

# ENCOUNTERS WITH INDEPENDENT GRADUATE STUDY: CHANGES IN LEARNING STYLE

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*This paper considers students whose undergraduate study was characterised for them by either natural or alien learning and examines the ways they evolve or change their style of learning when they encounter independent graduate study in mathematics. We explore the changes they undergo and, towards the end of the paper, fit those movements into a developing theory grounded in the data from interviews with all the PhD students at one medium sized mathematics department in the UK.*

## Introduction

What happens when you find yourself learning on your own? While the notion of a transition is fundamental to many areas of mathematics education, the transition we examine in this paper is perhaps the one that we might genuinely call ‘becoming a mathematician’: the transition to independent graduate study.

The transitions in understanding concepts, social transitions that accompany changes between schooling levels and transitions between levels of abstraction/generalisation have all been the subject of significant research programmes within the mathematics education community. Often these transitions may co-occur: new concepts or different levels of abstract thinking can come just as students move to a new level of schooling. In each case, the new situation requires the learner to develop both new mathematical ideas *and* new ideas about the learning of mathematics and the didactic contract which must be negotiated between student and teacher. In this paper, we consider the situation in which, while there may still be a teacher (in the form of a supervisor), the relationship between the learner, the knowledge and this teacher is radically different from all those at previous levels.

We consider some of these aspects in relation to the transition between undergraduate study and independent graduate study (which, in the UK context, we take to be a substantial doctoral study leading to an original thesis in some field of mathematics). This paper examines the form this transition took for 13 PhD mathematics students – the entire available PhD population, who were at various stages in their work – at one

UK university and, in particular, the ways in which the students' learning styles appeared to change in response to the new learning situation.

### **Background and research method**

The existing literature on learning styles is quite extensive, but has been built predominately from studies at school or undergraduate level. The theories which have been developed have been useful in analysing the difficulties students have in learning new knowledge they encounter. Many of these are built around a basic dichotomy between students who seek to connect new knowledge with old and those who do not. Relational and instrumental understanding (Skemp, 1976), deep and surface learning (Marton & Saljo, 1976), procedural and conceptual knowledge (Hiebert & Lefevre, 1986) etc. all place this split at the centre of their theory.

In our own work (Duffin and Simpson, 1993), we have developed a theory of the ways in which learners might respond to new knowledge by absorbing it into existing structures (a *natural* response), limiting or modifying existing structures to deal with it (a *conflicting* response) or by building a new, initially separate structure to house the new knowledge (an *alien* response).

Following Pinto's work with our theory (Pinto, 1998) we have extended this theory about responses to learning encounters to develop a split between learners. On the one hand we have those who attempt to make analogical connections between new knowledge and existing ideas and are loathe to accept knowledge which does not fit easily into existing structures (who we call *natural* learners). On the other we have those who are happy to develop a separate schema to cope with new experiences, perhaps only later using conflicts to connect pieces of knowledge together (who we call *alien* learners).

While student responses to the new learning environment they face in independent graduate study have been the subject of some research, it tends to be general, focussing across a large number of subject boundaries. The large, ESRC-funded projects reported in Burgess et al (1995), Pole et al (1997) while focussing significantly on the relationship between students and supervisors, suggested a split between students as 'technicians' (focussing on the skills required for research) and students as 'scholars' (focussing on the substantive knowledge uncovered). Similarly, Ford (1985) examined a split between holist and serialist graduate learners, albeit with students at masters, rather than independent doctoral level.

However, in this paper, we will see that when we focus more tightly on the specific topic of mathematics, the straightforward dichotomies of natural/alien, scholar/technician and holist/serialist need to be expanded.

We draw upon a larger paper based on semi-structured interviews focussing on two main areas of interest. We asked students about their personal learning histories from primary school onwards, but focussing more often on recent, accessible memories from their undergraduate study. We also asked them to consider their current learning

style, specifically about how they would respond to being asked to learn a new area of mathematics. In addition, all of the students had some contact with undergraduates, normally through tutorial teaching and we gained some insight into their understanding of their own learning from their discussions of their perceptions of others.

The interviews were conducted in the style of a 'conversation with a purpose' (Burgess, 1988), they were independently coded and initially analysed by each author and, while we inevitably had the existing learning style dichotomies in mind, we were careful about imposing the theory on the new situation so that any theory concerning how students respond to independent graduate study was grounded in the data. As we will show, we were right to take such care as this investigation caused us to expand and refine the theory in unexpected ways.

While we did not intend to gather data representative of a postgraduate mathematics population, the sample consisted of all the available doctoral students from a medium sized mathematics department in the UK and may be seen to provide access to the key themes which shape students' renegotiations of their learning style in response to independent graduate study. The number of issues raised by the data from this sample suggests the validity of this transition as an area of study that we plan to investigate across a much larger group.

## **Movements**

Clearly, the interviews were rich in issues to be investigated. In particular we encountered on student who showed flexibility in his learning, able to choose a style depending on both context and the value he placed on the knowledge to be gained. Another retained a strongly alien mode of learning, becoming an arch-formalist. Yet another defied expectation by appearing to move from a natural to an alien learning style.

However, in a paper of this length, we will concentrate on only the general sense of movement (in terms of the change of learning style) which the sample as a whole students revealed to us as the students described how they came to terms with their own changed circumstances as postgraduates.

Our independent coding clearly split the students on their undergraduate (and school) style of learning into natural and alien learners as described above. What we discovered, however, was that while the natural learners evolved their learning style to cope well with independent study, the alien learners had to adopt new styles – in two quite different ways.

### *Natural Learners*

Six of the students were classified as showing aspects of natural learning in their undergraduate style. The movement to graduate study seemed to be quite smooth for

them and we get little sense of change of learning style. A typical example is Brian, who described his attempts to learn new mathematics as a graduate student in exactly the same ways as he had as an undergraduate:

When I do try to look at the definitions of a new subject, I do try to think how it relates to different things I've done before, that does make me feel a lot more sure about it. For instance, like if you first look and it said the inner product on a Hilbert Space, I see that as a generalisation in multiplication and then it becomes more sort of meaningful.

(Brian)

However one notable aspect of the movement to graduate study for natural learners was that they viewed it with some relief: it gave validity to their way of working, in contrast to their undergraduate experience where they appeared to feel that they achieved less well than did those students who saw the mathematics as 'just something to be learned by rote'.

Thus Oliver, thinking of himself when he was an undergraduate observing fellow students, spoke of how he would tussle with a problem: 'I would interrogate it to death ... it took a long time for me to get it into my thick skull' while others 'just seemed to recite the mantra and see it as something to be learned'. His perception was that these students often appeared to achieve better than he did: there was, to him, a clear disadvantage to his learning style:

... for exams yes, which in some sense is a little silly and is perhaps reflected by the fact I didn't get a first. With some subjects analysis for example standard questions prove whatever theorem, and so there are some people who will just develop short term memory tricks just rather like an actor learning lines. ... I suppose in some sense I emerged with a greater understanding for having done so. But the downfall of that I suppose is that I would spend too long on learning certain proofs and therefore not learn enough proofs and would then invariably be left in the dark on certain questions.

(Oliver)

In graduate study, however, the "downfall" is less obvious as the sense of a frenetic pace of learning is replaced by a sense of confidence:

... it's just a question of, well occasionally talking to different people in the coffee room assimilating different examples, examples are important. Very, very, very slowly absorbing principally I guess through osmosis

(Oliver)

Not all the natural learners had completely left the frustration behind. Christos described his own learning as being "like a big building where I start all the way from the ground until the top of it". Although he felt he had been a natural learner throughout most of his school and undergraduate learning, he did undergo some changes on becoming a postgraduate student. He said that before graduating he limited himself largely to learning from his lecture notes and contrasted this with his

postgraduate work because he used books more at that level. However, he found that there still wasn't really time to do as he liked to do 'to get to understand every detail' saying "I know we don't have all the time in the world and life is short so I just try to understand as much as possible".

So natural learners seem to take their encounters with independent graduate study in their stride. The frustrations of the speed of undergraduate learning (or appearing to be surrounded by those who learn faster – if only by rote) are much lessened. Their fundamental learning style is rewarded by the freedoms of graduate study.

### *Alien Learners*

In contrast, alien learners, accustomed to the comparative safety of undergraduate learning where they had a set text to follow and procedural methods to use to achieve success, found that their accustomed way of working was no longer adequate to their new circumstances. It required them to be able to work independently and some tended to feel less secure and confident than hitherto. Lucy, for example, says

There's no set syllabus. I find that a lot harder ... It's a bit difficult if you are trying to muddle through by yourself. I like to be told. Once I've been told I can then understand. I don't really like finding things out for myself very much.

(Lucy)

Lucy was more articulate about her position than some of the others but her words sum up the general position for these students.

Our study found that these students who clearly showed that they were alien learners at the undergraduate level and before, tended to move in one of two directions. Some moved towards a more natural learning style, but others seemed to respond by developing a learning style which did not fit into our existing natural/alien split (or indeed, the general connected/disconnected learning styles of other theories outlined earlier).

While natural learners, or those who had been alien learners as undergraduates who moved towards natural learners as postgraduates, were interested in making analogical links between new mathematics and existing knowledge, some of the alien learners subverted their learning style to a new one (which we came to call 'coherence' learning). In response to independent graduate study, these previously alien learners appeared to search for a structure within the new mathematics, while still basically keeping it initially separate from their existing knowledge.

### Alien → Natural Learning

Alan spoke about his own way of learning as an undergraduate and earlier, indicating that he had merely tried to be a good student learning what he was being taught without giving much thought to whether he understood it or not though at the time he had thought he did understand it because he did quite well. 'I learned a lot of proofs

just by learning them and regurgitating them'. But now he thinks much more about what the mathematics is about:

I prefer it if he [his supervisor] first talks with me about it to give me an intuitive idea .....just on an intuitive level and then I try to make the mathematics fit to what my intuitive ideas are ... some proofs are intuitive ....but if the proofs are not intuitive ..... [I like] to work through it and think about how I worked through it ... I've matured a lot as a mathematician; I'm better as a mathematician but not as good as I thought I was before'.

(Alan)

This reflection, intimating the confidence and security engendered by competent alien learning, shows a growing recognition that understanding is not merely about successful reproduction of techniques and proofs. Instead, he is beginning to see the need for a 'fit' between the mathematics and 'what my intuitive ideas are' – a sentiment which sets him clearly on the path to a natural learning style.

Lucy, who so clearly enunciated the difficulties faced by alien learners in encountering graduate study, when asked how she viewed her current way of learning said

... instead of learning things by rote I'm having to go much more into the background and start with things I already know and learn by analogy or build them up; I found that a lot harder.

(Lucy)

Lucy and Alan both seem to be in the early stages of the transition but appear to be moving towards a new perception of what 'to understand' means in which they seek analogies and a fit between the new mathematics they are learning and their existing knowledge. They are in the process of moving more towards a natural way of learning.

### Alien → Coherence Learning

Not every alien student moved towards natural learning in response to the new learning environment. Indeed, some students were causing us some difficulty since their descriptions of their current, postgraduate learning styles did not appear to fit the basic natural/alien dichotomy (nor the relational/instrumental, deep/surface, conceptual/procedural theories discussed earlier). Instead they seemed to develop in a different direction. Yes, they were seeking structure, but not the structure *around* the mathematics which the natural learners and natural converts appeared to seek, but structure *within* the new mathematics they were learning

Rebecca came across as our archetypal coherence convert. She was highly articulate and had reflected on both her own learning and that of the undergraduates she taught as a Graduate Assistant.

I always want to know where it's going so the first thing would be to see where it's going to and to get there I've got to do each of the steps one after the other.

(Rebecca)

There remains a sense of the procedural, and no sense of the need for the support of an analogy, but while for her younger self, understanding lay in "getting it finished" and "I wasn't bothered about why I was doing it", now understanding comes gradually:

So I think I'm probably ... looking at each of the steps on their own to start with, to work out this bit and then the next bit, and then the next bit, until I've got that, and then eventually it all comes together

(Rebecca)

Sudeep, also a strongly alien learner as an undergraduate, really saw himself as a physicist rather than a mathematician but he too had come to have a strong sense of the internal structure of what he was learning as he came to his postgraduate work. He still saw himself as one who liked to become proficient in techniques and felt that understanding for him came through that proficiency, a characteristic of many alien learners, but this is increasingly mixed with this sense of structure within the mathematics:

I would to start with, I would try to find a certain structure in the piece of mathematics that I'm looking at, try to find some logical procedure that's involved and try to understand how and why the result is obtained.

(Sudeep)

So, for these learners, the encounter with independent graduate study has led them to adapt their learning style to accommodate to the new learning environment. Separate pieces of knowledge will no longer suffice. However these students do not move to the wholly cohesive sense of natural learning (as Alan and Lucy were beginning to do), instead they develop a learning style in which they need to sense the coherence of the new mathematics as a structure.

## Summary

Encountering independent graduate study is, then, a quite different experience for natural and alien learners. For the former, it is met with open arms, a vindication of a learning style which has been a struggle to maintain in other pedagogical environments with fellow students appearing to succeed with seemingly easier learning styles. For the alien learners, however, there is a need to change – the independence which the natural learners see as liberating is bewildering and even threatening to the alien learners. The procedures which could be followed and the pre-digested ideas which could be readily absorbed are missing and they must face the prospect of developing new knowledge for themselves. Some are able to do this

by adopting a more natural-like learning style – looking for analogies which help them make sense of new ideas. However, most excitingly for us in developing our theory of learning, some developed a different way of learning: seeking not analogies, but internal structure, which allows them to retain some aspects of alien learning (the initial separateness of the new knowledge) while enabling them to progress by building new knowledge into frameworks.

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