How to teach 'Smart Fashion' within the D&T curriculum: have we got it right?

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Abstract
The English Design and technology (D&T) curriculum places a greater emphasis on the teaching of electronic systems within a fashion context. E-textiles, are fabrics with embedded electronic circuits that create Smart Fashion products, which interact with the body and environment. Previous research by Davies and Rutland (2014) identified that teachers perceived this kind of curriculum as difficult to design and resource, within the classroom. In this paper we report on some of the initial results from the evaluation of a set of teaching

resources, that have been created and tested with teachers, as part of a larger study into how Smart Fashion curriculum can be supported in the classroom. Data collected from the teaching resources and teacher interviews was analysed against current theories of 'best practice'. The findings describe the potential of the resources to support learners in developing an understanding of what e-textiles are and how they can be made. This understanding can then be applied to the designing and making of Smart Fashion products.

Keywords
curriculum reform; e-textiles; teaching resources; tinkering; Smart Fashion

The Introduction

The English National Curriculum (DfE, 2014) and a new D&T examination for 16 year olds (DfE, 2015) places a greater emphasis on knowledge of electronic circuits and programming. This reform, aimed to modernise the curriculum, requires teachers that have traditionally worked within one material area of the D&T curriculum e.g. product design or textile technology, to develop skills across a variety of material areas that integrate electronic systems. One example of this is the inclusion of content that compels teachers to teach pupils about electronic systems within a fashion context.

The integration of electronics within fashion and textiles is an emerging field within interactive design (Seymour, 2008). Flexible circuits that use conductive fabric and small components are termed as soft and allow for ubiquitous computing that can be worn next to the skin and interact with the wearer and their environment (Buechley, 2006). This type of new and emerging technology can be expressed in a variety of ways (see Kettley, 2016 for definitions). For the purpose of this study we will refer to: fashion contexts that draw on interactive technology as (1) Smart Fashion and textiles with embed electronic properties as (2) e-textiles.

Davies and Rutland (2013) conducted small-scale research into previous attempts to modernise curriculum through the integration of electronics and textiles. They found that teachers often adapted new material and processes to meet existing curriculum aims that didn't match the integrity of the new technology. For example, the use of 'soft' flexible circuits to provide functionality within rigid products that might be more suited to traditional (hard) electronic components. The research also identified a perception amongst the teachers that they lacked the technical knowledge required to design and resource Smart Fashion in the classroom. This establishes the need to develop good quality learning resources to support teachers with the classroom implementation of Smart Fashion education.

In September 2014 the authors secured European Regional Development funding to collaborate with a local small manufacturing enterprise (SME). The aim of the collaborative research project was to investigate how Smart Fashion curriculum can be supported in school. We initially designed teaching resources to support the kind of knowledge learners would need to make e-textiles. It was anticipated that these resources would be the first step in developing technical knowledge that might be later used in Smart Fashion 'design and make' activities (Barlex, 2011). Five teaching resources have been created as part of the project.

In order to be confident that our e-textile teaching resources are of good quality and will support teachers with modernising the curriculum, we needed to evaluate them against current theories of teaching Smart Fashion. In this paper we report on some of the initial results from the first stage, of our on-going project evaluation. Three of the resources will be discussed in this paper, which reports on the first evaluation stage into how the (e-textile) teaching resources meet quality measures. We will explore current thinking on teaching electronic systems through Smart Fashion contexts, to establish a framework for quality.

Literature Review

E-textile teaching resources need to help learners to understand electronic systems and how they might be embedded into flexible textiles. According to Peppler, Gresalfi, Tekinbas and Santo (2013) understanding electronic systems:

> involves recognising the elements that structure a system, and, more important, the ways that those elements interconnect to impact each other and the overall function of a system.
>
> (Peppler et al, 2013, p. 21]

This type of knowledge is complex, abstract and perceived by some as difficult (Pulé & McCardle, 2010). With difficult knowledge there is a threat that teachers might rely on transmission models that ask pupils to follow instructions and plan every step, before doing. Resnick & Rosenbaum, (2013, p.164) warn that this kind of pedagogy "saps all spirit from the activity".

So, how do you make difficult knowledge joyful and accessible? Scholars that talk about strategies for dealing with difficult knowledge, share the view that tangible objects can be used to construct understanding, through problem solving activities (Perner-Wilson & Buechley, 2013; Resnick & Rosenbaum, 2013; Wilkinson & Petrich, 2013). Resnick and Rosenbaum (2013) refer to problem solving with objects as 'tinkering' and they go on to argue that these types of activities have the potential to support a wide range of learners.

These scholars draw on the theory of constructionism, which attributes 'objects-to-think-with', as a source of deeper classroom learning (Papert & Harel, 1991). 'Objects-to-think-with' provide a level of transparency that has the potential for pupils to receive instant visual feedback, in relation to the problem they are solving.

Kafai, Fields and Searle (2014) and Ngai, Chan, Cheung and Lau (2010) have conducted research with groups of young people into the way students use physical objects to enhance the learning of electronics and computational concepts. Their work focuses on the aesthetic aspect of making and technological transparency. Ngai et al. (2010) is distinct from that of Kafai et al. (2014) in their argument that the removal of sewing in the early stage of learning simplifies the process, and, makes learning the concepts less difficult.

Perner-Wilson and Buechley's (2013) research into a 'kit of no parts', exemplifies Papert & Harel's (1991) theory of 'objects-to-think-with' by enabling learners to play with the problem of how to make their own soft electrical component, which expose the inner working of the technology.

Rode et al. (2015) have supplemented the work of Kafai et al. (2014) and Buechley (2006) to develop case study materials that provide an emerging framework for teaching e-textiles. The emerging framework identifies five core skills that contribute to 'best practice' learning in e-textiles. The five skills of: aesthetics, creativity, constructing, visualising multiple representatives and understanding materials form the framework.

Research Design

Having identified current theory about best practice for teaching Smart Fashion we are better able to answer our research question about quality. To do this we used a flexible design (Robson & McCartan, 2016) to collect qualitative data as part of the on-going case study into Smart Fashion education. For this part of the study we are using documentary analysis and teacher interviews (Cohen, Manion & Morrison, 2011). The research adhered to the universities' ethical guidelines and teachers' responses were voluntary and based on informed consent.

The documentary analysis was completed on three of the five resources: (1) Simple Circuit, (2) Make a Soft Switch and (3) Make a soft Battery Holder. Each resource consisted of a tinkering kit and written instructions. The instructions were divided into separate learning steps/stages. Six secondary school teachers tested the resources during a professional development workshop held at the SME HQ. A stimulated recall interview (Schepens, Aelterman, & Van Keer, 2007) was set up to record the teachers' perceptions of how they learnt from the teaching resource activities. The data from the teaching resources and subsequent interviews were analysed using deductive reasoning (Wilson, 2012) against the Rode et al. (2015) framework criteria.

Findings and Analysis:

In this section we will be presenting the findings from the three e-textile teaching resources and teacher interviews.

Opportunities to learn how to construct e-textiles

All three teaching resources contain content designed to support the core skill of constructing. The resources ask learners to physically build simple circuits, using crocodile clips and conductive fabric. They also ask learners to develop traditional textile skills such as: cutting, measuring, hand and machine stitching. The soft component resource requires learners to: (1) join fabric together using hand-stitching with conductive thread and (2) machine stitch pockets and pouches with non-conductive thread. Learners are required to laminate conductive and non-conductive fabric using heat processes.

The teachers that tested the resources, talked about how the instructions for the soft component developed their construction skills through the use of pre-cut fabrics with etched guidelines (to guide the stitching line). Two of the teachers (Teacher A and D), said that these would be very helpful for developing the construction skills required to make Smart Fashion objects with learners, back in the classroom. Teacher D also identified that the conductive thread was "not easy to work with" (Line 231).

From the data we can see that through the range of making skills, including the construction of pockets and encasing conductive fabric within pouches, the resources provide opportunities to support learners with the skills they need to house electronic circuit within Smart Fashion objects. However, opportunities to practice skills related to using conductive thread on the sewing machine are limited. Teacher D, identifies potential barriers to using the thread which supports the concern Ngai et al. (2010) pinpointed when describing the need to remove sewing from the initial stage of making.

Opportunities to understand Smart Fashion Materials

All three teaching resources contain content that supports the development of material understanding. The two soft component activities challenge learners to apply knowledge of properties when assembling a soft switch and battery holder. The simple circuit resource provided content designed to allow learners to handle and use electronic components and crocodile clips.

When we trialled the resources with the teachers, they mainly talked about the components and their function within the circuit. The teachers talked about how the coin cell positive side "curled around the edge" (Teacher A Line 180) and how this affected the position of conductive elements in the circuit. They talked about how the coin cell differed from their tradition counterpart (pen cell) and one teacher raised the need for health and safety considerations, due to the small size of the components. The teachers also recognised the issue of short circuiting and the need for tight connections to be created with the thread. The teachers talked about current flow and how to break the circuit.

From this data we can see how the activities might provide opportunities for learners to experience and potentially understand Smart Fashion materials and components. This extends the Rode et al (2015) framework to include component understanding alongside materials. The teachers understood how the components interconnected and impacted on the circuit functionality (Peppler et al, 2013) this is essential knowledge for the types of design decisions that are required to design and make flexible Smart Fashion objects that will ultimately be worn next to the body.

Opportunities to creatively problem solve, abstract problems

All three teaching resources contain content that develops learners abstract knowledge. The pedagogical approaches require a level of creative thinking in learners for the active problem to be solved. The switch and battery holder resources allow learners to physically re-engineer existing products or follow step-by-step instructions.

Five of the teachers exchanged thoughts about how the resources helped them to problem solve the circuit design and soft component structure. Teachers D and A talked about how the use of the group activity made the problem solving competitive and Teacher D also acknowledged that working in teams was good for “sharing ideas and working together as a team” (Line 169) to solve abstract problems. Three teachers also identified that the problem solving activities had initially been easy and how this “built my confidence up straight away” (Teacher D, line 161), later the same teacher talks about “flying at first” (line 182) when describing how she solved the problem of making the simple circuit.

From this data we can infer that these teachers gained in confidence through the action of ‘tinkering’ (Resnick & Rosenbaum, 2013) with tangible objects early on. They later used step-by-step instructions, which may have modified the joy (Resnick & Rosenbaum, 2013). Interestingly the teachers talk about the social nature of the learning provided through the group ‘tinkering’ activities.

Opportunities to creatively express concrete solutions

The teaching resources are very prescriptive in the main. Only the soft switch resource provided an extension task that gave learners a free reign over decisions, when asked to ‘think about other soft switches that you could make?’ This means that opportunities for creative expression are limited across the resources.

Opportunities to visually represent 2D ideas into 3D objects

Three of the four teaching resources include two dimensional (2D) and three dimensional (3D) content. The switch and battery holder resources provide step-by-step instructions that are 2D drawings that need to be interpreted into 3D objects The simple circuit resource requires learners to create a working circuit that lights a light emitting diode (LED), from a bag of separate components and crocodile clips. After completing this the user of the resource is asked to draw a 2D circuit diagram that represents the working circuit they have just created.

Data from the interviews found that the teachers had been “pleased to handle components” (Teacher F, Line 14) and “start fiddling with things” (Teacher A, line 160). The teachers talk about “undoing” (Teacher C, line 69) and re-doing the circuit through the clipping and “quick to unclip” nature of the crocodile clips (Teacher E, line 31). Teacher A discusses how the LED gives her instant feedback when she says that “it is easy to see if you are doing it right or wrong because the end objective, the goal, to get the LED to light up isn’t working” (Line 168).

This demonstrates the potential opportunities for learners to work things out in reverse (Resnick & Rosenbaum, 2013). The resources also provide the kind of transparency identified by Parpert and Harel (1991) that provides visual feedback from the LED, to the learner.

Opportunities to make aesthetically pleasing objects

Learners make objects through the two soft component resources. When tested with the teachers, teacher D said “it’s always nice, isn’t it, to have something physical especially when you have done it yourself” (Line 240). The words aesthetically pleasing never came up and one teacher talked about how the teaching resources had taken “the aesthetics right out of it” because there was no “embellishment” and learning was focussed on “how it was going to work” (Teacher F, Line 84).

From this we can see that the teaching resources don’t support opportunities for the making of aesthetically pleasing objects unless the learners see the soft components as ‘aesthetically pleasing’ because they want (like the teachers) to take the objects home.

Conclusions and next steps

From this study we can start to see that these teaching resources have the potential to support learners in developing an understanding of what e-textiles are and how they can be made. This understanding can then be applied, at a later date, through the designing and making of Smart Fashion products. For these teaching resources to be of quality they need to include opportunities for:

- abstract problem solving,
- the development of material and component understanding,
- experiences in construction techniques required for this kind of hybrid activity (integrated electronics and textiles),
- the visualisation of circuits, simple and advanced and
- group work to support competition and team work.

The next steps in the research project will involve testing the remaining resources with teachers and conducting further enquiry into the social, creative and aesthetic aspects of e-textile learning.

We would like to acknowledge that this project would not have been possible without backing from the European Regional Development Fund and Kitronik PLC.

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