**Title:** Apprenticeship in science research: whom does it serve?

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**Abstract**

This article advances the thinking of Thompson, Conaway and Dolan's "Undergraduate students' development of social, cultural, and human capital in a network research experience". Set against a background of change in the biosciences, and participation, it firstly explores ideas of what it means to be a scientist, then challenges the current view of the apprenticeship model of career trajectory, before going onto to consider the nature of participation in communities of practice and issues related to underrepresented minority groups in science. Central to this analysis is the place that the notion of *habitus* plays in thinking about shaping future scientists and the how this can both support, but also suppress, opportunities for individuals through a maintenance of the status quo.

**Keywords**

Science research. Communities of practice. *Habitus*. Capital. Undergraduate biology.

## Introduction

This review essay addresses issues raised in Jennifer Thompson, Evan Conaway and Erin Dolan's paper entitled: *Undergraduate students' development of social, cultural, and human capital in a network research experience*.

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Jennifer Thompson, Evan Conaway and Erin Dolan's paper is concerned with how research experiences support undergraduate students studying on biological science degree courses to develop as scientists. Noting that research experience, typically as part of final year projects, provides both positive cognitive and professional gain for undergraduates, they argue that central to this success is the place of integration into the research team and social network. At its best, this apprenticeship in science encourages undergraduates to continue with their participation at the end of their degree, going on to work as a professional scientist. Rapid developments in bioscience mean that the ways in which scientists work is changing, with a much greater emphasis on interdisciplinary collaboration and sharing of expertise. Understanding the effect of this on development of knowledge, identity as a scientist and possibilities surrounding career choice are becoming ever more important. Their paper is timely because of their specific focus on undergraduates working in this emerging world of multi-institutional and interdisciplinary biology – so called 'network research'.

Thompson et al. are interested in how these new approaches to scientific research support students' development of cultural, human and social capital. They draw heavily on Bourdieu's notion of cultural capital as "dispositions of the mind and body" with reference to thinking and working like a scientist and argue that undergraduates are developing this through their participation in network research. Moving away from the more classical interpretation of 'high culture' *habitus* though, Thompson et al. consider the context-specific approach of Lareau and Weininger (2003). Thompson et al. recognise that capital associated with becoming a scientist is about knowledge, skills and values but equally 'who you know', both in terms of sharing of expertise knowledge across networks and 'ties' giving access to specific resources (both human and material). They also acknowledge that a tension exists where cultural capital can, in some cases, lead to a status quo of norms and practices which has adverse effects on social mobility and change. It is here that there lies a potential problem with the 'apprenticeship' model of induction into 'working as a scientist'. On one hand, there are established approaches in science which are inherent in becoming a scientist, but on the other hand, a conceptualisation of 'this is how science is done' is problematic, both in terms of how science develops and changes and how this perception of science may marginalise groups. This calls into question the privileged position of acquired *science habitus*, and demands scrutiny of its development, the role of enculturation into scientific working practices, the place of minority groups in science and the relationship between different types of knowledge and established scientific knowledge. These issues are addressed in this response article.

**Becoming a scientist**

The sciences, and especially the biosciences are changing. An examination of a university biology department will show that, firstly, it is almost certainly no longer called the 'Biology' department, and is more likely referred to as something like 'Life Sciences' and is often distributed across a range of disciplines in molecular chemistry, biomedicine, anatomy and computer informatics. The traditional view of biology as being the work of the professional natural historian is no longer applicable, and this is the world that students find themselves in while studying school science, and then if they continue as undergraduate 'biologists' and professional research scientists. Becoming a professional science is a complex process, with a trajectory which traditionally involves a bachelor degree, possible masters qualifications, doctoral research, short contract post-doctoral work and eventually a lectureship. Research expertise is developed through formal teaching, as well as the more informal, learning 'on the job' which Thompson et al.'s study examines. Alongside this runs the need to publish research findings, present at academic conferences and, eventually, bid for funding to support one's work and, potentially, ensure job security. This 'apprenticeship' model, explored in part by Thompson et al., of learning has changed little in the past 150 years, while the landscape in which science operates – both in terms of the developing interdisciplinary nature of scientific research and the relationship between science and society – has undergone major reformation.

How students become enculturated into this system starts with them identifying with science and developing their own scientific identity. The role that family plays in shaping students' engagement with, and aspirations towards, science are well documented (e.g. Stake 2006). However, this relationship is complex and evidence shows it to vary between ethnic groups (DeWitt et al. 2011). For example, Asian parents have been show to provide significant support for career aspirations in STEM subjects (Aschbacher 2010). Moreover, family influences are also important in explaining the gender gap in studying science, both in school and university (Tenenbaum and Leaper 2003). Social class also helps explain the unevenness of representation of science undergraduates (Aschbacher et al. 2010) with evidence pointing to the highest science achievers tending to come from more affluent families. These families are the ones which often process strong scientific social capital.

Becoming a scientist, it seems, is as much about the process of apprenticeship as it is having the opportunities that allow an individual to develop their own identity or identities of 'being a scientist'. This prompts questions about how much the apprenticeship model supports the uptake of science at university, how this passes through to school and 'family' ideas about science and how change here might better support the uptake of science at both school and university by underrepresented minority groups. The current apprenticeship-style model in science research draws much of its theoretical perspectives from Vygotskian ideas of constructivism (Hunter, Laursen and Seymour 2006) where the learner (in this case the novice scientist) develops knowledge and understanding through the assimilation of new ideas and ways of thinking with prior knowledge, through reconstruction. This process becomes social once it is set within the context of collaboration and two-way dialogue between master and novice, something common in science research. To be a true apprenticeship, this model needs modifying and developing into a ‘community of practice’ (Lave and Wenger, 1991). Through this the novice is inducted in the processes of science and is gradually able to shift from peripheral to authentic participation. This process is supported by the learner also developing cultural knowledge of 'how' to be an expert, as well as learning to think and act in appropriate ways. This is a potential double-edged sword. On the one hand, the enculturation into the practice of science may well not only support the novice in the established practices of science, but also provide them with skills and knowledge to answer, as yet, unknown questions; that is, to use their knowledge in new and creative ways. This is ever more important in the rapidly changing world of bioscience, where the future worlds we may inhabit are, in many ways, unknowable in the present. However, on the other hand, enculturation into an established community of practice may not encourage change but, as Thompson et al. identify, simply promote the status quo. This presents two problems. One is lack of progress and vision in research; the other is the development of a stereotypical identity of what it means to be a scientist.

A good example of the first of these problems comes from the world of evolutionary biology. In the 1970s, U.S. academics Stephen Jay Gould (Harvard University) and Niles Eldredge (American Museum of Natural History) proposed a radical neo-Darwinist explanation of evolution whereby speciation occurred not in a gradual and staged way (the traditional view of evolution) but through periods of rapid change, interspersed with long periods of stasis with little or not change – so called, punctuated equilibria. The evidence to support this hypothesis came from the scarcity of the fossil record and apparent 'diversity explosions'. This view as an evolutionary mechanism was challenged by biologists who took a more traditional view of gradualism, and interpreted the 'gaps' in the fossil record as being due to the rarity of fossils. Debate about gradualism versus punctuated equilibria was an important part of evolutionary biology throughout much of the 1980s and ‘90s. It is now widely recognised that, while probably being important at the level of micro-evolution, the ideas of Gould and Eldredge are probably less important in terms of large scale evolution.

So, why is this important? A biology student studying in Harvard throughout the 1970s to ‘80s would have undoubtedly been immersed in, and enculturated into, the punctuated equilibrium paradigm of evolution. It would have taken a brave undergraduate or early career researcher to have challenged this view – especially as both Gould and Eldredge were, quite rightly, perceived to be 'heavy-weight' biologists. This does not mean that Harvard was closed to the alternative ideas to explain evolution. What it does mean though is that to become a member of the Harvard Biology community of practice would mean developing knowledge, skills and eventually acceptance of the ‘punctuated equilibrium’ way of thinking about evolution – something which must have been discomforting to wrestle with as the evidence to support it started to be more robustly challenged.

But what of the second problem? What are the implications of maintenance of the status quo in science research for supporting innovation in science and encouraging underrepresented groups to identify with science as 'something for them'?

**Engaging in communities of practice in science research**

At the heart of Thompson et al.'s article is Bourdieu’s notion of *habitus* leading to effective use of capital, and how this can be usefully conceptualised to encompass the context in which communities of practice operate. *Habitus* has been effectively used to consider how individuals develop and establish identities and how they use these 'habits of mind' in what they think and do. Making the connection between both the formation *and* the use of *habitus* for capital has significant implications for the apprenticeship model of science research. Learning through experience in the workplace involves individuals participating “in the practices of social communities and constructing identities in relation to these communities” (Wenger 1998, p. 4) and the nature of activities and relationships in the workplace offer opportunities for this learning to happen. Billett (2004) argues that these opportunities are ‘inherently pedagogical’ and provide “access to the knowledge needed to sustain those practices” (p. 119). However, there is evidence to show that, as they start to develop new ways of working and thinking within a specific community of practice, some new academics find exerting agency a challenge (Knight and Trowler 2000). For example, as Jawitz (2009) posits, understanding the assessment of the development of skills and knowledge which are not always tacit can be problematic for the learner as they attempt to navigate their way through learning through imitation and copying of relevant social practices. Echoing Bernstein’s ‘invisible pedagogies’ (Bernstein 2003), this approach to learning is very unlike the model of teaching, learning and assessment observed in school where the importance of lesson aims, objectives and measurable outcomes mean learners are much more aware of expectations, and their own learning.

Central to situated learning is the relationship between the individual and the community into which they are attempting to become enculturated. Central to the theory of communities of practice is that knowledge is distributed throughout the community and that understanding this can only come through a model of what Lave and Wenger (1991) call 'interpretive support'. The 'community' comes when this knowledge is shared and all members are able to develop the shared repertoire of skills and knowledge. This is what Thompson et al. argue is happening to most of the undergraduate students they describe. However, for this to truly be the case (i.e. the new members display *legitimate peripheral participation* moving to *authentic participation* in the community) there are a number of stages which Lave and Wenger (1991) and Wenger (1998) argue are vital: firstly, carrying out meaningful, legitimate tasks which have low levels of responsibility; and secondly, moving on to have opportunities to identify personal trajectories which link past experiences with future possibilities for the community. Drawing on this second point, Wenger (1998) goes on to suggest that certain trajectories are more significant than others, especially those embodying the community history – so called ‘pragmatic trajectories. These ‘paradigmatic trajectories’ are the most influential at providing full acceptance into a community of practice, but may well conflict with the personal trajectories of the newcomer. This is a challenge which Thompson et al. do not have space to explore but it is an important one. If the personal nature of learning, the individuals' abilities to identify and make use of social, human and cultural capital, and career aspirations, are not recognised in the apprenticeship of science research then opportunities may well be lost. Additionally, individuals may be put off from attempting to become members of the science research community in the first place, something which has obvious implications for participation.

Thompson et al. recognise that their study was limited in not being able to explore the role race, ethnicity and gender play in how students gain access to research opportunities or how these lead to desirable outcomes, but these omissions are important. Not only does their omission say much about the homogeneity of the 'science research' group but also the lack of opportunity certain underrepresented groups perceive they have, or do have within science research, and how their individual capital is both potentially and actually operationalized. This is final issue I wish to explore.

**Status quo in science research**

As discussed, a potential problem with the apprenticeship model of the science research is that it encourages the passing on of skills and knowledge which inhibit change – some of which could be very significant in terms of research opportunities, future visions and access to all.

Ovink and Veazey (2011) discuss the pressing problem of the lack of minority students in the science and medical sciences. As they argue, increasing participation from these groups would have two positive outcomes: 1. it will almost certainly lead to new, innovative ideas in science research and, 2. it will also better serve the population in terms of their relationship with, and use of, scientific information and knowledge. As Ovink and Veazey (2011) explain, while the lack of enrolment of underrepresented students in universities is a problem across all programmes in a majority of countries, the situation in science is often the worst. For example, in 2009 less than 10% of these students were studying on science programmes in the U.S. (National Science Foundation, 2009). The situation is even worse in terms of transfer from undergraduate to postgraduate degree.

Encouragingly, studies that are similar to the experiences that Thompson et al. describe in their network approach to enculturation in science research have been shown to be effective for underrepresented minority students (e.g. Bernier, Larose and Soucy 2005). A key barrier to integration seems to be the failure to recognise the individual capital, both social and cultural, that these students bring to university, with too much emphasis being given to the 'making them fit' model of science research rather than allowing them the opportunity to explore their response to enculturation at a personal level (Fox Sonnert and Nikiforova 2009).

It is important to recognise that Bourdieu identities capital as a means of groups (elites) obtaining and maintaining power; it should go without saying that the language of 'elites' and 'power' has implications for how people perceive 'experts'. That is not to say we do not want scientists to be elite and expert; it would be odd if they were not encouraged in this way – imagine supporting such a notion for top sports people representing one's country. But how other, non-members of the group might perceive these positions of elitism and power is potentially problematic in terms of their engagement and aspirations in science. Bourdieu’s work says much about class and how *habitus* is developed in terms of class-specific tastes, dispositions and preferences (e.g. Bourdieu 1990). Importantly, he argues that cultural capital is a product of the *habitus* we possess in our social class of origin. This means that the non-elite are limited by expectations which means they are inhibited from accessing different cultural capital.

The typical approach to examination of underrepresented minority groups in their education is to take the Bourdieuian perspective that these groups are suppressed by the power and authority of capital (Ovink and Veazey 2011). Here these groups are seen to be underprivileged because of low economic status. But the issue is more complex, because gaining access to capital is a product of both access **and** knowledge of acquisition; the issue of 'knowing the right people' or 'making ties', as Thompson et al. put it. What seems particularly important is that as minority students move into university, they do not leave behind their cultural capital to take on a new, academic capital but opportunities are presented which allow integration of these two, potentially clashing capitals (e.g. Maldonado, Rhoads and Buenavista 2005). This contrasts sharply with the apprenticeship model that Thompson et al. describe.

So, what can be done? If Bourdieuian notions of *habitus* are right, that it is developed early in life and, significantly, is resistant to change, then we need to consider the interactions that take place within a community of practice as well as consider how *habitus* is created through practice. At the same time, we should, as Ovink and Veazey (2011) argue, stop viewing our conception of *habitus* as constraining to one where limiting *habitus* may be motivating. Providing greater opportunities for undergraduates to work with others they identify with as 'like themselves' is central to this. Unfortunately, the current position of the science researcher apprenticeship is far removed from this model and as such perpetuates the status quo.

## The future

The changing world of bioscience research calls for new, creative and exciting ways to think, utilise knowledge and bringing together varied and potentially clashing ideas. Thompson et al.'s model of networks of scientists working in collaboration is a promising approach and their article provides interesting insight into how this might be cultivated and enhanced for the next generation of scientist. However, caution is needed when the apprenticeship into this more radical way of working in science is still traditional, with planned trajectories, designed by powerful 'others' and removed from the individual. An approach that maintains the status quo is dangerous; stagnation, boredom and lack of innovation loom heavy in such situations. If we want a scientific elite which draws on the best ideas, is open to change and sees the individual as an important part of that process, we need to reconsider how *habitus* is conceptualised along with notions we have of the place that the individual has in society.

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