Design Learning

Pedagogic Strategies That Enable Learners to Develop Their Design Capability

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Abstract (not in the original version)

In this chapter we focus on the importance of the human capacity of design capability and how this can be fostered through design and technology education. Historic undervaluing of developing design capability in formal schooling is highlighted and counteracted by identifying recent recognition of embodied cognition and the role design education has to play in developing this. We forefront how learning that holistically links the head, hand and heart can be achieved by engaging learners in design contexts that are meaningful and have resonance with them and illustrate this through a case study of eleven year old learners designing for a public space. We provide background to how understandings of design processes have developed to enable more authentic approaches to design and technology education and how both summative and formative assessment can support these approaches. We place emphasis on pedagogic processes that maintain the authenticity of design processes whilst supporting and nurturing learning. This involves giving learners the skills of working with open and closed projects, how this many vary with the age and experience and how they can develop autonomy whilst also being collaborative and develop empathy. We highlight the importance of helping learners to draw on their own experiences and understand how they can utilise these when designing. Finally we explore how assessment is an important and integral part of pedagogic strategies when developing design capability. We provide a model for formative assessment that can be used directly within design projects based on a resource that actively uses formative assessment to Make Design Learning Visible.

Key words

Design capability, Design education, Embodied cognition, Assessment, Scaffolding, Autonomy, Episodic Knowledge

Chapter 19

Design learning

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Introduction

What is design and why is design learning important?

A fundamental characteristic of being human is an innate desire to make things to be how we want them to be, to change things, improve things, make our world one that meets our needs, wants and desires. Our potential to imagine how things could be and our ability to create our imaginings is a capacity that has shaped the world for centuries. Just as humans are born with the ability to use language – what Chomsky referred to a Language Acquisition Device – so Baynes argued that humans are also born with a Design Acquisition Device, a "wired in pre-disposition to explore and change their environment" (Baynes, 2010, p.7). This pre-disposition becomes visible in small children at the point in which their play becomes purposeful, such as when a bedsheet becomes a camp, a stick becomes a wand. Nurturing this pre-disposition in early years education allows children to develop their imagination and learn how they can impact their environment, their world.

Early Years Education systems across the world support and nurture these intentional making, playing and designing activities that create the foundations of design and technological capability in small children. Building on this development as children grow and education becomes more formal is important, but this importance is not always recognised. Shifting to more formal education is often marked by an emphasis towards what are seen as essential basics – literacy and numeracy. But this can be at the expense of learning within a broader curriculum. In the UK (and maybe elsewhere) we have a phrase that refers to these basics as "the three R's" – Reading, Writing and Arithmetic. In addition to only one of these actually starting with an 'R', Bruce Archer pointed to the fact that these "three R's" only encapsulate two areas of education – literacy and numeracy, areas that can be seen as the foundations of humanities and sciences. He went further by highlighting the ways in which civilisation has also been formed by a third area – that of material culture. This third area, which incorporates creating, designing and making, he described as a critical third dimension of being human. Material culture is, and has been, much valued by societies globally, but in the context of formal school education, and particularly in the case of design and technology, it is often undervalued. Whilst recognising the interlinking of design and technology, in Archer's terms design being the "envisaging what" while technology is the "knowing-how", in this chapter we focus on design and design learning, making the case for

how important design capability is for humans and therefore why this should not be undervalued in formal education.

Craft and making skills have formed a part of formal curricula in many countries for decades and, in some instances, centuries. But the value of these skills has frequently been undermined by stereotyping them as the skills of 'doing' and of 'do-ers' as opposed to more intellectual skills of 'thinking' and 'thinkers'. This age-old prejudice lingers in education systems today, but in recent decades a growth in recognition of the significance of design has caused some shifting of ground. The recent embracing of the concept of "design thinking" and its application beyond the disciplinary area of design (and design and technology) is an illustration of this recognition – even contributing to mainstreaming the value of designing.

In a school context, understanding the importance of design learning within the disciplinary areas of Design & Technology, or Technology Education supports learning in ways that go beyond learning specific decontextualised practical skills. Increased focus on practical learning and embodied cognition, the mind and body working together in developing knowledge, skills and understandings, recognises the complexity of human actions that link the 'doing' of the body with the 'thinking' of the mind. Recent research also suggests that 'doing' may even precede (nearly instantaneously) 'thinking'.

> The brain is designed to put 'doing' before 'seeing' or 'thinking'. We have evolved to be fundamentally active, not contemplative creatures. The idea that human cognition proceeds in linear sequence from *Perceiving* through *Interpreting* to *Thinking*, *Deciding* and then *Acting* is out of date. Before we open our eyes in the morning, our sensory systems are primed by what we want to do and what we are able to do, and the interaction between *Wanting*, *Doing*, *Perceiving* and *Thinking* is near-instantaneous (within hundredths of a second) and continual" (Claxton, Lucas & Webster, 2010, p. 4)

Designing is purposeful, addresses challenges, meets needs, takes opportunities and changes worlds. Taking together understandings of practical learning and embodied cognition with the purposeful nature of designing underscores the importance of developing design capability. This capability neither exists nor is developed in a vacuum. It is nurtured most effectively when engaging in rich and challenging contexts that have resonance with the concerns and aspirations of those being educated. For young learners to develop competence and confidence to engage in design activities, design projects need to have genuine relevance for them. When a learner sees a challenge as important and motivating there is also the 'added value' that the *doing* of the hand and the *thinking* of the mind are joined by the *engagement* of the heart. Such tasks not only build practical skills but also cognitive skills, empathy, design skills and agency as learners become conscious of the positive contributions their designing has made.

A Design project on Time

The Project *Time* organized by Delft Municipality illustrates how engaging learners in a real and motivating challenge can build both capability and agency. For years there was no

clock on the ground floor in the Delft train station, stores and city hall that are all part of the same building, see figure 19.1.

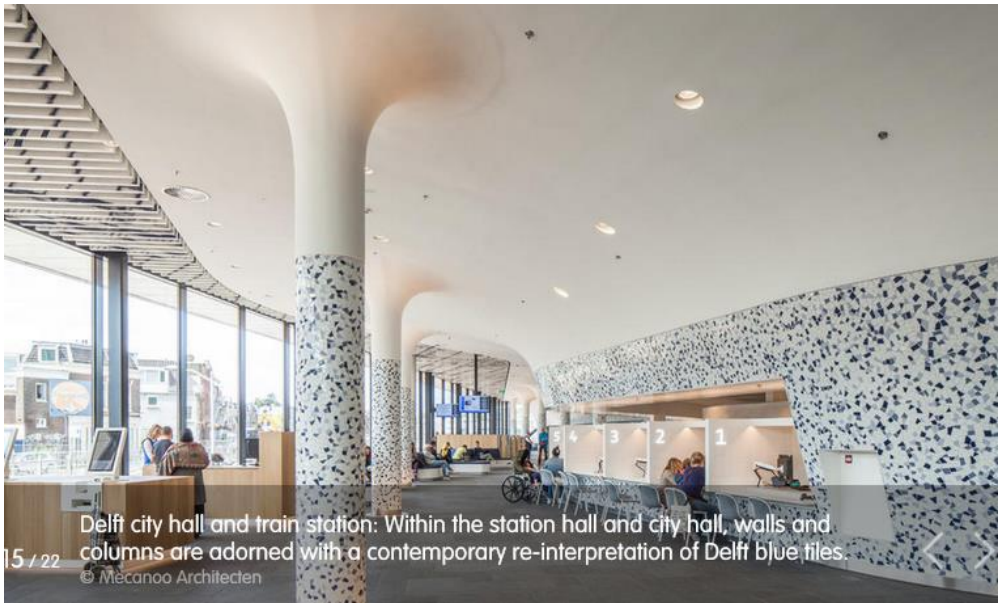


Figure 19.1. There is no clock in the new Delft city hall and train station. (@Mecanoo)

The Alderman of Delft therefore asked eleven year old pupils to create a design that would indicate time for the visitors of the city hall and cater for the needs of all involved stakeholders. However, an ordinary clock was not allowed.

The pupils of eight schools explored the needs and wishes of different stakeholder groups using the city hall. The students held interviews with visitors, desk clerks, door keepers to explore needs and wishes of different stakeholder groups, summarizing these in personas. Discoveries were made, for example desk clerks and visitors did not wish to know the exact time because this would aggravate waiting and lead to stress, while many of them were proud of the history and culture of Delft.

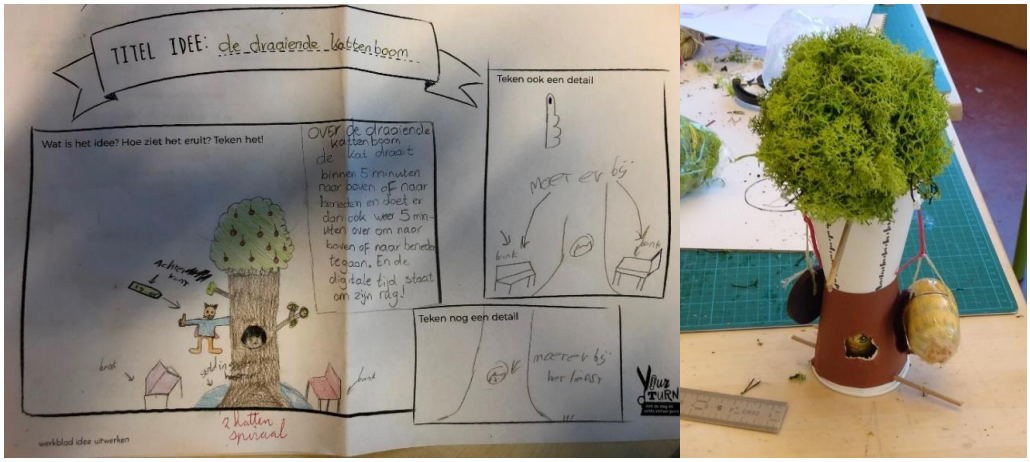


Figure 19.2. A moving cat in a tree signals the time. The cat goes up in five minutes and down the tree in five minutes.

To find an answer to the many needs, wishes and limitations set by the architect and client, pupils cooperated in design teams, generating, selecting, elaborating and testing ideas, see figure 19.2 and 19.3.

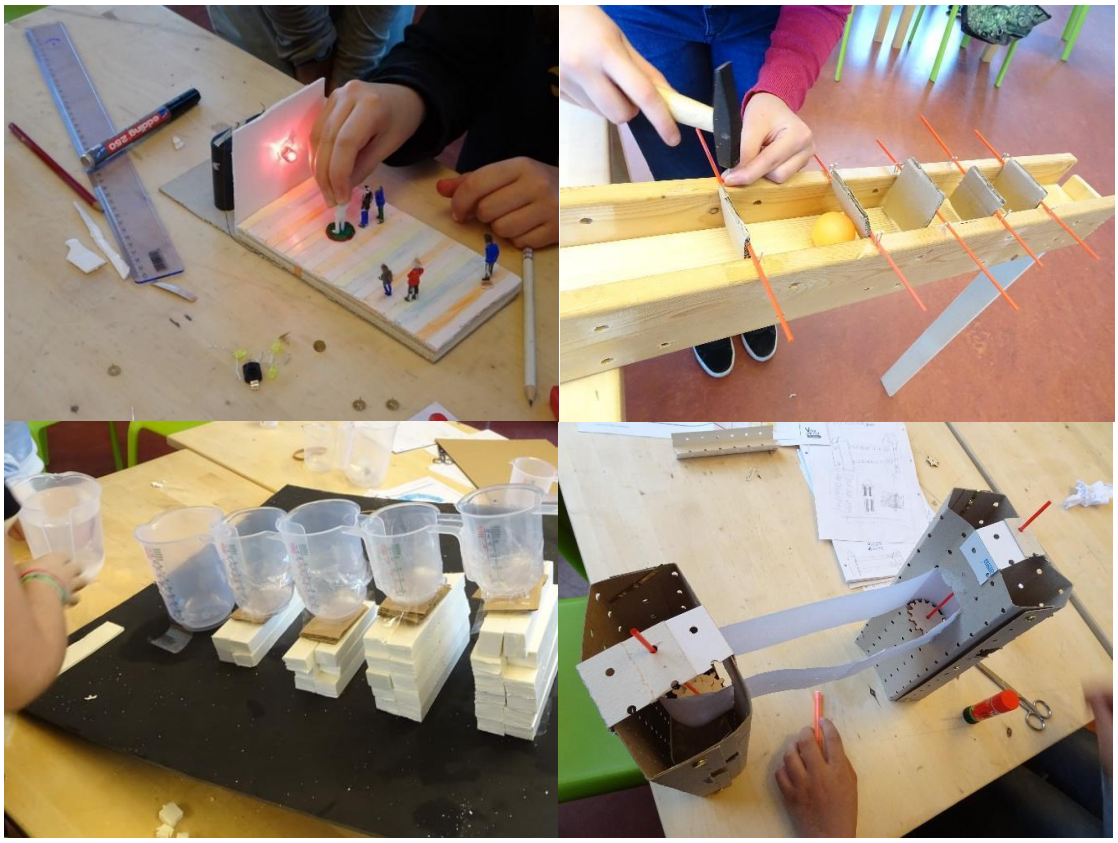


Figure 19.3. Prototyping the time – indicators

All ideas and prototypes were presented to a jury presided over by the Alderman of Delft and an exhibition held for the general public, see figure 19.4.

Figure 19.4. Agency is developed – ideas are explained

Pupils developed design skills such as empathy and creative thinking and learned to switch between thinking, making and reflection. Agency to contribute in a positive way to your own neighbourhood was developed as each design was brought into the public sphere. The idea to illuminate buildings to show the time, figure 19.5, was selected by the jury,

further developed by a design studio in cooperation with the young designers and revealed during a grand opening.

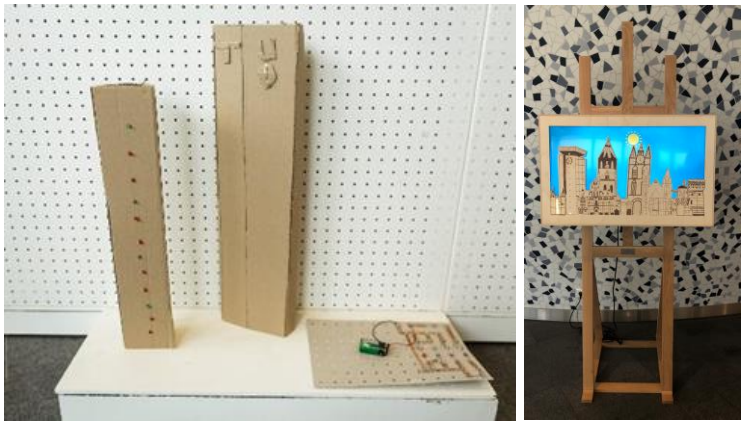


Figure 19.5. Prototype and implemented final design of the time indicator

Parallels can be seen with other demands for learning that develop a broad range of skills, such as those sometimes referred to as 21st Century skills. As an example, curriculum development work at Delft University in the Netherlands has located design skills that can be developed from a young age as contributing to 21st Century skills, as illustrated in Table 19.1.

21st century skill		Design skill	Explanation
Creativity Problem solving		Think in all directions	Pupils generate many, diverse and original ideas. They combine, associate and imagine. They seek inspiration in unusual places and look at problems from different perspectives. And most important, they postpone their judgement.
		Bring ideas to life	Pupils express and elaborate their thoughts and ideas in appropriate, meaningful ways and use tools such as stories, drawings, models and prototypes.
		Make productive mistakes	Pupils try out- at the earliest possible stage - their beliefs, ideas and solutions. They iterate and use mistakes to learn from.
Communication Collaboration		Share ideas	Pupils share their ideas and collaborate within their team. They involve users and other stakeholders in their design process and they look for collaboration with people outside

			the process to improve, spread and implement their ideas. They design together
Social and cultural skills		Develop empathy	Pupils empathize with and understand other users. They experience the problem themselves, investigate the users and context and actively seek input and feedback. They focus on the user's wishes.
Self-regulation		Make use of the process	Pupils switch between different ways of thinking within the design process. While steering the process, they reflect and use feedback and discover most suitable methods for themselves and the project.
Critical thinking Information skills		Decide on your direction	Pupils organize their ideas and develop an overview of their project. They form an opinion about the essence of the problem and the desired quality of the solutions. They make value judgements and decide on their design direction.

Table 19.1. Links between 21st Century skills and design skills (Klapwijk, Holla and Stables, 2019)

Learning to design by envisaging and creating futures – products, systems and environments - is relevant for all children. It is for this reason that we are claiming its importance in this chapter. Design learning is multidimensional and multimodal and involves learning knowledge, skills and understandings that engage the head, the hand and the heart. Linking these requires an holistic approach and we now turn to the importance of understanding processes of designing that underpin this approach and can be developed through design and technology education.

What are the fundamental features and processes of designing? How can they be applied in an holistic and authentic way in learning situations?

An interest in how people design, as opposed to what they design began to emerge in the 1950s and 1960s alongside a growth in systems thinking and a massive expansion in technological developments. Designers began to focus on the concept of design process – seeking to improve the quality of design by identifying and describing components of design methods. Many different approaches were identified, but there was a commonality suggesting that first a problem needed identifying, then a solution needed to be created and finally the

solution needed to be evaluated. The focus on process rather than product sparked interest in areas of design and technology education. As an example, in the UK a simplified model of what became labelled 'the design process' emerged. A particularly influential version of this came through a national research project – the Schools Council Design and Craft Education project – and a linear model became the guide for teachers and then the format for the assessment of design projects. The model was made up of six stages: 'situation', 'brief', 'investigation', 'solution', 'realization', 'testing'. The shift in emphasis from product to process was a major influence on teachers beginning to recognize the value of developing design capability in young people and can be seen as forming the foundations of modern day design and technology education. However, the subtleties in the process became overlooked and a simplistic linear structure took hold, in some countries (for example the UK) becoming more of a pedagogic management process, tied securely in place by its link to summative assessment regimes. High stakes assessments saw mark schemes linked to steps in the process, for example resulting in marks for evaluation only relating to a final evaluation, giving little or no credit to ongoing evaluative decisions while marks for idea generation linked only to initial ideas. Assessment requirements negated the iterative reflective and active nature of designing, resulting in a formulaic rather than authentic approach dominating the pedagogy.

By the 1980s both designers and design educators had begun to recognise an artificiality to a step by step simplistic process and to investigate the realities of how designing actually happens. In education there was recognition that the 'stages' weren't isolated and more cyclical models were produced, recognising that evaluation linked back to the initial design challenge and then further developed by a recognition that evaluation was critical at every step. Understanding was further influenced by concepts of reflection-on-action and reflection-in-action, emerging through writings of Donald Schön clarifying the nature of human processes when designing.

During this era a major national research project on design and technological capability began at Goldsmiths, University of London. The research, the Assessment of Performance in Design and Technology (APU) Project, aimed to assess the design and technological capability of the nation's 15 year olds by assessing 10,000 learners undertaking two short design projects. The detail of this can be found elsewhere (Kimbell & Stables, 2007), but the research team quickly identified that to do this research, the young people who found themselves being assessed needed to be given an authentic a design challenge and that the design and technological 'tests' needed to enable students to iterate between action and reflection as their ideas developed. Through initial trials the team created a new model for designing that was neither linear nor cyclical. It was iterative – and is illustrated in Figure 19.6.

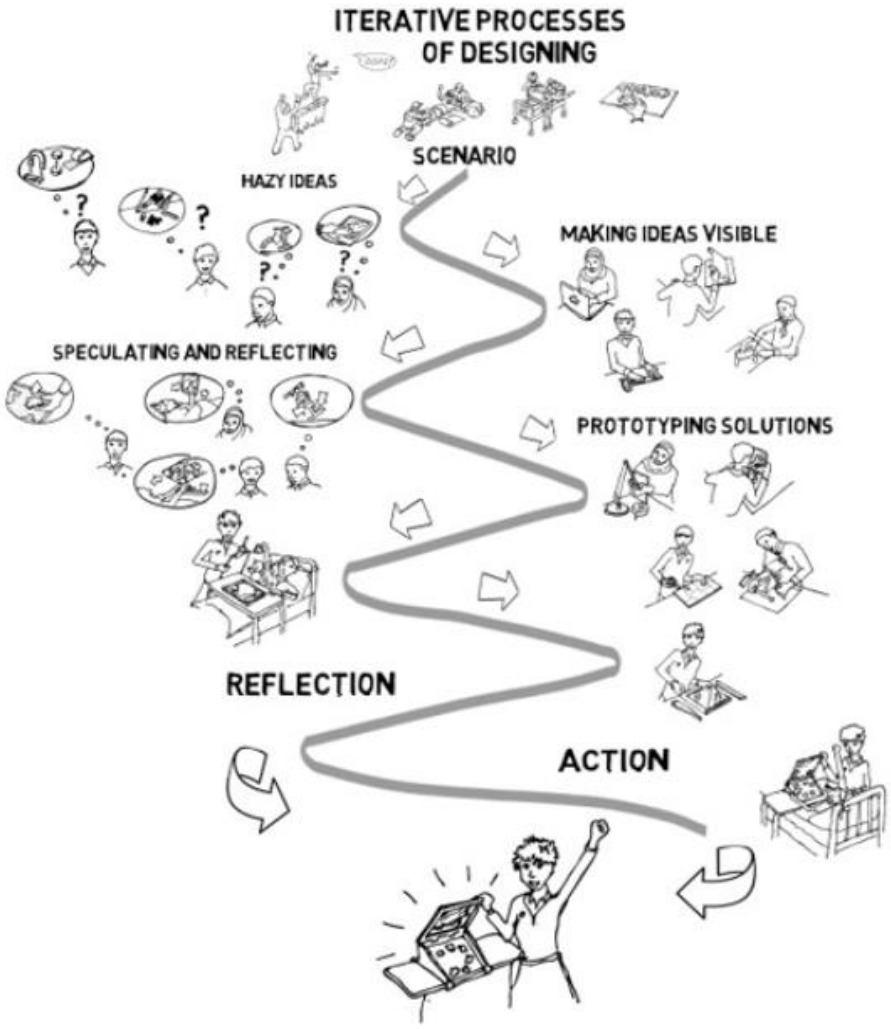


Figure 19.6 The APU Design and Technology iterative model of designing

To cut a very long story short, not only did the research validate the team's iterative model as reflecting how designing actually takes place but also allowed the team to differentiate the quality of the designing that took place. Of importance was the finding that the more balanced and frequent the iteration between action and reflection, the higher the quality of designing was. The model was more than a construct of reality, it reflected the actual reality of processes of designing. It also echoed other research on design processes, for example the work of Archer, Baynes and Roberts on the creative capacity of humans to imagine new ideas cognitively, inside our heads, and model these ideas physically to develop them. Further insight came from design research that was identifying the complex nature of designing, the extent to which design challenges are ill-defined and contain 'wicked' tasks – those that are full of uncertainty and have multiple solutions rather than single 'right answers'.

The zeitgeist of understandings of the nature of designing, of the complexity and uncertainty that surrounds activities of designing, heightened recognition of challenges that this presents in supporting design learning in busy classrooms, studios and workshops. There

are various models, approaches and terminology utilised today in design and technology education across different parts of the world. But there are also constants in the importance of developing and nurturing design capability; the need for designing to be undertaken in motivating, authentic contexts; supporting learners to see needs or opportunities to address; and the need to pedagogically support iterative processes of action, reflection and critique.

Earlier we highlighted how, in some countries, summative assessment had negatively impacted on early understandings of stages of designing that effectively ossified processes. With the greater understanding of both designing and assessment that has come in recent decades, there is now more clarity about how both summative and formative assessment can be used effectively to support learning and teaching in design and technology. In the next section we focus on the 'how' of learning and teaching design, the pedagogies for managing learning and developing design capability and the symbiotic relationship between these pedagogies and sustainable formative and summative assessment approaches.

What can be said about the pedagogy and didactics of design?

Design education is a relative newcomer to schools and universities. Although 19th Century education systems involved making, this was crafts-based. Approaches were different, for example in Scandinavia the Sloyd system encouraged a holistic approach whereas in the UK the focus was on technical skills, teaching girls 'plain needlework' so that they could clothe their families and teaching boys 'plain metalwork' to fit them for roles as artisans. No formal design education could be followed, but at the turn of the 19th century, various design schools started, for example Bauhaus in 1919 and the influential Ulm School of Design (HfG - Hochschule für Gestaltung) in 1953, both located in Germany. Here the pedagogic concept of the design studio was born.

In design studios, students and, for periods of time, tutors form a community of working and learning together. They work on authentic design projects, usually different ones. There is much unscheduled time when students are free to work in their own way, alternated by scheduled events, like talks with the tutor or sessions in which students present their work followed by conversations about their work and new moves to make in the design process. "Should I do more research?" "Could the problem be reframed?" "Is there a need to generate and explore new ideas?" "What needs to be solved in the current design?" The design studio concept has been described by Orr and Shreeve as a "signature pedagogy" of design in higher education and is used in design curricula across the world. It is a major learning tool as students learn to apply iterative processes of action, reflection and critique whilst engaging with peers and supporting each other.

In primary and secondary education, pedagogies can resemble the studio model. Learning is most effective when students learn to design by engaging in authentic design processes, exploring the problems and wishes of certain stakeholders and resolving these through a designed artefact, system, service or environment, as is illustrated in the earlier example of *Project Time*. Generally a design challenge allows for multiple solutions. Contexts need to be attractive, motivational and related to the age-group to spark the interests of the students. For pupils in the first grades of primary school, contexts related to their lived

experience enable pupils to engage meaningfully with a challenge. Links can be made across learning areas, such as designing and modelling safe ways to cross a busy road or develop housing to accommodate guinea pigs that will visit for a week. Contexts can be fictional if children are immersed in a highly engaging situation. This could involve children creating their own stories through a drama activity, as was illustrated by a teacher of 7 year olds, linking history, drama and design and technology in which children set sail for a new world, were chased by pirates, shipwrecked and washed up on an island inhabited by wild beasts. Designing and making shelters that would protect them became a very real design challenge for these young children (Kimbell & Stables, 2007). It could start with reading a traditional story, as two teachers of 5 year olds did by providing a context for designing from the story of the Billy Goats Gruff who needed help to cross a river (McLain et al., 2017). Upper primary school students are ready to design for topics that captivate their interest at another level. They may engage in designing biomedical solutions, educational games, recycling for climate change or a playground for elderly people. Designing escape boxes containing puzzles that have to be solved or way's to experience art for blind people are exciting for teenagers. However, it is good to notice that many design challenges are relevant for all ages, e.g. designing seating or toys could be done by pre-schoolers but also by university students, the challenges set to nurture design expertise at different levels.

Design studios and the use of authentic design projects are considered key strategies in learning to design. While the concept of a studio is often linked to art education, research has shown how studio teaching and learning in design and technology can make pupils "more resourceful, resilient, reflective and collaborative in their approach to learning" (Claxton, Lucas and Spencer, 2012). Authentic design projects are engaging and motivational. However, there is more to this. Designing is a situated activity, related to a specific context. In science, one has to take the laws of nature into account, and these laws are usually context-independent. Semantic or rule-based knowledge is applied. Designing is about understanding a unique situation. What are the needs and wishes of the stakeholders and which solutions are an adequate response? Design is thus specific and subjective and empathic understanding is needed. In contrast, science is often based on abstract and objective understanding. Remember the project about time in the city hall (Figure 1). The type of time-indicator that is needed in the context of the Delft city hall is quite different from the needs around a train station buzzing with travellers. Therefore, a real context or a rich description of a context is needed to provide a holistic learning situation for design. Novice designers need to learn to research into a context and use this to frame design problems and develop criteria that the designing needs to meet.

Another reason for using authentic design projects is that designers have to learn to integrate. Solutions have to be generated, elaborated and tested. In this process it is of great importance to create solutions that fulfil a great many needs. Needs may even be conflicting. For example, a suitcase needs to be strong and at the same time we don't want it to be heavy. Needs of different stakeholders vary and may conflict. In the city hall project, some civil servants may long for a quiet place as it helps them to concentrate on their work, while visitors may want an appealing time-indicator that alleviates the waiting time. In their book Design Expertise, Lawson and Dorst suggest that generating ideas that are an integrative answer is the most difficult to learn. Fourth year academic students designing a new system

to collect litter in a train were better than the second years in analysing the design situation and describing all the different needs. However, the second years who were unaware of the many complications were able to generate solutions more fluently and happily created imaginative solutions. These final year students had developed expertise in analysing the situation and understood the complexities better, however this got in the way of becoming creative. As such they were still on their way to become experts in the creative, integrative activity that is at the heart of designing.

Design is about thinking, acting and reflecting on the results so far. Design is thus embodied cognition and it is not possible to think of design education without modelling, prototyping and making. Materials and knowledge of technologies inspire the generation of solutions. Students need materials to model, build, test and move ideas forward. Where more experienced designers are able to mentally simulate many of their ideas before making, novice designers are less able to manipulate and evaluate ideas mentally. Lawson and Dorst argue that being involved in a great many design projects is probably related to the importance of episodic knowledge in design, analytic and rule-based knowledge is not sufficient. Episodic knowledge is collected through personal experiences. For example, Visser studied how a designer developed a pack-to-bike solution. Besides general rules such as "in pack-to-bike attachments, the centre of gravity must be kept as low as possible", the designer recalled personal biking experiences to inform the design, e.g. "That looks a kind of classy, having a backpack in the centre; in fact when I biked around Hawaii as a kid, that's how I mounted my backpack…… If there is any weight up here, this thing does a bit of wobbling and I remember that is an issue." (Visser, 1995, p. 173). The designer also tapped into experiences of other users by contacting a bicycle firm to ask for user experiences with similar carrier devices. Students in design disciplines are therefore stimulated to study the canon of objects in their field and to collect experiences in logbooks, through observing and drawing objects and noting down personal experiences. However, little is known about how students can learn to use these so called precedents. Teachers are often afraid that students will copy examples instead of using this to inspire their designs. By shifting the context, clients or requirements, learners have to move beyond existing designs and the solutions they became fixated on.

Balancing autonomy, competence and relatedness

Design projects are key to learners becoming effective, skilled designers, however, there are impediments that may hamper learning. When pupils are not engaged they can be passive or frustrate the learning of others. Effective environments need to be engineered for design learning to take place, otherwise it is difficult for pupils to engage, to iterate and to learn from the experience (Looijenga, 2021; Klapwijk & Van den Burgh 2020).

Autonomy is highly valued in the literature on design and technology education and it is often argued that this should be provided by allowing pupils to select their own design quests and approaches at an early age. There is truth in this when we think of designing as think, make and reflect. Through reflection the next design move can be made, and there are no rules for this. However, various studies have shown that this approach in the early years of schooling is too overwhelming (Looijenga, 2021). Even for expert designers, very open design questions are not easy to work on. Often experienced designers solve this "blank

canvas problem" by developing limitations or by an initial concept or idea, sometimes referred to as a primary generator, that can be tested out, developed or rejected, but that allows the whole challenge to be better understood. For novice designers this is not easy and, for pupils managing the early stages of an open project, learning will need scaffolding. The Goldsmiths team hit this problem in our early research. We identified learning and teaching challenges with both open and closed design projects. At the open end, there are so many issues it is difficult to know where to start. At the closed end the project can be so tightly defined that authenticity is lost. We created a model that supported teachers and learner to work from either end – as ultimately designing involves being able to do both.

Design projects exist on a continuum. At the tightly defined end of the continuum there is a need to scaffold activities that will help the learner see the broader picture of their project – the stakeholders who need to be considered, the impact their project could have on, for example the environment. Too broad a starting point can leave pupils floundering, too tight and they can find themselves in a straightjacket, allowing no room for creativity or addressing user needs. At the more open end where a broad context is the starting point providing a rich collection of prompts and activities that 'fast forward' learners into a context can be invaluable and support pupils in identifying their own focused design challenge where they can be innovative and develop their autonomy.

As an example of working from the open end, teachers working with 14 year olds set a design challenge in a broad context of 'design for the future' with a focus on empathy. This focus was chosen as empathy was their current topic social studies class. Students worked in teams of four and were provided with moodboards depicting future scenarios and technologies, along with a briefing sheet. They were asked to design and make a prototype. Each team initially narrowed their project to a particular reference where design could support empathy, then on a specific idea within this. Intermittently they presented ideas to other groups and received peer feedback. Teams pitched their final prototype to the whole class. The most popular prototype was made by a group who focused on empathy for soldiers who worked with bomb disposal dogs. They designed and prototyped armour for the dogs to save the grief of soldiers whose dogs might otherwise have been killed in action.

In contrast, a teacher working from a more focussed starting point working with 15 year olds took an overarching context of 'charity and giving' and a specific brief of designing a flat-pack charity collection box that could be sent through the post. Students were given specific requirements such as the collection box having a security system, expanding as money was put in and including an element of surprise that 'rewarded' the person donating. Each student chose their own charity as a guiding reference and worked on their own project but within a group of three critical friends, allowing intervals of self and peer reflection, critique and feedback. The teacher consistently brought their attention back to the overall context of charity and giving. Students pitched their ideas to a visitor to the class. One prototype was for the charity Water Aid. The collection box featured a pair of hands in a giving posture and a collapsible collection tube that signified flowing water. Figure 19.7 shows the structure of each project, illustrating how students worked between open and closed starting points in the two examples given here.

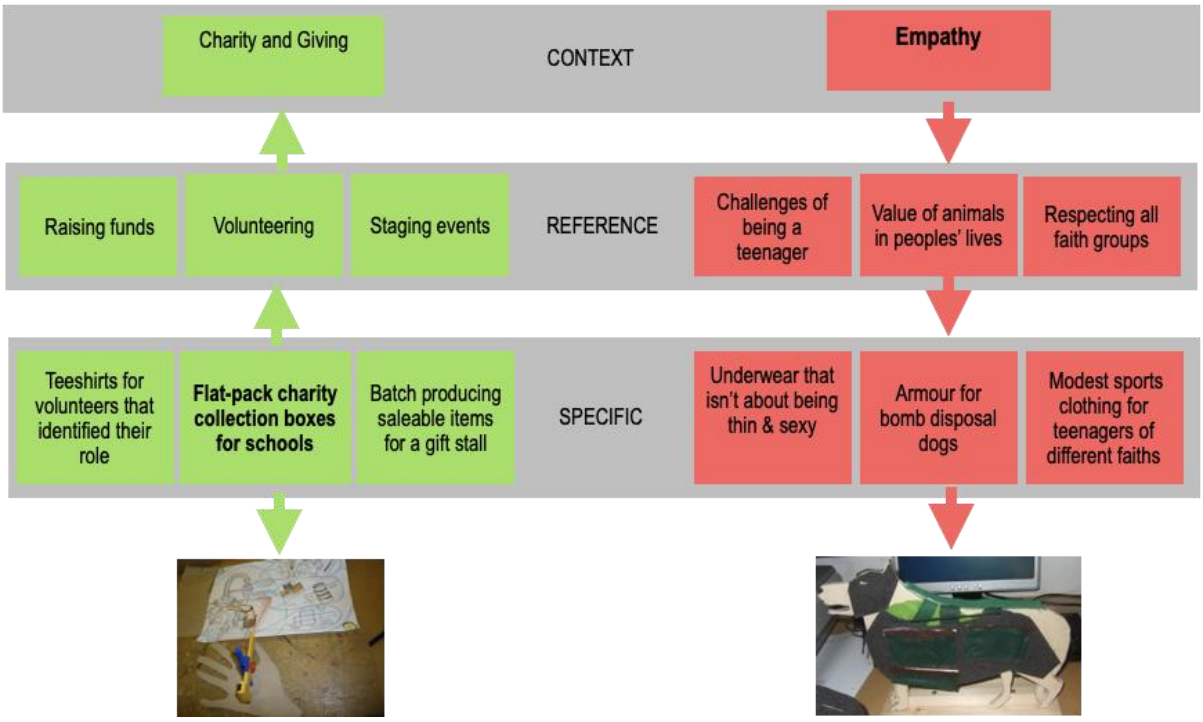


Figure 19.7. Scaffolding design projects starting from specific briefs to open contexts

Most recently in English schools this approach has become very important as the current National Curriculum and linked external assessment at ages 16 and 18 require learners to design within authentic design contexts wherein the learners create their own design briefs.

Autonomy of learners needs to be balanced with competence and relatedness. Looijenga (2021) conducted a number of case-studies in primary design education and points out, on the basis of the self-determination theory developed by psychologists Deci and Ryan, that disengagement arises when a learner's needs of autonomy, competence and relatedness are not fulfilled. When design activities meet these three conditions, it is expected that it will foster high quality forms of motivation and engagement in design as well as enhanced performance, persistence, and creativity. Looijenga developed various solutions that warrant autonomy and freedom to approach a design task in one's own way, but that are better geared to pupils in the early years of schooling levels of design competence.

The first solution is using well-defined tasks and success criteria to guide pupils through the design process. When pupils learn to design, some are well able to deal with vague goals. However, to engage all pupils, Looijenga advises to use clear goals and success criteria for each design activity. For example, design a carrier that is able to transport as many marbles as possible. Through counting marbles, pupils can assess their success.

The second solution is the use of joint presentations to share personal knowledge and insights leading to understanding other perspectives and a growing sense of belonging. In a joint presentation each pupil shows and explains his or her design. In a joint presentation neither the pupils nor the teacher provides feedback. As pupils learn from each other's ideas and perspectives, they engage in playful, iterative design trajectories. The relatedness condition from the self-determination theory is met and through joint presentations each pupil's perspective gets attention.

Another problem that is often encountered in design education is that the novice designers do not iterate enough. The process of thinking, making and reflecting can stop too early and pupils accept their design idea uncritically. Design fixation occurs at any age. Joint presentations are a solution, the exchange supports learning. However, it is also thought that feedback from peers, a jury, client or tutor is helpful in building design expertise. Providing the right kind of feedback is important here. Schut showed that design feedback may lead to emotional imbalance and adverse reactions from the receivers of feedback. Helping pupils to give and receive feedback that is positive and constructive, whilst also having an edge of critique helps develop peer feedback. By providing examples and using scaffolds, pupils are more able to give feedback that was considered as helpful by their peers (Schut et al, 2019). They became more feedback literate and developed expertise in selecting the feedback they thought was most useful and developed more mental images of the design in use and this stimulated further iterations.

During prototyping, novice designers frequently have no clear purposes in mind. Teachers can guide this process by asking each design team to explicate one or two goals or things they want to find out through making. A whole task approach when learning to design is effective. However, it is not the only way to learn to design. Groundwork, a term coined by Looijenga, describes an approach in which specific design skills that can aid success in a planned authentic design project are developed before the project is embarked on. Demonstrations and exercises to develop skills to think creatively, to observe, to communicate and ask questions or to work with specific materials or tools provides insight into how this can be successful in supporting designing within a project. For example, a teacher may decide to practice observation of the made world and ask pupils to look around until they have discovered something they have not seen before, a short five minute task with a clear success criterion that can be monitored by the pupils. After a few short observation exercises, pupils become sensitive to their environment and use the skill spontaneously. Observing and evaluating the made world is an important skill as design is situated and context dependent.

In design processes, reflection is essential to make the next move and also crucial in learning design skills such as creative thinking and collaboration. This is the topic of the next section.

Assessment that moves design learning forward

In education, one needs reflection on learning. Ideally, teachers embed formative assessment in the design activities to enhance learning. Delft University's Make Design Learning Visible project developed a formative assessment framework drawing on five key-strategies that have been classified by formative assessment experts to develop the model shown in figure 19.8. (Klapwijk, Holla and Stables 2019).

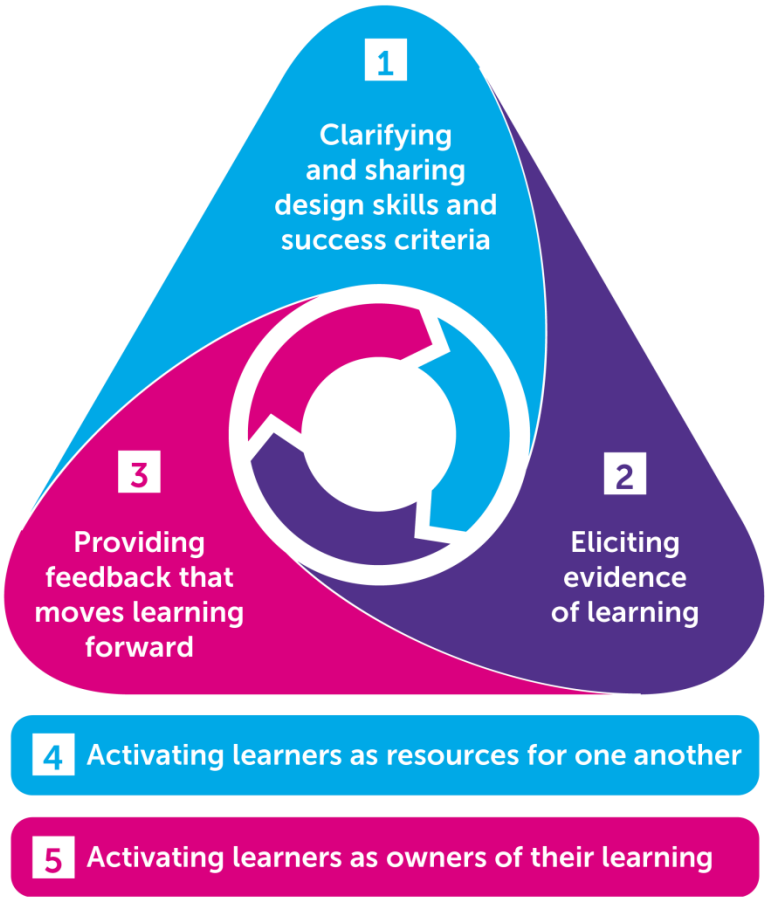


Figure 19.8. Five key-strategies for formative assessment from the Make Design Learning Visible approach. Source: Klapwijk, Holla and Stables 2019.

In design projects, many learning intentions are possible due to the 'whole task approach' ranging from scientific and technological principles, to design skills creativity and practical skills. Applying focused assessment where one activity in a design project is chosen as the focus for assessment, such as exploring the problem, interviewing users, generating ideas, or communicating ideas is practical and manageable. Choosing one specific angle for assessment and identifying specific ways collect evidence of this during the selected design activity gives a clear focus for both learners and teachers.

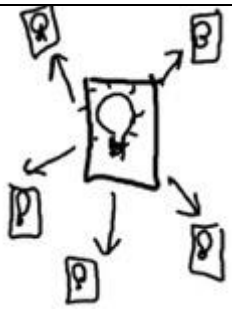
The idea to share learning goals and success criteria before a design activity (strategy 1) means students will know which design skill they are learning and can apply the success criteria to monitor themselves. An example of this is when, before a brainstorm, a teacher asked 11 and 12 year old's how they could think divergently and the class then collectively made small drawings on the smartboard to visualize the skill of divergent thinking (Klapwijk & Van den Burg 2020). Half-way during the brainstorm session, students were asked to assess their brainstorm results and divergent thinking skills in a collective reflection. The students their own expressions such as don't stick to your ideas, mix your ideas with other ideas and think of opposites to talk about what divergent thinking looked like and were able to diagnose their own strengths and weaknesses. This helped them to improve some elements of their divergent thinking during a second brainstorm. Using, analysing and ranking exemplars - work of other students on a different design challenge – on specific criteria also helps students to understand success criteria at the start of a design activity.

1. You need a team, everybody thinks in a different direction

2. Collect many ideas.

3. Do not hold on to your own idea

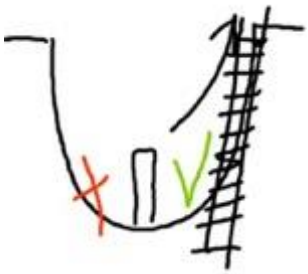
4. Combine ideas



5. Use an idea to develop a new idea

6. Talk together about ideas

7. Think about the opposite



8. Perservere, do not stay trapped in your "learning" pit

Figure 19.9. Collective drawings on how to think divergently. Source: Klapwijk and Van den Burg 2020.

To collect evidence and elicit real time evidence of using a design process (Assessment Strategy 2), e-portfolios affording multi-modal responses (text, drawing, photo, audio) can help collect valuable evidence of learning. This rich evidence can be used to diagnose a design skill, (Assessment Strategy 2), provide feedback to move learning forward (Assessment Strategy 3), support peer learning (Assessment Strategy 4) and help learners reflect on their own design skills (Assessment Strategy 5).

Peer feedback is a well-developed approach in design education. The feedback could focus on specific design skills, but also on design outcomes. We have already discussed ways of helping learners provide constructive feedback as projects progress. A further idea is to use Adaptive Comparative Judgement. Pioneered as a strategy for peer assessment in higher education by Seery, Canty and Phelan (2012), students compare a sequence of pairs of design outcomes of their peers, deciding which of each pair is best overall and identifying the reasons why they think it is best. Using this peer feedback procedure, students develop a nose for quality and are better able to judge their own design outcomes. This approach has also been used in school settings with equally positive impact. Other studies have focused on eliciting evidence through thought-provoking questions that help students to intermittently

evaluate their design ideas throughout a project (Benson & Lawson, 2017; Stables, Kimbell, Wheeler & Derrick, 2016).

Formative assessment supports the learning journey and in the context of design learning, has parallels with the importance and value of reflection-in-action. There are many different tools available, a number of them are brought together in *Make Design Learning Visible* (Klapwijk, Holla & Stables, 2019) and the TAPS project from the Bath Spa University examples (https://taps.pstt.org.uk/). Advice is to focus assessment on specific skills during design activities, allowing time and space to share and clarify learning goals, collect evidence, provide feedback and then room to practice a skill again. Contributions can be made by self, peer and teacher formative assessment. Reflection-in-action forms a basis for formative assessment that develops both designing and learning capabilities.

Summary

Learning to design and to be creative by envisaging the future is relevant for all and should be nurtured in our educational systems starting at an early age. We are born with a wired in pre-disposition to explore and change our environment. Through design learning, we can become active citizens that can empathise with and understand others and generate and build original and relevant solutions for society. Integrative activities are at the heart of design and this calls for learning through authentic, studio-like design projects. In design learning, reflection in action as well as interaction of mind and hand are central. Episodic knowledge is combined with analytic knowledge and learners apply design skills such as empathy and creative thinking. For progress, engaging in design is not sufficient. To ensure progression, pedagogic strategies are needed including strategies that fulfil the needs of autonomy, competence and relatedness and those that stimulate reflection on both design and learning processes.

Key words

Design capability, Design education, Embodied cognition, Assessment, Scaffolding, Autonomy, Episodic Knowledge

Questions

- How is designing and design thinking valued in your context? How could it become more highly valued?
- Think about when you were young and your everyday activities. How were you involved in designerly thinking? How might this be similar to learners today and how could they be supported to understand and use their everyday design thinking and capability?
- Why is reflection on design processes and intermediate outcomes crucial in learning to design? What strategies do you already use to encourage the iteration of action and reflection. How could you improve these?

- What strategies involving self and peer assessment do you already include? How can this chapter help you extend and develop these?
- Envision a design project that you might do with learners. How would you make the learning visible and collect evidence? (NB the Make Design Learning Visible resource could also be useful)
- Look at the design skills. Why are these crucial for any designer? Which design skill would you like to develop more? Think of some routes and activities to support it's development.

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