Subject Knowledge in D&T Teacher Education: Exploring the gaps.

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ABSTRACT

Determining the key subject knowledge that should underpin D&T Teacher education in England has never been easy. The fundamental range of the subject (with a scope of materials that includes food, textiles, engineered materials, computational systems… used to design and make products across a limitless extent of context), continuing developments in many of the technologies that underpin it, the breadth of experience that entrants to D&T teaching bring with them, the heterogeneity of approaches to D&T subject matter in schools (including the move in many English schools to teaching some of the above areas, especially textiles, through Art & Design) and ever changing statutory and examination requirements all have their influence. In the past the D&T Association (2003) has provided guidance, but, as noted by Martin as long ago as 2008, this guidance has lost relevance as the landscape has changed.

There are, of course, in addition to all the above, broader debates that are current about the role of subject knowledge in school education, and these have led to various explorations about how the fundamentals of subject knowledge in D&T should be constructed.

In this paper we describe the way that subject knowledge content in our PGCE D&T curriculum has been, and still is, evolving in response to these diverse and not always complementary forces. Underpinning this, using survey data from past and present ITE students and placement schools, we explore how the subject knowledge content of our PGCE course matches with the needs of our students and the curricula of their placement and first teaching schools.

We end by suggesting possible avenues of development for D&T ITE subject knowledge in the English context, and draw out some principles for building a relevant and robust subject knowledge base for teacher education in D&T.

Key Words: ITE, Subject Knowledge, Curriculum Development

1. INTRODUCTION

Preparing people to be teachers is complex. Preparing them to teach D&T is at least as complex as any other subject; the breadth of subject knowledge encompassed by the subject is broad, the knowledge people bring to a training course is generally comparatively narrow but, we hope, has depth. One task of teacher preparation is to, add some breadth to this depth. Notably similar issues arise in the education of professional designers (Peters, 2012).

The topic of D&T subject knowledge has been made more challenging for schools by curriculum changes that have focused on the raising the profile of subject knowledge in school subjects leading to a relatively new national curriculum for D&T in English schools (DfE, 2014) accompanied by new GCSE specifications (this is the national exam for 16-year-olds) (Ofqual 2021a, 2021b). Alongside these changes have been national debates about the nature of knowledge in school subjects (Baynham & Frank (2021).

SUMMARY OF THE RESEARCH

Every year we adjust the detail of the subject knowledge elements of our PGCE. These changes take into account the statutory framework, the big ideas of D&T (Barlex et al, 2017) and the feedback of students and mentors. Every year we find ourselves constrained by the limited time that students have in the university in a 1-year PGCE course. Always in questions is the way that we balance subject knowledge development between learning in our university environment and learning in placement schools. So, a question that arises is, are we providing a reasonable foundation of subject knowledge that gives our partner schools a platform to build on.

To explore this question, we surveyed our students asking how well prepared they felt for their placements in terms of their levels of subject knowledge. At the same time, we asked the school mentors how well prepared they felt the students were. A survey approach was chosen to allow busy mentors and students, during a school placement, to provide a comprehensive overview of subject knowledge demands without demanding too much of their time. Clearly there are limits to the evidence one can elicit this way, but we were pleased by the high response rates (reported below) and the overview these provided. The surveys used questionnaires in Microsoft Forms with a mix of open and ‘pick from a list’ questions.

2. RESPONSES TO THE SURVEYS

Data was collected from our current students during their first school placement, and we had a 100% response (n=11). At the same time, we asked their mentors a partially overlapping set of questions and got responses from 15 mentors; this included some responses from the same school and in what follows we have counted these only once (this represented 12 schools; one student left the course partway through the placement). We repeated the mentor survey near the start of the students’ second placement and had responses from 4 new schools; their data is also included below, where pertinent. The total number of individual schools represented was thus 16.

At the same time, data was collected from students from previous years and their subject mentors covering the years 2018-19 to 2021-22. We had responses from 33 previous students out of a possible 50, and 9 subject mentors.

2.1. Aspects of D&T taught at KS3 in your school.

2.1.1. Current students and mentors

The first question asked students about the topics within D&T that they were teaching, at Key Stage 3 (KS3 11–14-year-olds), on the placement, similarly we asked the mentors about the range of D&T topics offered at KS3 to the school's pupils (Table 1).

Choosing the 'topic' headings for this question raised many questions for us; we wanted to capture the broad kinds of knowledge content that students and schools would recognise from units of work descriptors, while avoiding getting into a highly detailed list of content. We recognise that there are many other ways that we could have carved this up (for example asking about units of work that are 'mainly making', 'mainly designing' etc., or asking about the details or openness of the design contexts driving the work). However, we were particularly keen to focus on subject knowledge, and scrutiny of the students' placement timetables suggested the topic headings shown in Table 1 would be recognisable to both target audiences.

Table 1:
KS3 content (current students and mentors)

	Content taught by PGCE students (n=11)	**Content offered by the school (n=16)**
CAD	3	12
Electronics	2	11
Engineering	0	9
Food & Nutrition	8	14
Graphics	2	10
Hospitality and catering	1	4
Mechanisms	2	5
Metals	1	8
Plastics	1	11
Product Design	2	12
Structures	1	7
Textiles within art	3	4
Textiles within D&T	7	15
Timbers	2	13
Other	0	2

In response to a request to detail any 'Other' topic areas, the list we got was largely comprised of items that we viewed as either subsets of the topic headings above or core aspects of D&T; for example, 'machines, tools', 'gears, mechanisms, forces', 'CAD/CAM', 'biomimicry', sustainability, and 'aerodynamics'. There were also references to aspects of the curriculum that D&T departments have responsibility for, but that we don't tend to consider to be core to a D&T

PGCE; in particular aspects of Art and Design ('Art, craft and design:3D', 'Photography', 'pottery') but also 'Child Development'. These responses are indicative of the rather porous disciplinary boundaries that 'D&T' in schools often experiences, driven by combinations of staff shortages, limited funding and timetable pressures. It is noteworthy that we felt we should include 'Textiles within art' in our list of content as we see this increasingly being seen as a responsibility of the D&T department.

However, some 'Others' represent items that we might well include in any future iterations. These include robotics, and work with microcontroller systems (perhaps 'Physical Computing' might be a better heading than 'Electronics in the table above?).

2.1.2. Previous students and mentors

Asked about the D&T topics currently taught in their schools, they responded as shown in Table 2 below.

Table 2:
KS3 content (previous students and mentors)

	Content taught by previous students (n=31)	**Content offered by the school (n=9)**
CAD	15	7
Electronics	10	5
Engineering	8	2
Food & Nutrition	20	8
Graphics	14	6
Hospitality and catering	4	2
Mechanisms	8	3
Metals	11	5
Plastics	16	7
Product Design	18	8
Structures	3	4
Textiles within art	4	0
Textiles within D&T	15	6
Timbers	18	8
Other	4	3

The response to the 'Other' question was similar to that from our current cohort (e.g., 'CAD/CAM', 'Isometric and orthographic drawing'). One former student mentioned 'Health and Social Care', and that this is a part of the D&T department in many schools. Another made the interesting comment that 'I *have not taught any other aspects of D&T during my career since graduating the PGCE however I do use my knowledge within the department to help out other teachers and use my limited understand to help out ideas [sic]*.'. This seems to suggest a question that is well worth asking; how far ahead are we thinking about a current student's career when planning our PGCE content?

One mentor noted that 'D&T and Food & Nutrition (F&N) are two different dept in school'; which is arguably tangential to the question asked, but, when viewed alongside the current structure of the D&T KS3 National Curriculum and separated GCSE specifications for D&T and F&N, raises its own questions about how teacher training in this area should be organised.

Finally, here, questions arise as to whether the areas mentioned most often by the schools are the ones where we should focus most time in the PGCE or, conversely, whether we should give attention to those less often taught in schools on the grounds that these are important aspects of the national curriculum and GCSE specs in which students are less likely to get support in learning while on placements.

2.2. GCSE courses taught in your school.

The options provided in this section of the survey were based on the range of Key Stage 4 (KS4 14-16 year-olds) qualifications available in England that we know are taught in at least some D&T departments – for this reason we did here explicitly include Art and Design.

2.2.1. Current students and mentors

Here we asked students which KS4 courses they had had the opportunity to teach in their placement. Similarly, we asked the mentors about the range of KS4 courses offered at KS4 to the school's pupils (Table 3).

Table 3:
KS4 courses (current students and mentors)

	KS4 courses taught by PGCE students (n=11)	**KS4 courses offered by the school (n=16)**
GCSE Design and Technology	5	13
GCSE Engineering	0	1
GCSE Food Preparation and Nutrition	5	14
GCSE Art and Design	1	10
Level 1/2 Engineering	0	7
Level 1/2 Health and Social Care	0	6
Level 1/2 Hospitality and Catering	2	5
Other	0	7

Noting that the students were in their first placement, it is unsurprising (but reassuring) that the majority were being asked to teach the 'core' GCSEs of D&T and F&N. The student teaching within A&D was focussed on textiles work.

The responses to 'Other' from the mentors included a wide range of 'non-GCSE' (that is, vocational) qualifications related to D&T, including Graphic Design, Construction and Child Development, as well as some qualifications more related to A&D including 3D Art and many mentions of Photography.

A question raised for us by this data is whether, in the limited time available to us on a PGCE course, we should be giving a higher profile to ~~v~~ocational courses for 14-16 year-olds related to D&T.

2.2.2. Previous students and mentors

Again, we asked the previous students and mentors about the range of KS4 courses offered at KS4 to the school's pupils (Table 4).

Table 4:
KS4 courses (previous students and mentors)

	KS4 courses taught by previous students (n=31)	**KS4 courses offered by previous mentors' schools (n=9)**
GCSE Design and Technology	15	8
GCSE Engineering	2	0
GCSE Food Preparation and Nutrition	14	6
GCSE Art and Design	6	1
Level 1/2 Engineering	3	1
Level 1/2 Health and Social Care	3	1
Level 1/2 Hospitality and Catering	3	2
Other	7	4

As expected, the majority of our previous students are teaching D&T and/or F&N at GCSE. The number teaching A&D is noteworthy. The range of 'Other' KS4 courses mentioned is quite interesting (Table 5).

Table 5:
'Other' KS4 courses (previous students and mentors)

KS4 Course	**student**	**school**
Level 1/2 Construction	1	2
NCFE Level 1/2 Graphic design	1	
GCSE Photography	2	
Vcert Food and Cookery	1	
IGCSE Cambridge Food and Nutrition	1	
WJEC level 1/2 Constructing the Built Environment	1	
GCSE Design and Technology Textiles		2
GCSE D and T Graphics		1
BTEC Award Art and Design		1
Level 1/2 (vocational) Creative Design and Production		1

Firstly, we note that there is no such thing as a GCSE in either 'D&T Textiles' or 'D&T Graphics', but it is interesting that some schools appear to be, in effect, subverting the spirit of a single-title GCSE in D&T by, presumably, advertising the GCSE to students (and parents) as a single

material-focused qualification. One could call this simple honesty as we know that this is the approach that a great many schools take to D&T GCSE, but rather less explicitly.

Secondly, the table indicates the wide range of things that D&T departments have to turn their hands to, albeit at relatively low numbers. As teacher trainers it leads us to ask to what extent we should try to include subject knowledge related to this wide range of vocational courses within the limited time we have with students.

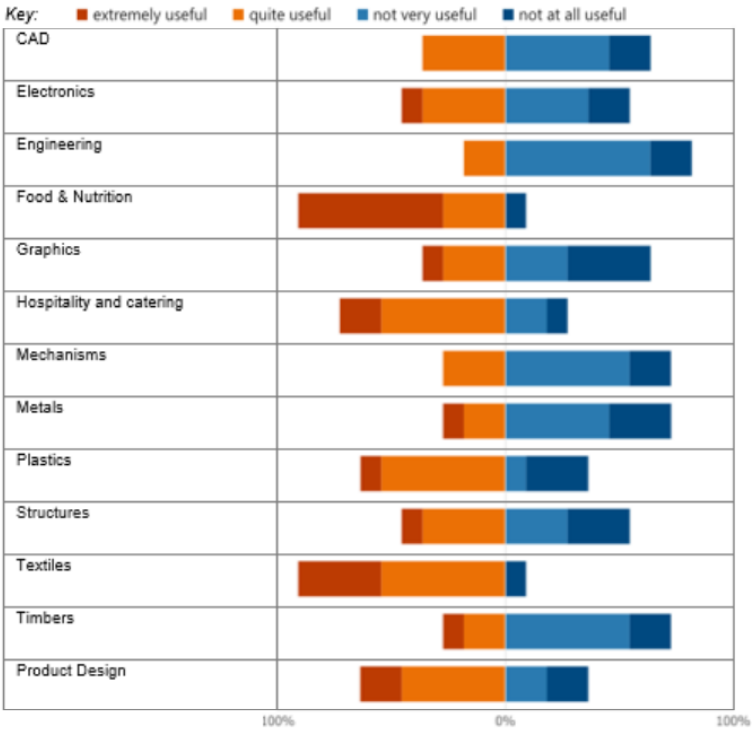
2.3. The 'usefulness' of the teacher training subject knowledge content

The surveys next turned to asking the student teachers and their mentors how well the subject knowledge the students had been exposed to in their PGCE and pre-course Subject Knowledge Enhancement (SKE) courses matched the subject knowledge demands they had met in teaching.

2.3.1. Current students and mentors

Seven out of the Eleven students had completed a SKE course prior to starting the PGCE. Five of these had been totally online, two with a blended course. They were asked which elements of subject knowledge covered as part of their PGCE/SKE have been the most useful in their placement. Their responses are shown in Table 6.

Table 6:
Usefulness of course subject knowledge (current students)



Asked about subject knowledge gaps that they encountered on placement, 8 of the students said they had encountered such gaps and these spread across the full range of D&T content as shown by the word cloud in Figure 1.

Figure 1:
A summary of subject knowledge gaps noted (current students)

Asked about the subject knowledge they had needed to develop on placement they provided a similarly wide range of responses as shown in Figure 2.

Figure 2:
A summary of subject knowledge developed on placement (current students)

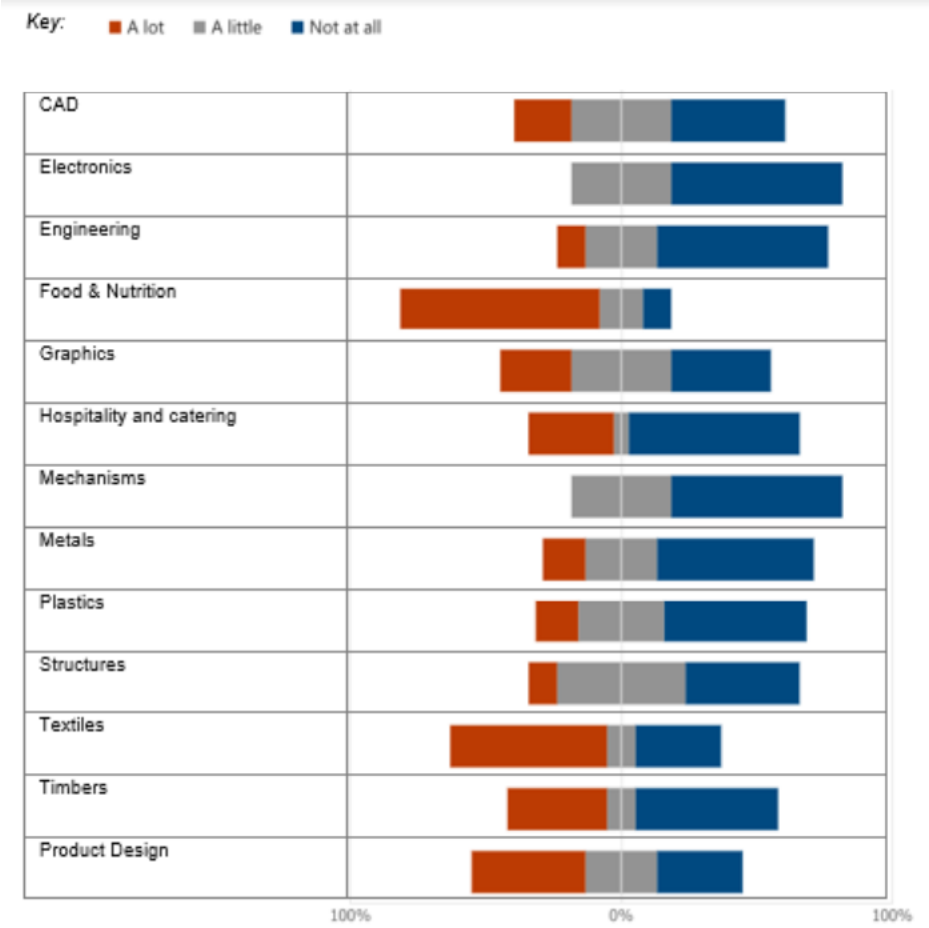
These cloud summaries lack a great deal of precision and also stray well beyond our interest (for this study) in specific subject knowledge. They do however provide an insight into students' concerns towards the start of their first school placement that will be fed into the next round of PGCE course planning. Extracts from two of the longer responses shown below provide some context and seem to us to capture two realities of learning to be a D&T teacher:

> I feel I know a lot more than I thought I did. I haven't struggled to explain things or answer pupils' unexpected questions and have had positive feedback from mentors & SLT regarding my subject knowledge.

> It is very hard with Design and Technology as a subject to become a specialist and build knowledge to teach everything at a high level. This makes it naturally much harder to teach all lessons at a higher level and ups the work load compared to other ITT subjects.

The subject mentors were asked which elements of subject knowledge the students had needed to use in this placement. These responses are shown in Table 7.

Table 7:
Subject knowledge used on current placement (current mentors)



Tables 6 and 7 have broadly similar shapes which provides a degree of triangulation in relation to understanding of subject knowledge demand between students and mentors. There is a fairly strong indication in these tables that technical areas of the curriculum (electronics, mechanisms, knowledge of materials, structures) are less in demand. However, we recognise that when the survey was conducted the students were in their first placement and mentors may well have constructed their timetables around areas perceived as less demanding in terms of subject knowledge. It is also the case that the surveys were conducted before the second university-based phase of the course, where there is further significant subject knowledge input. Finally, it is worth

noting that, given the proportions of time allocated to university- and school-based training, it is inevitable that schools will need to contribute to trainees' subject development.

Mentors were also asked to detail subject knowledge gaps that they had noted as the trainees started their placement, these are summarised in Figure 3.

Figure 3:
A summary of subject knowledge gaps noted (current mentors)

We also asked mentors to say where they felt the university-based course should place more emphasis. The responses included the following:

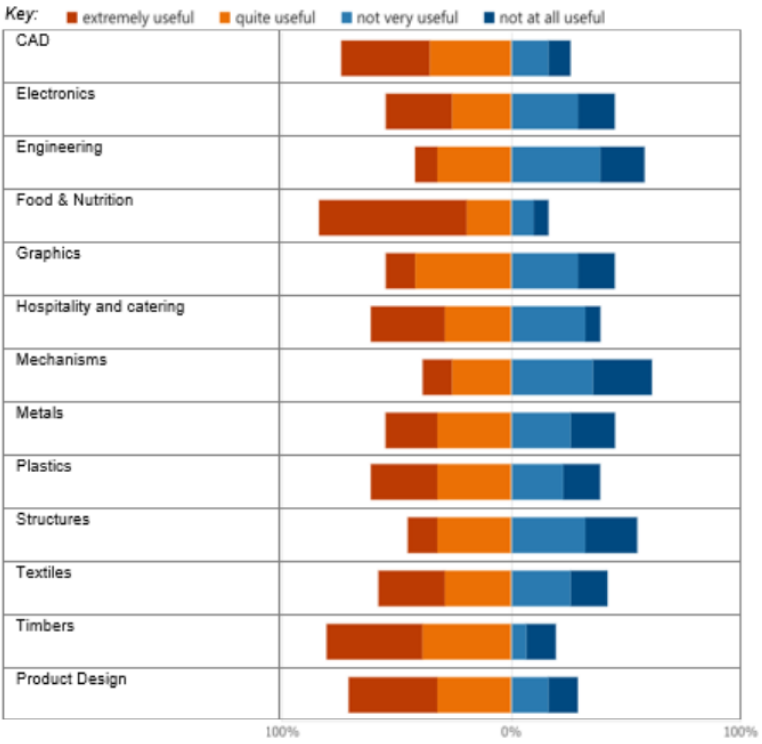
> Sustainability in D&T
>
> Photography
>
> More Textiles knowledge e.g. sources of fibres and how to use a sewing machine.
>
> There are very few students with practical metal working experience. Few are able to operate centre lathes, milling machines. Most have never done any heat treatment, welding, casting, etc. Some have basic wood working skills but very few are able to produce things like a dovetail joint or operate a wood lathe.
>
> Use of CAM and systems and control
>
> More practical aspect of running practical lessons with students, i.e. how to watch them, where to position themselves in the room, setting short tasks and getting them to be more independent in the lesson. Assigning student specialists to take the pressure off the teacher. Setting extension tasks for more able students.
>
> More graphics
>
> I think this is difficult with the way the SKE course was offered this year as much was delivered remotely and did not cover the same content as previous years. Getting back to hands on delivery would be best. Consider 'delivery of lesson' classes to try and provide an understanding to PGCE students on how to project voice etc.

This is not the place for a detailed response to these (the list is a mix of things we had done with the students, would cover between the two placements and are never likely to achieve with the wide mix of degree backgrounds that PGCE students bring with them). However, we think the significance of this list is that mentors here are demonstrating to us is that there is a gap between their expectations and the course's realistic aspirations given the constraints. This is an opportunity for better communications between the partners in teacher training.

2.3.2. Previous students and mentors

The same questions about subject knowledge were asked of our previous mentors and students. 18 out of the 33 students had completed a Subject Knowledge Enhancement (SKE) course prior to starting the PGCE. Three of these had been totally online, the rest blended. Asked how useful they felt the SKE and PGCE content had been in their teaching posts, they responded as shown in Table 8.

Table 8:
Usefulness of course subject knowledge (previous students)



Asked about subject knowledge gaps that they encountered when they first started teaching, 19 of the students said they had encountered such gaps, and these spread across the full range of D&T content. When asked about aspects of subject knowledge that they had had the opportunity or need to develop since starting teaching, a range of responses was provided, as summarised below.

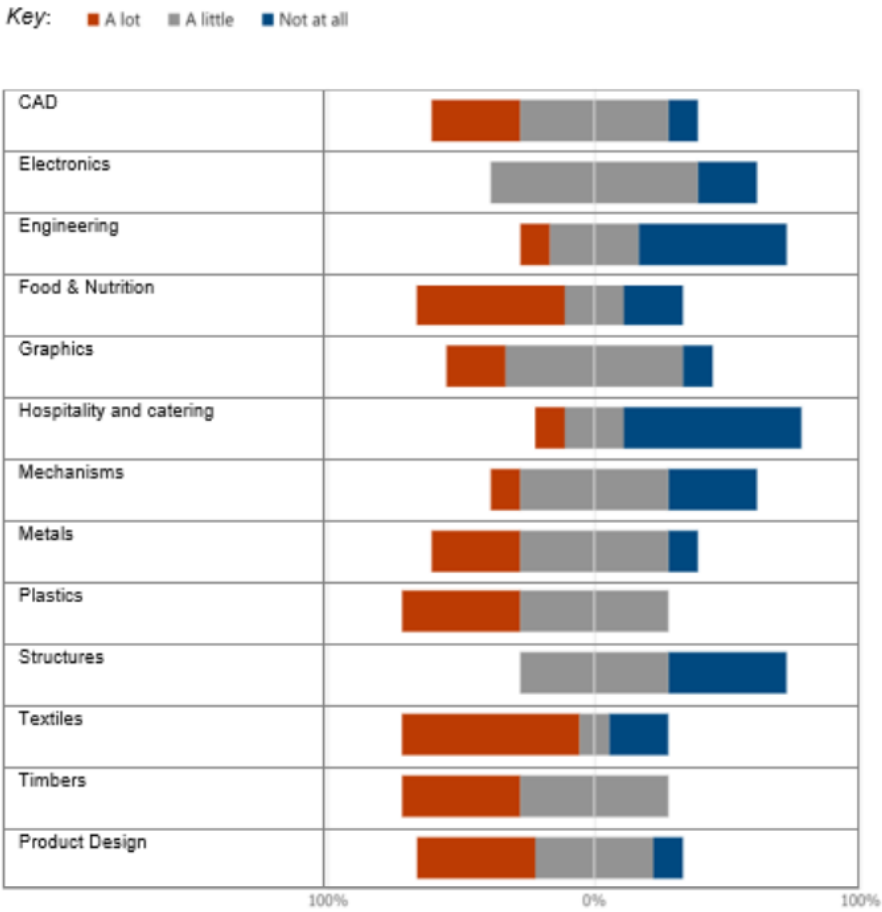
> *Particularly, textiles and food science. Strengthened knowledge on timbers, metals and plastics.*
>
> *One area I did need training on was Marking GCSE NEAs.*
>
> *Electronics CAD RM practical*
>
> *Graphic design, I had to teach myself perspective drawing and use my industry knowledge of adobe illustrator*
>
> *3D printing, laser cutting CAD*
>
> *Maybe the fibres and types of fabrics in textiles.*
>
> *All of food prep and nutrition*
>
> *Health and social care*
>
> *Being a product design specialist I have had to continually develop my subject knowledge in graphic design and food.*
>
> *Timbers hand tools ks4. 3d modelling fusion 360*
>
> *CAD. Using machines such as 3D printer and laser cutter.*
>
> *Food and nutrition*
>
> *CAD, electronics*

Asked about things they felt should have been covered in the PGCE, a list of things very similar to the above emerged, though it was quite heartening to get comments like:

> I feel everything covered gave me more than enough knowledge and confidence to go into teaching and start teaching well. There are some things that maybe weren't covered in detail for example marking assessments and coursework or preparing for parent evenings. However those things you can not really understand and learn from until you actually do it in teaching. So I feel everything covered was more than sufficient.

Once again, the previous subject mentors were asked which elements of subject knowledge the students had needed to use when on placement. These responses are shown in Table 9.

Table 9: Subject knowledge used by students on placement (previous mentors)



The profile here is quite similar to that in Table 7 (current subject mentors), through with a higher profile for Metals and Plastics. Given the small numbers we are working with, we don't think we can read too much into this.

The range of responses to questions about the gaps that students had when starting their placements and what other aspects of subject knowledge they felt should have been covered in the SKE and PGCE were very similar to the responses from current mentors.

2.4. Concluding thoughts

As well as confirming the very wide range of subject knowledge that D&T teachers can be expected to teach – ranging well outside what might usually be considered as core to the subject, the following key aspects of subject knowledge development within a PGCE arise:

- A tension between preparing students for the subject knowledge they will need in a specific placement and preparing them for the wide range of knowledge they could meet when they start teaching.
- A tension between preparing students for the most commonly taught D&T subject areas in schools and introducing them to topics (such as physical computing) that are important parts of the subject yet (for a host of reasons) relatively poorly represented in many schools' curricula.
- A tension between preparing students for the 'core' subjects of D&T and FP&N and also acknowledging the wide range of vocational courses that D&T departments can be required to teach.
- A tension between preparation to teach D&T and to teach FP&N; these areas are, in many schools and increasingly, being taught as separate subjects – and recent work from the Food Teachers' Centre (2023) suggests momentum in this direction.
- The need for strengthened communications between PGCE providers and partner schools about how subject knowledge development can best be shared coherently so as to best serve the needs of not only the PGCE students but also the placement schools.

One of the interesting things that emerged for us from the data was the way that mentors, given the invitation to provide us with feedback, wanted to talk about much more than just subject knowledge. Like any PGCE, we have a programme of mentor training meetings, course reviews, discussion with mentors on school visits and so on, all of which seek to elicit mentors' views. But mentors are busy people, pulled in many directions; it seems that the format of a survey (assuming mentors find time to complete it) provided a bit more time for thought and expression of views. With hindsight this is unsurprising and suggests to us that wider ranging surveys of mentor's views are needed.

More broadly what emerges from the data is the need for more detailed communication between PGCE and subject mentors, allowing for the sharing of views and shared planning of content that leads ultimately to a clearer understanding of the shared responsibility for subject knowledge development.

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