

# Achieving Teacher-Free Child-Led Design and Additive Manufacturing Using the Sense

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## **Abstract**

**The ability of a child to be creative in school is often impeded by the fact that an adult is always present and exerts a significant amount of influence over the child. This paper proposes an approach to design that will reduce adult influence and allow children to take more ownership of the design process. Specifically, children are given the Sense, a hand-held 3D scanning device which allows children to scan an object and then upload the image to a 3d printer, The benefits of this include that it will lead to the development of artefacts that are not influenced by adults and will allow children to more enterprising with their designs. This has significant implications for the development of curricula in art and design subjects as well as the pedagogical approaches of teachers. This study investigates the possibility of this approach and considers pedagogical approaches. The methodology included the development and experimentation of the approach to independent design and creativity and a post-experiment focus group to reveal the children's experience.**

**The results revealed that the children clearly acknowledged the absence of a**

**teacher and that this had a positive effect on their design, moreover, the children appreciated the fact that they were given the opportunity to design alone and have control over the design process. From a practical perspective, children found using the Sense to be easy and they did not require help from teachers. Overall the approach to design proposed in this study allowed children to be more enterprising in design if teachers only took a minimum facilitatory approach.**

## **Keywords**

**Children's design, 3D objects, 3D printing clay craft, product design, pedagogy.**

## **Introduction**

When children are being creative and are engaged in the design process they are often under the influence of adults. In a classroom setting teachers provide instructions, materials and facilitate the technology for children to design, and throughout the design process they provide children with feedback and encouragement. The main contention of this study is that this extensive involvement by an adult is a significant form of influence of children when they are designing and therefore, an influence on design outcomes. It is proposed that if we remove such influences from the design process it will create a better opportunity for children to be independently creative and that design outcomes will reflect the child's imagination rather than pedagogical influences. In this study these principles are extended to the practical production of clay artefacts whereby children do not require adult help. Specifically, children are able to reproduce hand-crafted pottery items using 3D printing facilitated by the Sense.

Often when children are involved in handcrafting clay designs the process requires the involvement of a teacher to fire the clay objects in a kiln. This paper proposes that there should be an alternative design and production process whereby children are given the opportunity to design independently of adults through replicating their designs using additive manufacturing. This is made possible through the use of the Sense, a hand held scanning device that can scan 3D objects and create a computer generated 3D rendering which can be used to replicate the design using additive manufacturing, specifically in this study 3D printing using the Cube Pro.

Through the use of technology this extension of the design process will allow children more opportunities to be creatively expressive as the technology will provide children with the opportunity to alter their designs in terms of material, colour and form. The benefits of this include that children are involved more in design, introduced to new design possibilities and it opens a new design paradigm for teaching design to children. Moreover, it removes the need for an adult in the design and manufacturing process. However, it is important to note that although the approach removes the teacher as an influence in the design process, the teacher is not removed completely, instead the influencing factors that come from judgement, advise, encourage and feedback are removed. Therefore, the role of the teacher, in order to remove such influences, is reduced to minimum involvement. This level of involvement is referred to here as the 'Independent Approach' which was developed by Madani (2017) which is a development on the Participatory Design Continuum by Read et al. (2002). The latter included the least amount of involvement as being where the teacher has a facilitatory role, referred to as the 'Facilitated Approach' where the child designs and the adult is only the facilitator, the development by Madani (2017) was even less involvement by the adult and included that the child creates, designs and realises design with minimal adult involvement. The use of the Sense allows an independent approach because the teacher is not required to set up the technology and render the scanned data for the 3D printer because the device simply requires scanning by hand and then connecting

directly to the printing and includes the required software.

Another major benefit of the proposed approach of the study is that it will allow children to take ownership of the design and production of their designs and therefore, will lead to the idea of children being more enterprising in design. It is proposed that this extension to the design process will help children to create multiple copies of their design and will introduce children to the idea of mass production and entrepreneurship, that their designs can be reproduced for everyone.

The main research question that was asked in the study was the following: ‘Will the replication of children’s hand-crafted clay pottery by additive manufacturing using the Sense device extend the design process and design possibilities for children?’

## **Preliminaries**

### **Pure art and Independent Design**

Franz Cizek is considered to be the first to put forward the idea of Child Art and this idea was based on his principle that there should not be a set way of teaching, instead he advocated the idea that a minimal involvement from adults was an effective way of fostering self-expression and nurturing creative tendencies that are within the child by allowing them free exploration of ideas together with a wide choice of materials (Viola, 1942). Furthermore, Cizek place a great deal of value on children’s art and he considered it pure and he believed in creating a conducive environment in which children could be creative (Viola, 1942).

Another advocate of pure art was Jean Dubuffet. Dubuffet was a French artist who was opposed to the cultural position and tried to look for new art forms that were distant from what he described as official production (Dubuffet Foundation, 2013). He was intrigued by the art of children and considered what they produced to be raw and accordingly he coined the phrase ‘art brut’, which basically means raw art. The crude and violent energy that Dubuffet saw in

the work of children that was not influenced was incorporated into his own art (Dubuffet.com, 2003). Dubuffet himself offered a definition of this art brut which included the following: ‘we mean pieces of work executed by people untouched by artistic culture, in which therefore mimicry, contrary to what happens in intellectuals, plays little or no part, so that their authors draw everything. . . . from their own depths and not from clichés of classical art or art that is fashionable. Here we are witnessing an artistic operation that is completely pure, raw, reinvented in all its phases by its author, based solely on his own impulses’ Jean DuBuffet. (1949). This definition of what Dubuffet call raw art by children is one of the inspirations for the design of an independent approach that allows children to be creative without the dictates of adults and convention or the influences of adults and would produce an art that is solely based on the impulses within children, and would therefore, be a true reflection of childrens’ creativity.

There is considerable support for the idea of allowing children to be creative independently, and that the art that is produced by children in this way is valued for its purity in comparison to some of the suggested approaches to participatory design where there is always considerable adult involvement. This relates to the notion that creativity should be democratic, that creativity is something for everyone and does not belong to the elite understanding of creativity which says that only certain people have creativity ability, and in reference to education, unfortunately, this approach was considered as an appropriate way of viewing creativity (Robin Report, 1999 cited in Sharp, 2004 p.6). Jackson (2009 p.259) put forward the idea that children should be allowed to create their own original ideas and that children have the ‘capacity for infinite acts of creativity’. McArdle (2002), in reference to the Nurture Nature approach found in participatory design, said that art created through this approach is valuable because it is a product of freedom for self-expression, as well as the fact it can be beautiful, unique and spontaneous. Cassou (2004) says that pure creativity and self-expression go hand-in-hand.

## Participatory Design Issues

There is a much written about participatory design with children whereby children are engaged in the design process with adults (Driskell, 2002, Day et al., 2001, Hart, 1992). Children's involvement in design processes does vary and children, however, children are considered to be socially competent (Gattenhof and Radvan, 2009). There are a number of different reasons why there are limitations on children's participation in design process, mostly these are related to power structures that exist between adults and children and also biases that adults have about children (Druin, 2002), moreover, the relationship has to be negotiated and children are not always comfortable working with adults (Taxen et al., 2001). Moreover, according to Druin (2005) children are not given the opportunity to express their opinions and are not taken seriously; and Taxen et al., (2001) say that children demur to adults.

Another factor that limits children's participation is that children do not have the required skills to use technology or they require adult supervision, examples of this are creating 3D renderings of designs in CAD and using 3D printing technology or using clay ovens for firing pottery. Inevitably an adult would have to be involved in the design process. Druin (2002 pp.1, 2) says that consultation for design is done with adults so that it is 'all-knowing' and 'all-learning', which results in children depending on adults.

One of the premises of this study is that adult involvement leads to adult influence on the designs outcomes. This idea is supported by Gardner (1990 p.ix) who says that designs are influenced by classroom learning. Influence may be verbal suggestions and advice (Burkitt et al. 2010), ideas about how designs can be improved and constraints on the form of instruction (Roth, 1996) and type of support (Einarsdottir et al., 2009).

## **Crafting in Clay**

It is very important when children are engaged in creating art and craft objects that they are confident and that they can use their imaginations. According to Abraham (2005) using manipulative art materials such as clay are very important for emotional development, specifically in terms of creating a sense of control and feelings of success and competency. Moreover, Abraham (2005) also brings attention to the benefit of creative development because using malleable materials allows for open ended creative expression, individualism and development of the imagination. Certainly, clay modeling is recognized as having benefits for allowing children to express themselves (Sekar, 2007).

Because clay is malleable children appreciate the freedom to form it in imaginative ways and through children's experience and the desire to express themselves, they learn the skills that are required for them to form and change the clay in a purposeful way (Government of Ireland, 1999). Moreover, clay not only allows children to show their artistic abilities but it also allows them to invent objects that can be used (Government of Ireland, 1999).

Clay is malleable and therefore, it allows children to use their imagination to form and change the material to design objects (Nunan, 2009). In relation to the study, clay is considered an open-ended material and is suited for allowing children to draw on the creative inner resources so that they can clearly express themselves (Drew and Rankin, 2004).

## **Imagination and Creativity**

In this study it is important to understand a child's imagination and how they realise that imagination in their designs using their creative ability. An image that a child has in their mind is inwardly manifest, and they use creativity as a way to outwardly manifest that image (Holzer, 2009). However, this process also works in reverse, meaning that in order to be creative children have to learn to imagine first (Holzer, 2009). Cohen and MacKeith (1990) say that the child's

imagination is formed based on the external influences they encounter and it is not something that comes purely from an internal source. It is not purely formed by internal influence, this is because the child learns from the world that they live in, and such influences include other people and experiences. It is an important premise of this study that it is recognized that children can produce something new in the way of design, and that they do not always simply reproduce what they have been taught. In light of this idea although children are able to reproduce what they have seen, they are also able to create new images of things that do not exist; for example, life in the future (Vygotsky, 2004).

There are numerous theories about what creativity is. Chan and Zhou (2010) say that there are specific skills that are required for creativity; they bring attention to Vinacke (1952) who said that it however original an idea may be, it can only be realized through skills. Unfortunately, this idea only views creativity as a practical ability and does not consider creativity as a subjective personal quality which is associated with the personality and personal style of the individual (Amabile, 1995).

Franz Cizek said that children's art is produced from an 'unconscious, innate "laws of form"' (Wilson and Wilson, 2009 p.43) that apply to all children, regardless of their environment or their upbringing. Wilson and Wilson (2009 p.44) also believe that this universal language of visual symbols that is inherent in children is something that should be tainted by interference by adults.

## **Methodology**

The methodology employed in the study involved the development of a practical approach to designing and realising children's clay designs in 3D objects using the Sense and the Cubify Pro 3D printer, the following section will describe the development of the approach including the criteria upon which it was developed and the approach structure. The methodology also in-



cluded an experiment of the approach and a post experiment focus group to uncover the feelings and opinions of the design process.

### **Development of Design Approach**

The development of a design approach was achieved through an understanding of participatory design and its limitations on design outcomes. Specifically, there was consideration of how teachers engage children during creativity processes which are eliminated in the development of the design approach. In addition to this, the aims of this study were considered in the development of the approach, for example, the absence of adults and production processes that require no adult supervision. Moreover, the design approach was developed by establishing a number of criteria based on the aims of the study and the need to remove the need an adult from the design process.

#### *Approach Criteria*

Based on the review of the literature of participatory and collaborative design approaches, a number of system criteria were established which aimed to remove the involvement and influence of the adult from the design and manufacturing processes. Specifically, the criteria were that children were allowed to be independent throughout the design and manufacturing process, the children should not be monitored, the teacher was not permitted to discuss designs with children, including providing feedback and judgment, and the children were allowed to manufacture their designs using the Sense and Cubify Pro. The engagement that was carried out by the teacher was considered in relation to the structure of the class itself, this meant that teacher involvement was considered as instruction, engagement and evaluation. This study focused particularly on engagement whereby the teacher offer suggestions, has a discussion with the pupil and offers encouragement. In addition to the practical help, these types of engagement can be eliminated in the approach to children designing. An important focus in this study was the

participation that was related to facilitation of the use of equipment and materials, in this case glazing and the kiln, which was removed by using the Sense and the Cubify Pro.

### **The design process experiment**

An experiment using the proposed approach to design was carried out with children. In total there were 10 children who took part between the ages of 9 to 12 years. The experiment was designed to determine if the children could engage in the design process independently and whether not they benefited from the opportunity to design in a new way without the involvement of adults. Furthermore, the experimentation was designed to determine if children felt they benefitted from the independence that was offered.

### **Focus Groups**

Because this study was concerned with allowing children the opportunity to design free from adult influence, it was important to reveal the children's experiences of using the approach. All of the children who took part in the experiment approach took part in a focus group after the design and manufacturing exercise. During the focus group it was important to find out if the lack of presence of an adult had any bearing on the overall experience and whether the children felt any benefit, in addition to seeing if they found it easy to use the technology and if they ever felt that they needed a teacher, and if so, why?

It is important to note that this study did not judge or evaluate the design outcomes for their creativity or inherent qualities that reflect a child's work not tainted by adult influence, but rather to found out if the children felt that they were given the opportunity to design freely while and the same time taking ownership of the design process which also created the possibility of being enterprising with their designs.

## The design approach experiment

The first part of the process is for the children to create initial designs on paper. The children used paper and a pencil to sketch out their ideas for objects that they will later make from clay, these sketches also included the pattern designs.

The design process in this study was divided into five stages, illustrated in the following:

1. The first stage involved the children creating the objects in clay Figure 1. This involved the same techniques that children had learned in the classroom. It was important that at this stage that there was minimal intervention by an adult, at the most the adult present was a facilitator because they provided the children with materials but they were not involved or influential in the creation of the designs.



Figure 1: Clay

2. Once the clay designs had been created they were scanned with the sense Figure 2. At this stage there was no need for the clay to be fired, this is not necessary because the final product will be printed in ABS using the Cubify printer. The children were briefed about how to use the sense.



Figure 2: The sense

3. The third stage of the process is to transfer the scanned 3D images of the designs to the Cubify Pro Figure 3. This is made simple by the fact that the Sense and the Cubify Pro are designed to interface with each other, there are no CAD skills required, the images are simply uploaded to the printer.



Figure 3: 3D images

4. The fourth stage is the printing of the objects using the 3D printer Figure 4. The children are able to do this by themselves because the printer is suitable for use by children.



Figure 4: 3D printer

## **Production Techniques**

The children were then allowed to render their designs in real clay; standard pottery tools were available which included the pottery wheel and various crafting tools. Normally at this stage once the clay items are ready a teacher will assist in placing them in a kiln for firing, however, the main difference in the proposed approach is that there is no teacher present so the children will scan the clay objects using the Sense. Once the clay objects were scanned by the sense the children transferred the file to the Cubify Pro so that the object could be replicated in ABS (acrylonitrile butadiene styrene).

Consideration of the material was important as the entire process has to be child-led and therefore, materials have to be suitable for use by children. This material is suitable for the approach because ABS is resilient and can withstand high impacts; moreover, it is easily moulded and is suitable for objects that will be used by children. Moreover, ABS absorbs colours better than other polymers and is often used for making toys, a classic example being Lego (Ashby & Johnson, 2013).

Children will be involved in creating vases, bowls, jugs and cups and it is likely that these items will be exposed to sunlight or other heat sources and ABS has a high resistance to low and high temperatures, in fact ABS is often used for kitchen appliances (Ashby & Johnson, 2013).

It should be noted that one of the limitations of using a 3D printer is that an adult is often required for the 3D rendering of a design in CAD before it can be transferred to the 3D printer for printing. However, the Sense overcomes this limitation and allows the 3D rendering to be directly transferred to the Cubify Pro. This is something that can be carried out by the pupil without any help.

### **Sense 3D Scanner**

In order to create 3D renderings of the clay designs the children used the Sense 3D scanner. The Sense is fully integrated with the Cubify Pro so that the children can directly transfer the 3D scan to the printer without the help of an adult. Some of the advantages for use by children in a classroom setting are that the Sense has automatic object recognition so that the background will be eliminated and the Sense can also produce 3D printable images within minutes.

### **Cubify Pro**

The 3D printer used by the children was the Cubify Pro. The advantages of using this printer is that it is designed primarily as a hobbyist printer for use in the home and is easy and safe for children to use, and it is the latest and largest in the Cubify range and is 2.5 times larger than the average desktop printer. Advantages for children include that the cartridge is easy to install and it is easy to set up and because the printer uses a glue-based adhesion system which means that children can easily remove the object once printing is complete (Brown, 2012). Other advantages are that it has an enclosed print environment unlike previous models which is safer for children and offers high resolution settings.

## **The results focus group**

The children were questioned to reveal whether or the absence of an adult had any influence on the children's experience of designing and the design outcomes themselves.

The children clearly acknowledged that there was no adult present and felt that that the experience was very different from design sessions in school. Moreover, it was very clear that at no point did they feel that they needed a teacher's help or advice. Moreover, there was no evidence that the children sought inspiration from adults or their approval. The children were questioned further to find out if they felt independent and in control of the process. There was a high level of feeling independent among the children and they felt especially privileged that they could use the technology by themselves. This freedom or independence translated into a sense of high achievement. There was also a very high expression of feeling motivated which was associated with the fact that they were trusted to design alone.

Importantly, all of the children acknowledged that there were opportunities for them to become enterprising with their designs, they were aware of the potential mass production capabilities of the techniques and that their design could be bought by adults. The children clearly expressed that they understood the idea of being enterprising and that it was something new for children. Often designs for children are done by adults where the child merely informs the adult about what they want, or the child is an equal partner in the process, or they lead the process and the adult in the facilitator, however, the approach that has been proposed in this study has gone further so that the child is engaged in a design and production process independent of adults.

## **Conclusion**

In conclusion the study has shown that it is not always necessary that when children are engaged in design there should be an adult present. Although participatory design between adults and

children is the norm, this study has shown that there is real scope for children to design and create by themselves. This study does not aim to discredit the idea that children are engaged in design with teachers because they need to be taught the required skills and instructed in the use of materials, but rather it offers a new approach of allowing children to engage in design without certain adult influences.

The study showed that the approach offered children a new approach to design by extending the currently used approaches, children were able to visualise their designs beyond what would be possible using a simple process of creating clay design. Importantly, the proposed approach allowed children to understand and visualize how they can be enterprising with their designs. Overall, the approach allowed children to take ownership of the entire design process which a feeling of independence and motivation.

Importantly, this study has implications for the design of curricula and for pedagogical approaches to design. The study has shown that there is the need to completely revisit the way that teachers engage children while they are involved in creative activities. Furthermore, this research has significant implications for the role of the teacher. There is a need to reconsider the role of the teacher as a negative influencing factor in the creative processes of children. Reconsidering the teachers role has been shown in this study to have a number of benefits which can be transferred into other subjects where children are required to be creative.

A recommendation for future study would be to carry out an assessment of the design outcomes from the proposed approach. The designs could be judged by experts to determine if there is a change in the creativity or if the designs show less signs of influence from adults. This would be significant because it will further support one of the premises of the study which is that teacher involvement can have a negative impact on creativity. Furthermore, such an exercise will reveal a new design paradigm which would be a demonstration of children's creative ability that may have not been revealed before.



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