its canonical meaning of a process which brings into existence a new substance or substances not present at the outset. I say "at least, if" as the English National Curriculum does not seem to set out any sense of what a chemical reaction is at the level at which humans beings can actually observe or carry out such a reaction: but only at the theoretical level of what happens to molecules, ions, etcetera. Whilst expert chemists do tend to have a strong focus on this realm of molecules, this is as the basis of explanatory models of what is going on at the observable level at the bench. Bizarrely the ENC seems here to ignore the level at which children can observe chemistry, and jump straight to the world of unobservable, hypothetical entities. I would imagine it is obvious that is a dubious decision even to those of you who are not chemistry education experts!

the compromises needed in teaching, and so forth. Someone else could *acquire* such expertise, but why would they, as that is not likely to be valued work in a chemistry department. [30]

That said, other errors in the document (see Figure 17) should be spotted by anyone who knows about chemistry - raising the issue of who actually wrote or checked the document!

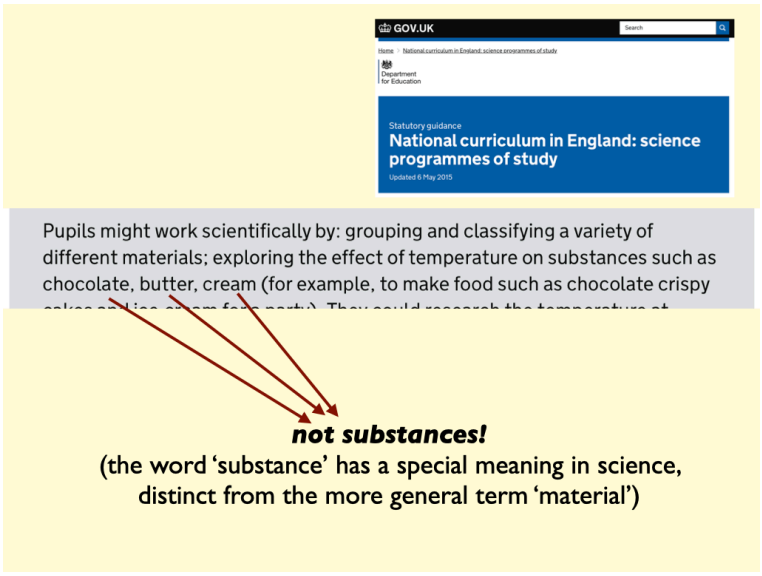

Figure 17. A 'schoolchild error' in the wording of what is to be taught to schoolchildren

This brings me to the other issue raised by this small extract (in Figure 18), that:

> "energy is conserved in chemical reactions so can therefore be neither created or destroyed"

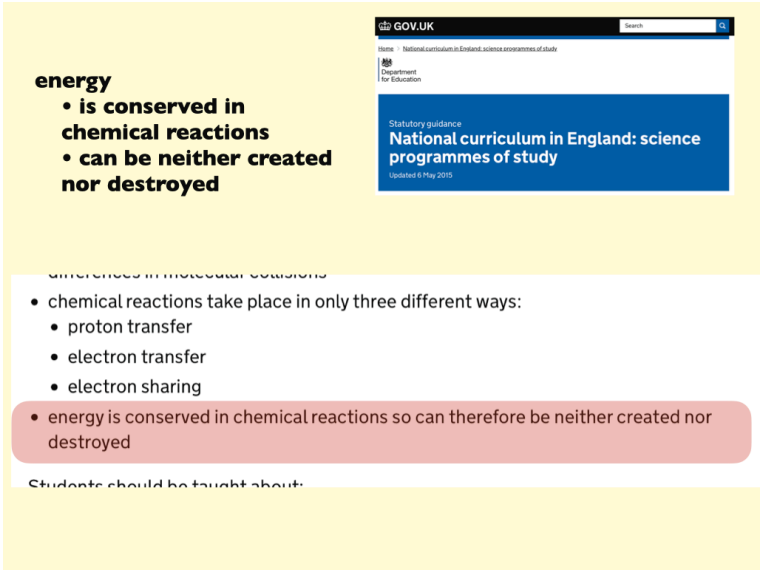

Figure 18. A logical 'howler'

[30] At least, in the UK. This may not be so true in some other national contexts.

This comprises of two elements, both of which are independently fine (see Figure 18). There is a fundamental law of physics, believed to always apply, that *energy is always conserved*, that is, it can never be created or destroyed. As (we think) energy is always conserved in all processes, this must include chemical processes such as reactions. So it is reasonable to say either:

> "energy is conserved in chemical reactions as (or because) energy can be neither created or destroyed"

or

> "energy can be neither created or destroyed so is (or must be/will be) conserved in chemical reactions" [31]

What we have here ["energy is conserved in chemical reactions so can therefore be neither created or destroyed"] is an error of logic. This is akin to saying:

> Socrates is a man;
>
> Socrates is mortal;
>
> so therefore all men are mortal [32]

In terms of logical structure, that is not that different from saying,

> Socrates is a man;
>
> Socrates played football for Brazil;
>
> so therefore all men play football for Brazil

Of course to appreciate that

> "energy is conserved in chemical reactions so can therefore be neither created or destroyed"

is a logical howler one has to both appreciate syllogism, which should apply to anyone we would considered educated enough to be writing, or checking a national curriculum document, [33] and know enough science to appreciate that conservation of energy is a higher level, more general, principle than conservation of energy in chemical reactions (see Figure 19). I do not think that is a particularly high bar given we are talking about the people entrusted with specifying the science all children in England should learn.

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[31] It is possible the wording is actually meant to be explaining what 'conserved' is, that is, perhaps the intended reading was along the lines: "energy is conserved in chemical reactions [which means that it can] be neither created or destroyed". This avoids the logical error, but suggests an error in the use of English which seems just as unacceptable.

[32] A standard syllogism is that "All men are mortal; Socrates is a man; therefore Socrates is mortal". The conclusion of "Socrates is a man; Socrates is mortal; so *therefore all men are mortal*" (i.e., that all men are mortal), may be correct here but that does not make it a logical deduction from premises that Socrates is a man, and Socrates is mortal… The football example makes this clearer as the conclusion is clearly not true. Those too young to remember Socrates (the Brazilian footballer) should note that presumably he was not the same person as the Socrates (the Greek philosopher) as that might imply Socrates was *not actually mortal* after all, which would offer a new perspective on why he (i.e., Socrates the philosopher) was prepared to take the hemlock when convicted of a capital crime.

[33] The work of Luria (directed by Vygotsky) suggested that understanding of syllogism may not be something spontaneously acquired without formal education. One would hope that those entrusted with preparing a national Curriculum might be selected from among those themselves having been educated to some reasonable level. (Luria, A. R. (1976). *Cognitive Development: Its cultural and social foundations*. Cambridge, Massachusetts: Harvard University Press.)

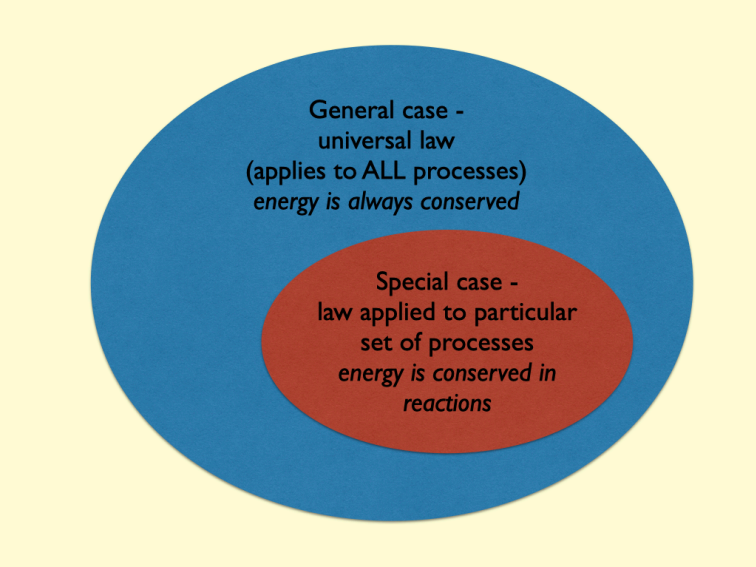

Figure19. One can infer the specific when it is subsumed by the general - but not vice versa.

Okay, errors occur. But how is it no one spotted this howler? [34] How is that the people responsible for preparing the requirements for examinations did not spot and correct it? How come the subject specialists in the exam boards did not spot this, and correct it? How come the teachers in the schools reproducing this gross error on school websites did not spot this and correct it? I can only assume hundreds of people have spotted this error, but felt that they are not in a position to call out the government. (Whether teachers teach this nonsense, or discretely just teach a corrected version remains a matter for speculation. I obviously hope the latter.) One group of people who can call out such errors are academics (see Figure 20) - those with the academic freedom to be critical without fearing this might be held against them.

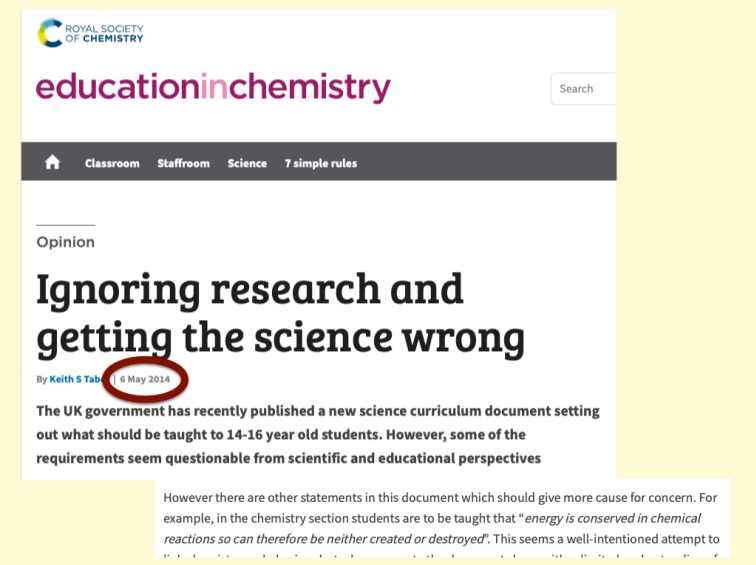

Figure 20. Those with 'tenure' and academic freedom should call out governments errors (even if they are not always taken notice of)

[34] When I say 'no one', I mean no one in the system. I actually pointed this out at the time the curriculum was first published in draft form. Taber, K. S. (2014, 6th May 2014). *Ignoring research and getting the science wrong.* educationinchemistryblog. 6th May 2014. Retrieved from https://edu.rsc.org/opinion/ignoring-research-and-getting-the-science-wrong/2010044.article. The Department for Education has been directly informed about these issues, but has no plans to make corrections at this time.

There have been a number of attempts to include more emphasis on the nature of science in the science curriculum - but largely undertaken without proper research and development to support teachers in acquiring subject knowledge, or advising on pedagogy or teaching resources. This is an area where there is a particular need for careful disciplinary scholarship, and the development of a viable curricular model that can be represented for school age students. Instead it seemed to be assumed that simply putting information in curriculum documents was sufficient. Arguably, there was a political and administrative process - but not an educational one (see Figure 21). [35]

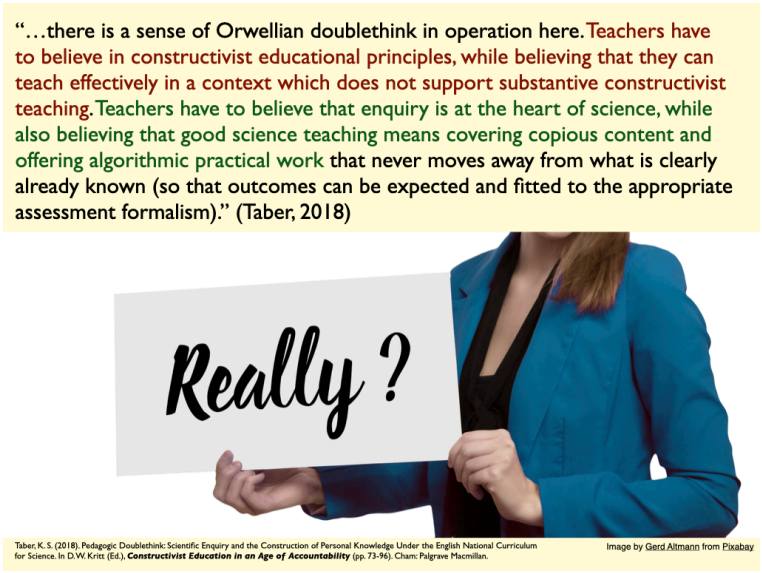

Figure 21: Curriculum change by fiat is not taken seriously when what is prescribed is inconsistent with the wider systemic context. [36]

Pedagogy

Turning then to pedagogy, I will refer to one other example where I think it is clear that subject-specific pedagogic expertise is needed (see Figure 22). As part of the initiatives known as the Key Stage 3 Strategy and later just the National Strategies the government commissioned subject-specific guidance on pedagogies in some areas of the curriculum. There was an irony in how this initiative was 'rolled-out', with trainers provided with script-like training

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[35] A key issue in the national curriculum for science has been the balance between teaching the products of science - the models, the theories, the principles - and teaching the nature of science - how science comes to knowledge, and the nature of that knowledge as reliable yet strictly provisional and open to question in the light of new evidence or a new way of looking at data. (Strictly here I am dealing with the ENC up to the point where former Secretary of State Gove seemed to decide to implicitly define knowledge in terms of facts, in complete disregard to the nature of science!) Over a number of years there were various tweaks, and indeed revolutions, in how this would be presented in the curriculum - both in terms of practical work and more widely, such as the role of science in considering socio-scientific issues.

Yet, ultimately, the intention to represent the nature of science in the ENC was a failure. Teachers were often not comfortable with this aspect of the curriculum, and did not feel well-resourced. What was needed was much more support from those people who were well placed to consider the subject matter, and the learning demands, and the way the subject matter could be represented appropriately in learning resources, and the best kinds of pedagogy to employ. This expertise is not found in governments or in university science faculties - but *among subject experts within education faculties*. These people can engage with the subject matter, the policies, and also work alongside teachers in classrooms, appreciating their constraints and speaking to them in a common language. Of course, many of the classroom teachers themselves have the nexus of knowledge and skills needed to engage in this kind of work: but we seldom give teachers the time or resources to do this kind of work, and it is unreasonable to expect a classroom teacher to be able to commit to prioritising such work. Whilst teachers should not expect to be given scripts for their classes - as pointed out above, that is not good pedagogy - they do need support in analysing concepts in terms of student learning characteristics, and in developing and testing resources and teaching approaches.

See, for example, Brock, R., & Taber, K. S. (2019). "I'm sad that it is gone": teachers' views on teaching the nature of science at Key Stage 4. *School Science Review*, 100(373), 69-74.

[36] Quote from: Taber, K. S. (2018). Pedagogic Doublethink: Scientific Enquiry and the Construction of Personal Knowledge Under the English National Curriculum for Science. In D.W. Kritt (Ed.), *Constructivist Education in an Age of Accountability*. Cham: Palgrave Macmillan.

materials to train school representatives who were asked to then cascade back to their colleagues. That is, the pedagogy modelled in the initiative seemed to assume that knowledge, including knowledge about good teaching practice, could be codified, represented in bullet points, and communicated in a fashion somewhat like the undergraduate lectures I parodied earlier. To be fair, the training did include interactivity, but based on a very standardised approach - along the lines, "now show figure 3 and ask this question,… and when you get this response, say…"

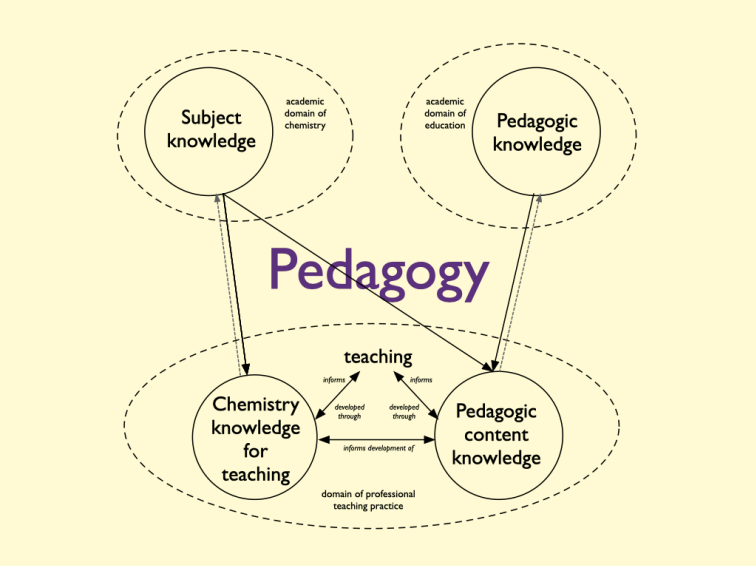

Figure 22: "The teacher's professional knowledge draws upon several knowledge domains and forms a dynamic system which develops through the application and evaluation of knowledge in teaching"
[37]

However, the actual advice offered included much of value, and in particular much that derived from research and scholarship in science education. Top academics in the field, such as Prof. John Gilbert and Prof. Robin Millar made inputs into the materials. One might argue that the key messages should not have been necessary for anyone who had completed teacher preparation on a PGCE [38] or similar route, [39] but even then there is a strong case that all learners need time for consolidation and reinforcement of key ideas: and there is no harm in reiterating research findings to those now settled in posts.

But even in this context the lack of expertise of those charged with compiling the initiative materials was clear. The materials put a good deal of emphasis on the idea that students come to class with alternative conceptions and

[37] Taber, K. S. (2020). *Foundations for Teaching Chemistry: Chemical knowledge for teaching*. Abingdon, Oxon.: Routledge.

[38] Post-Graduate Certificate in Education: a one year full-time course taken by graduates offering M level credit (which can often be put towards an MA or MEd degree) and professional preparation, and including much time in school classrooms work ing alongside qualified teachers.

[39] Another shift I have seen in my time working in education that is relevant to this point is the expectations of teacher preparation. Not so many years ago the government wanted a master's level profession, and attempted to put in place a new type of master's degree course, a Masters in Teaching and Learning (Burton & Goodman, 2011), which could relatively and quickly and cheaply achieve this aim. Like so many government attempts at quick fixes in the public services, the initiative soon collapsed. Since then the government has decided to relax the expectation that teachers should normally have qualified teaching status across the public sector. There are of course many excellent teachers who have entered the profession from various routes, but in the last decade it has become increasingly easy to enter teaching in England though routes which offer limited background in educational thought.

Burton, D., & Goodman, R. (2011). The Masters in Teaching and Learning: a revolution in teacher education or a bright light quickly extinguished? *Journal of Education for Teaching,* 37(1), 51-61. doi:10.1080/02607476.2011.538271

unhelpful intuitions which can lead to them not understanding or misunderstanding science teaching. There is an extensive literature in this area, that informs teacher education in science, much of it going back to at least the 1980s.[40]

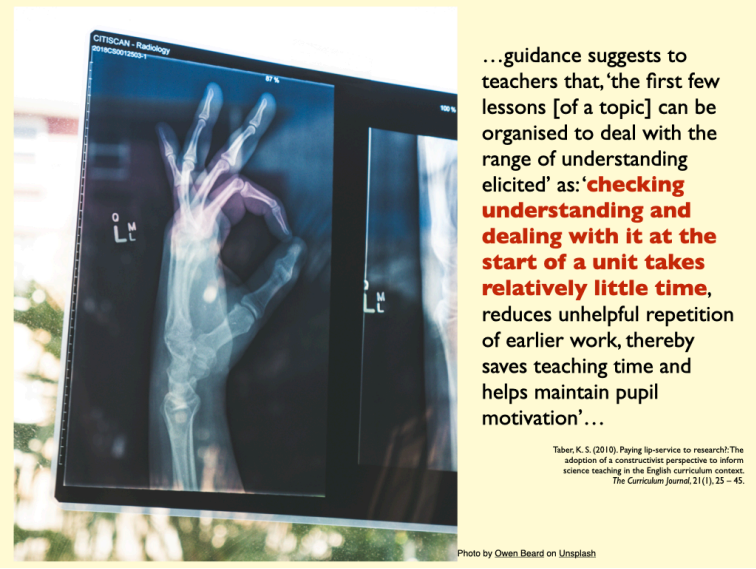

Figure 23: Addressing issues with learners' prior understanding trivialised [41]

The core message in the Strategy materials in this regard borrowed from an idea argued in much of the key literature: that when teaching a new topic, so one should first explore students existing ideas, and inform teaching accordingly to seek to shift students towards more canonical thinking. The Strategy accordingly recommended that teachers start a new topic with activities to elicit students' ideas. However the gist of the advice was little more that to find out what alternative conceptions students had, and then challenge them. This very much gave the impression (or at least gave me the impression) of advice from someone who had made the effort to find out what research said but had never actually taught any of the subject matter concerned at school level themselves (See Figure 23). That advice was fine, as far as it went, but it was not enough to help a teacher, especially a new teacher or a biologist teaching a physics topic (or vice versa) as so often happens.

This is a bit like telling a novice researcher to first pick something to enquire into, then develop their research design, then collect and analyse their data, and then wrote up their findings: that is, it may be fine as an overview, but it invites a lot of questions about precisely how to follow the advice. [42]

Now there is a good deal of research exploring conceptual development in science, and in approaches designed to shift student thinking in different topics. This is, generally, research undertaken by discipline-specific education experts who have expertise in the subject matter, and in what happens in school classrooms, and know about student thinking in the subject and the kinds of pedagogy likely to be effective. The Strategy materials *did* reference some of these findings in specific places, but in terms of the overall gist of the guidance 'now address the misconceptions you have found' was at the level of saying to a medical student once you have diagnosed the heart condition the patient suffers from, now proceed with the appropriate medical or surgical treatment. A little more specificity and detail would be useful.

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[40] This area of work is reviewed in Taber, K. S. (2009). *Progressing Science Education: Constructing the scientific research programme into the contingent nature of learning science*. Dordrecht: Springer.

[41] Quote from: Taber, K. S. (2010). Paying lip-service to research?: The adoption of a constructivist perspective to inform science teaching in the English curriculum context. *The Curriculum Journal*, 21(1), 25 – 45.

[42] I recall actually receiving guidance along these lines at one point in my career.

My point is that even in a context where there was an attempt to provide guidance for teachers that was research-informed the final results suggested that the job of compiling and authoring was entrusted to people without sufficient experience of actually working in real classrooms trying to teach the subject matter to real students.

This is a real concern when we consider recent government thinking about initial teacher education as something that should be largely entrusted to the schools (cf. Figure 24). That is, seeing learning to teach as something of on-the-job acquisition of craft skills and induction into existing custom and practice. Of course, there are many skilled and intelligent people working in schools who can make excellent teacher educators, and the model used in Faculties like this is a partnership model incorporating this expertise. Many of these same people would also be perfectly capable of progressing educational studies through scholarship and research, should they be so inclined, as long as they are sufficiently prepared for, and resourced in, such a role.

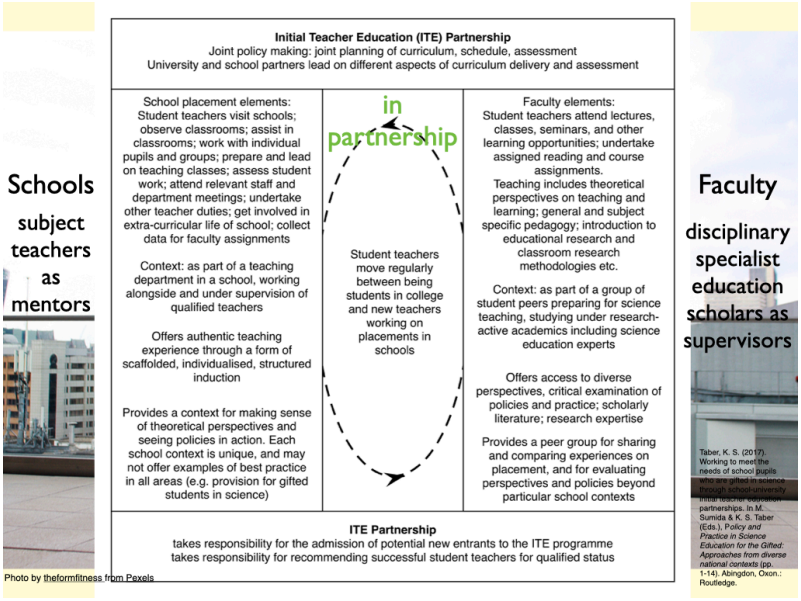

Figure 24. Initial teacher education as a partnership that allow iterative professional learning [43]

In general, though, a model of teacher preparation based exclusively within schools themselves is an insular model at best intended to reproduce and tweak the status quo, rather than question, challenge, and transform, educational practices. It is also a system in which there are inbuilt expectations to follow, rather than critique, government policies and initiatives.

I wonder if a teacher educator working in such a context would be given the freedom to give a public talk of the kind I am presenting today without someone wanting to preview and perhaps even censure comments that could be seen as critical of the institution, the system, the government, or its agencies? The scholar afforded academic freedom, the right to research and write as seen fit, without external interference, could be seen as part of the fourth estate that plays an important role in any democratic society.

In conclusion

The point of a faculty of education is *to further research, scholarship and practice in education*.

[43] Image from Taber, K. S. (2017). Working to meet the needs of school pupils who are gifted in science through school-university initial teacher education partnerships. In M. Sumida & K. S. Taber (Eds.), *Policy and Practice in Science Education for the Gifted: Approaches from diverse national contexts* (pp. 1-14). Abingdon, Oxon.: Routledge.

Education has as its key foci, teaching and learning, and these should then be key foci of any faculty of education. Learning occurs all the time, deliberately and inadvertently, in formal and informal contexts, and is a focus of psychological studies. Education implies something *more* than incidental learning - it suggests learning that is intended by someone (the learner, a parent, a teacher, the society) such that conditions are deliberately organised with the aim of supporting that learning.

Teaching and teachers are therefore central.

Curriculum is central because that is the business of deciding what it is worthwhile to learn, and what it is sensible to try and ask particular learners to engage with. Pedagogy is central because that is the process by which teaching can be undertaken, more or less effectively. General pedagogical principles are important, but are not enough to guide good teaching. Effective teaching requires detailed work on analysis of subject matter, development of curriculum models and teaching models, and targeted resources, to support learning (see Figure 25). It requires specific guidance on learning difficulties, and sensible sequencing, and pacing. There is also room for expertise on working with particular groups of students - the deaf, second language learners, the 'gifted' and so forth - and this may mean collaborations between curriculum subject specialists and others.

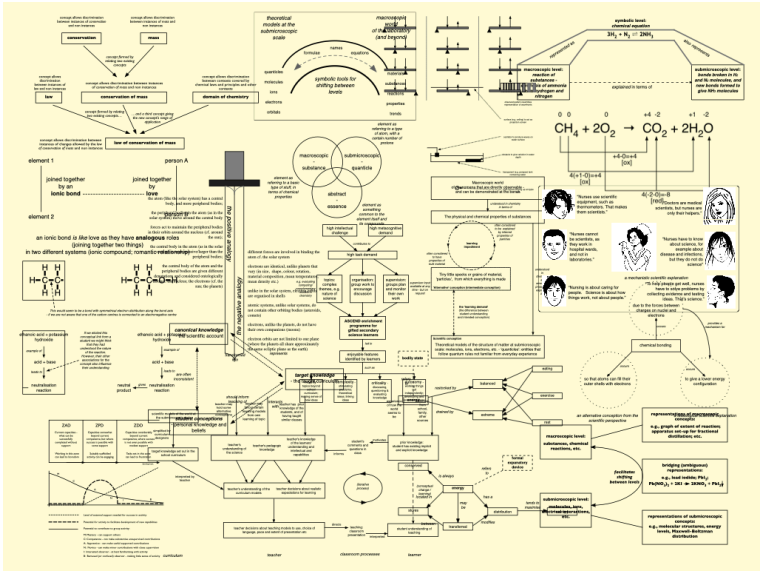

Figure 25. Effective teaching requires detailed work on analysis of subject matter, development of curriculum models and teaching models, and targeted resources, to support learning

There is certainly a need to find ways to break down the compartmentalisation of learning that our artificial (but often practically necessary) timetable structures can encourage. So, there need to be opportunities to open up the timetable for cross-curricular projects for example: but this will only be successful when it engages expertise from the different areas of subject teaching involved.

There is certainly room for a faculty of education to do much more, but if we are to meet our social contract and justify our public support, as well as our unique place in the academy, we must ensure that we support society in improving education, and an important part of that depends on disciplinary experts working to induct and develop teachers, and carrying out the scholarship and research to support practice, and to advise, and where necessary criticise, governments on policy (see Figure 26).

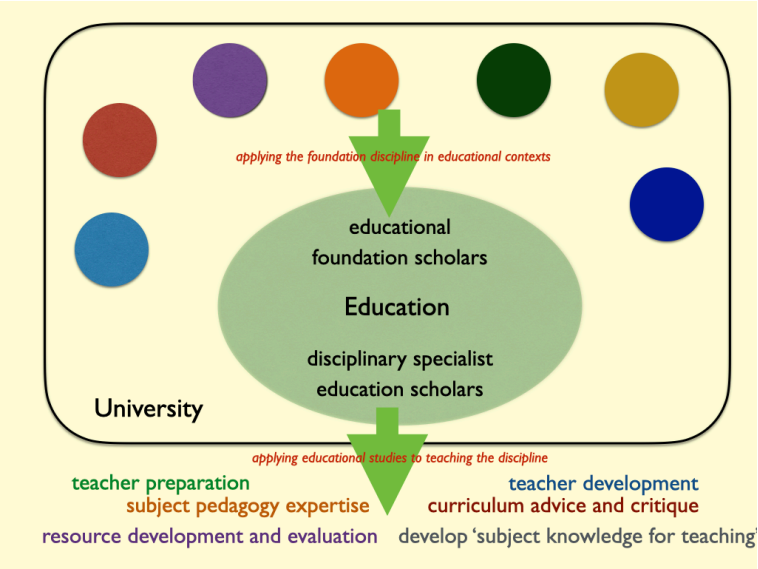

Figure 26. Improving education depends on disciplinary experts working to induct and develop teachers, and carrying out the scholarship and research to support practice, and to advise, and where necessary criticise, governments on policy

That is the USP of a faculty of education, and that is what most taxpayers will understand as the point of a faculty of education, and that is *what the Faculty can tell the University it can do that cannot be done just as well somewhere else in the academy*.