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Thinking with Card: Curriculum-Led Making Activities Integrated with Distance Learning

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Abstract | This paper describes the integration of creative making activities into existing curriculum components primarily for Chinese (Middle School) students (approx. age 7-14). The strategy is built on an understanding and experience that while such activities are crucial to the development of design and spatial ability, their presence is generally undervalued and marginalised in favour of higher status subjects. In developing learning tools that reinforce more traditional subject areas, (particularly STEM), the project aims for a greater acceptance of design-led and making activities. The provision of a free (bilingual) online repository of these activities has made them highly suited for use during the Covid-19 pandemic and corresponding increase in distance learning and home-schooling. Early user tests indicate good acceptance of the concept, and recent government policy announcements may improve acceptance further. The design of new models has been built into a standard course for undergraduate design students.

KEYWORDS | EDUCATION, ACTIVE LEARNING, MAKING, CREATIVITY

1. Introduction

This paper presents novel strategies for improving access and acceptance of art and design making activities in the curricula of Chinese middle schools. While recent years have seen some enthusiasm for reform in the area of 'aesthetic' education, this has rarely translated into increased access to making activities in art or design fields (Yang, 2019). The project described in the paper, "Thinking with Card" attempts to integrate these valuable making skills into more traditional subject areas, thereby gaining acceptance as a means of augmenting learning in the traditional setting. These students generally lack the opportunity to engage in hands-on lab activity in science subjects and have limited scope for exploring their learning outside of lectures, essay writing and problem solving (Tatlow, 2019). The project is aimed at Chinese (Middle School) students (approx age 7-14) but has been developed in a bilingual model so that it is also suitable for UK (Key Stage 2 and 3) students. These activities are designed to be available for download from a website and then printed and made at home using simple and widely available tools. The outcomes serve not only to illustrate complex ideas in subjects such as maths, physics, biology and geography, but also to develop students' skills and interest in making card models. This in turn is intended to boost students' spatial and construction ability which is seen as crucial in developing design and problem-solving capabilities (Hughes & Milton, 2006). We have sought throughout the project to gain feedback from both teachers, students and parents in order to enhance the material. Derived as a means to improve making and spatial skills at an early age, the project has also been integrated into a course for undergraduate students (to develop new card models). This is a way of ensuring the sustainable development of the project as successful outcomes from the students work can be incorporated back into the resource.

2. Educational Reform and Shortcomings of Creative Education

While represented in the core curriculum up to grade 10 in China, art education is generally limited to 'Art Appreciation' type courses in secondary schools (Wang, 2003). The responsibility to provide more familiar 'hands-on' learning in this area has therefore fallen to parents rather than schools in China. In the last decade this has created a boom in extra-curricular art and design education as the growing middle classes recognise the importance of this type of activity in terms of creative thinking and problem solving (Tatlow, 2019). Previously only part of a national strategy in the broadest terms, there are signs that the traditionally conservative Ministry of Education is working to improve access to art education for Chinese students. On July 8th 2019, the Communist Party Central Committee and State Council published new guidelines for education reform including a call to strengthen 'aesthetic training with more art curriculums and activities." (Communist Party of Central China Central Committee and State Council, 2019). This includes a desire that "More information technology should be integrated into school teaching with more free and high-quality educational resources in rural and remote areas." These guidelines have evolved into

more concrete proposals such as the announcement on October 20th, 2020 that further promotes 'aesthetic' education in schools. These proposals culminate in a pilot policy that for the first time, assessment in art subjects will be included in the general standards for high school enrolment over the whole country by 2022 (The Chinese Ministry of Education [MOE], 2020).

The issue remains, however that in practice there is much misinterpretation of the guidelines and huge differences between the quality and quantity of arts education, much of it continuing to focus on the accumulation of knowledge to pass exams rather than the merits accorded arts education in a broader developmental sense (Yang, 2019). In terms of fine art, this is likely to mean the ability to assess a movement, style or individual artist from a prescribed viewpoint, in turn taken from a sanctioned historiography of art history (Yue, 2009). Given the large class sizes and limited resources this content is generally delivered in a lecture or powerpoint format. There is little opportunity for the appreciation of real artefacts and even less for hands-on experience of materials and techniques. In some circumstances the guidelines ascribed for 'Aesthetic Education' are interpreted as more akin to citizenship - assessed in relation to being well-disciplined or doing good deeds in public (Li, Xue, 2020). It becomes clear that while there is recognition at a government level as to the importance of creative activity, there is often little enthusiasm for space within the curriculum given the existing pressure on examined subjects.

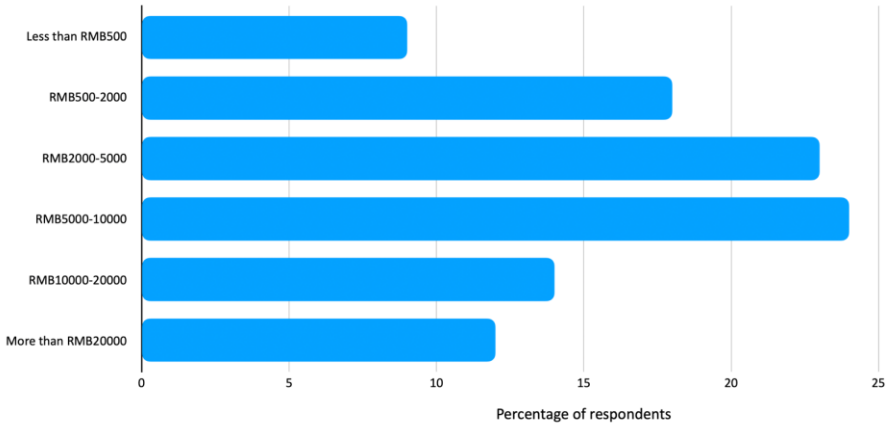

Figure 1. Projected annual expenditure per child on extra curricula art classes (sample taken from parents whose children already enrolled in extra curricula art classes. (Wang, 2020).

This shortfall in provision is therefore left to the parents to pick up - those sufficiently keen to promote creative practice in their children's development (and sufficiently affluent to provide it). Demand in this area has created a growing industry of specialist institutions who provide extra-curricula activities in a wide variety of subjects - painting, ceramics, textiles,

drawing, sculpture, art appreciation. One such provider is Big Ink Dandelion (大墨蒲公英素质美校) which boasts over 200 sites in 150 cities throughout China. The company claim to have taught over 10,000 students (ages 3-16) since their founding in 2001 (http://www.dmpgy-art.com). The branch in Weiyang District, Xi'an, Shaanxi Province has 11 teaching staff and between 500-600 registered customers. In order to better understand this market and some detail of parents' attitudes, spending patterns and interests, a survey was conducted in collaboration with Big Ink Dandelion in September 2020. 100 parents from the company's database which fit the profile of our target audience (age 7-14) were canvassed (Wang, 2020). It was found that while the vast majority of parents expressed their interest in art and design courses, 80% felt unprepared to provide access to these kinds of activities at home. 51% of all parents were planning to purchase art related activities in the next year, prepared to pay over RMB5,000 (U.S.$760) per year, rising to over RMB20,000 (U.S.$3050) for 12% of respondents) for the privilege (figure 1). In terms of the aims of this investment, it was clear that parents didn't expect the children to move into arts education, but that they considered the outcomes beneficial to their children's overall powers of imagination and creativity (51%) and appreciation of art (46%).

As a 'New First Tier City' (Yicai Global, 2019), Xi'an has a wealthy middle-class population where parents are evidently happy to spend money on their children's education outside school, but this research is by no means representative of the whole population. It is reasonable to extrapolate a broad picture, however, of a growing market for, and importance placed on, the provision of suitable art and design activities.

3. A New Strategy for the Integration of Making Activities

In developing a strategy for the promotion of making activities in schools, three issues were considered in relation to each other: Firstly the lack of provision of studio or art-room based teaching in Chinese middle schools; secondly, the acceptance of and demand for creative training amongst middle school parents and thirdly, the traditional focus on core examined subjects in the curriculum.

The strategy itself is based on an understanding of the importance of making in relation to creativity and design (Williams et al, 2010). The author's own experience with hundreds of design students in Chinese Universities reveals that only a small proportion have been able to acquire anything beyond the most rudimentary making skills and that the accepted practice is for model-making requirements within a design course to be farmed out to professional companies. The level to which this approach is normalised runs counter to evidence that links making practice to creativity and problem solving in the design process (Hallgrimsson, 2012).

This project aims to combine the benefits related to the making of physical models with the benefits related to the use of practical elements within the teaching of STEM subjects in

schools. In the UK, this has its origins in the Nuffield Science Projects of the 1960's which imagined the 'Pupil as Scientist' and encourages the natural curiosity of students with the effect of a deeper learning experience with better recall (Millar, 2004). While this has even extended to the teaching of science in a distance learning format in the UK (Fox, 1994), it is relatively uncommon in China where a teacher-orientated approach means that even laboratory work is taught through demonstration or even video rather than direct experimentation (Fulmer et al 2015).

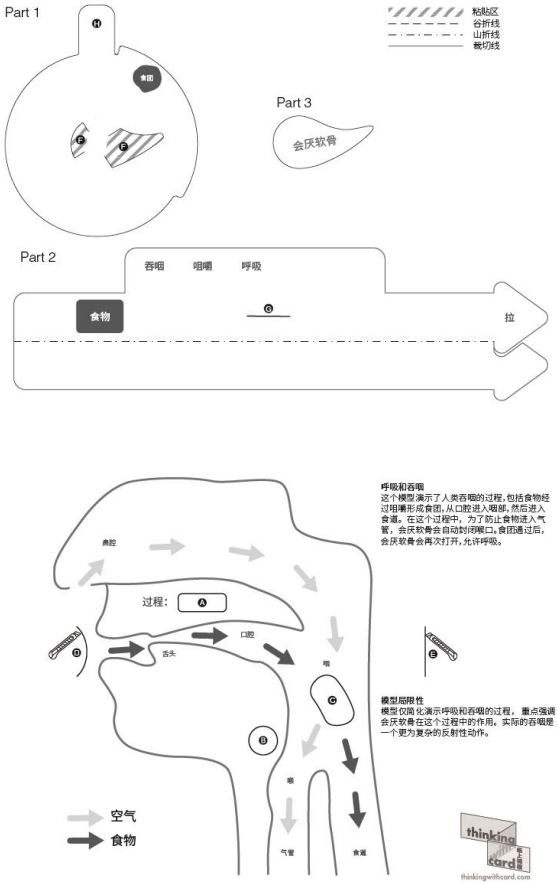

Figure 2. Thinking with Card Epiglottis Function Interactive Model Example (printed spec).

The Thinking with Card project provides targeted curriculum support material that is relevant to specific knowledge that the student needs to acquire. This is a step towards a

more experiential learning model (Dewey, 1938), which is not widely implemented in China. This novel teaching material is in the form of print specifications in PDF format which may be downloaded via a computer or mobile phone and printed out (figure 2). This material comes to life when it is constructed by the student using simple tools either at home or in school. The resulting interactive model, intended to show the concept in an engaging way, adding an extra dimension to existing teaching materials which should in turn lead to greater comprehension and recall. The models generally contain supplementary information to support the concept being demonstrated, but may also be amended and added to by the student. The making and interaction with the model is intended to bridge the gap between the theoretical model of the world (required in order to reproduce the information) and the physical world (that which is directly experienced by the student). This 'changing of register' to make the phenomena appear in a different medium (Figure 3) is thought to help students better construct meaning to their knowledge and be able to apply it in more abstract ways (Tiberghien, 2000).

Figure 3. Categorisation of Knowledge Based on Learning Experiences. Adapted from "Towards Research-Based Design of Teaching Situations in Physics at the Secondary School Level." (Tiberghien, A. 2000).

Whilst the 'hands-on' nature of the learning experience is itself only another representation of the phenomenon described, the fact that this model can be subject to physical interaction and repeated movement makes it a far more valuable resource than a diagram or even a series of diagrams. It becomes possible to represent opposing elements within a particular concept, for example the relationship between current, movement and magnetic field in the process of electromagnetic induction in a coil, (figure 3). This making activity and subsequent interaction provides the kind of opportunity for the reconstruction and retention of knowledge in the mind of the learner that is so valuable (Driver et al, 1994).

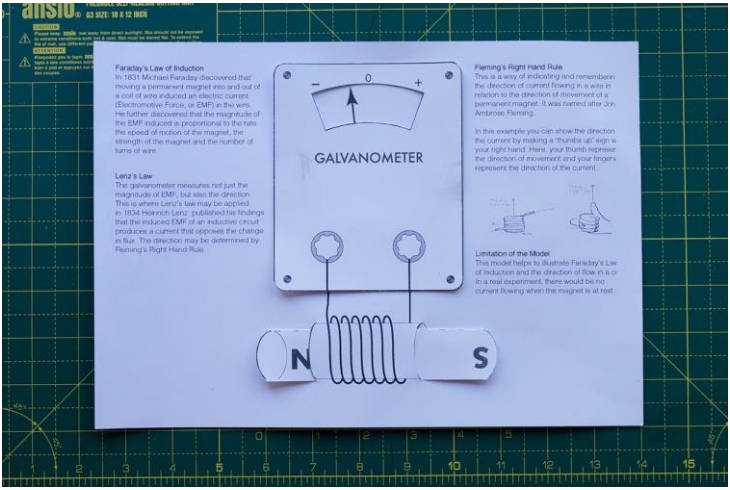

Figure 3. Thinking with Card interactive model demonstrating electromagnetic induction in a coil, Faraday's Law, Lenz's Law and Fleming's Right Hand Rule.

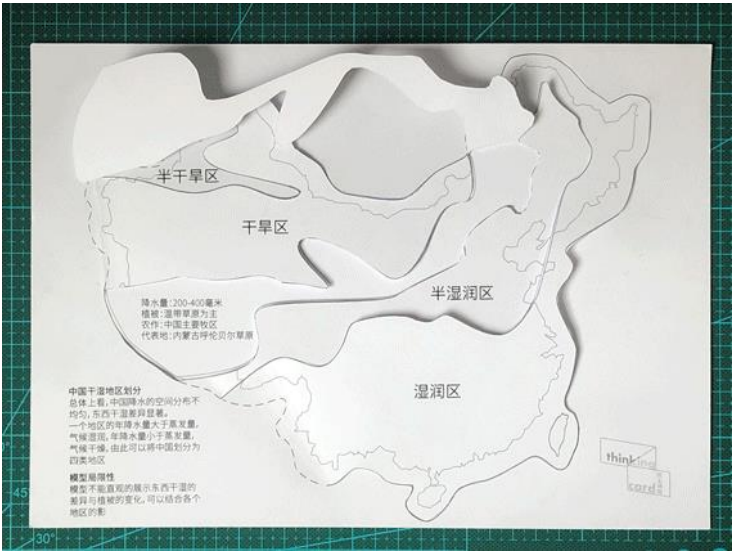

Figure 4. An interactive map demonstrating the zones of Chinese climate based on rainfall. One of a series of interactive models based on standard elements of the geography curriculum.

4. Integration of New Strategy into Learning Schedule

The route to integrating the model and making activity into a student's schedule may be instigated by either teacher or parent. Each activity is intended to fit with a subject in the STEM curriculum, although there have also been models added that relate to the History and Geography curricula (Figure 4). The parent or student can download the PDF model onto a computer or smartphone and print this out either at home or cheaply at a local print shop. Each .pdf document is available in English and Chinese and includes both the parts needed to make the model and the instructions to be followed (Figure 5). Certain models are intended to be made from paper, others in thin card (180-250gsm). Where the latter is required, the model may either be printed onto paper and mounted on card or printed directly onto the card. The basic tools required include a cutting mat, knife, glue stick and metal ruler, with instructions given on how to use these safely.

Figure 5. Example of the instructions required to make one of the models, in this case the structure and function of the middle ear (Chinese Version).

The strategy developed makes use of relatively simple materials and processes but aligns these with the high penetration of computer and smartphone use and the availability of printing resources either at home or in local print shops. The website was created with a simple interface through which teaching models can be downloaded and printed out. This meant that the models can be used both in established school curricula, those developed in

response of the Covid-19 pandemic (and greater need for distance learning tools), and those developed for home schooling.

The website started with a handful of models in order to demonstrate the concept. From this, we sought advice and feedback from teachers, parents and students in terms of identifying suitable models for development. This led to a set of 14 models which address the various areas identified. There are several more models in development, but the complexity of some leads to a lengthy development period. It is interesting to note that while this project was undertaken to address a particular set of concerns, it is not unique in its outlook. In the course of developing the project, we came across interesting historical examples of card models both for education in a conventional setting and also through promotional items. One significant example is a series of card models published in Manchester by John Heywood Ltd. This series of articulated cardboard models show detailed schematics of piston and valve timings in several engine types including diesel, petrol, Corliss steam and simple steam engines (figure 6). These models are similar in concept to models in the Thinking with Card project, albeit more sophisticated and detailed. It goes without saying that the user is not required to make the models, but their implementation, along with instruction in the included booklets, engineering students can create complex calculations related to efficiency and pressure (Jones, 1903)

In addition to historic examples of card models, the potential for combining home printing technology and card modelling techniques as an educational tool have been explored by researchers in the past.

> "As many teachers and parents are aware, building pop-up books and cards can be a compelling creative activity for children. Pop-up forms manage to combine, within a single artefact, artistic and creative invention, spatial and mechanical motions of paper, and (often humorous) writing." (Eisenberg et al, 2003 p.2)

While the activities described do not quite fit the model described in this paper, they share two key components: mechanical pop-up forms and making activities for children. In terms of the development of creative skills, there is broad consensus in the design education community regarding the importance of prototyping and model-making. While the role of visual models and prototypes are fairly familiar, it is also acknowledged that sketch models and experimental models are also crucial throughout the development process.

"Prototyping is a key problem-solving activity in product design. It starts right from the beginning of a project and continues right into production. Given the complexity of product development, it is critical to take as much of the guesswork out of the design process as possible, and prevent surprises from showing up later in a project." (Hallgrimsson, 2012 p.7)

While many design texts focus on the use of foam, clay and timber models, it is clear that card models are widely implemented and valued for their speed, accuracy, reproducibility and cost-effectiveness (Saul G. et al 2010)

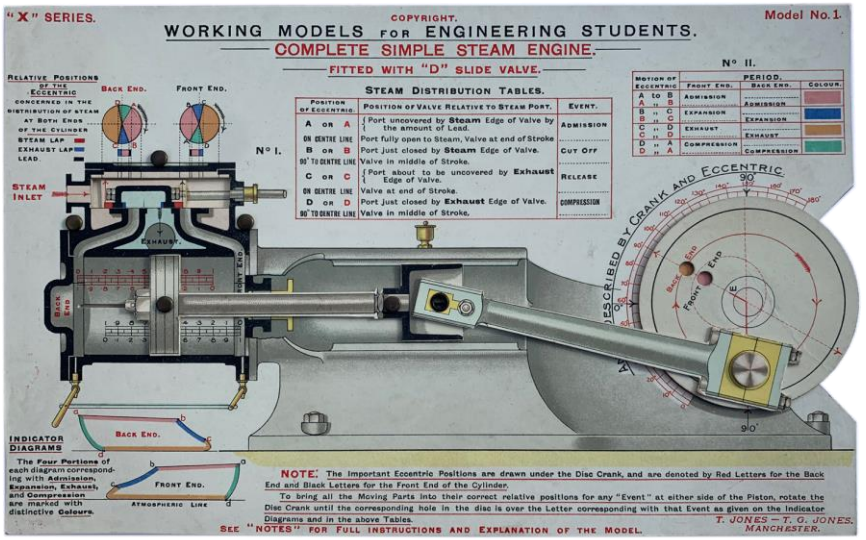

Figure 6. Example of an articulated card model used to teach engineering students the parameters of steam engine performance and design. (Jones, 1903)

5. User Testing and Feedback

From the beginning of the project, an attempt was made to develop an ecosystem for the project from which feedback may be sought from teachers in the area targeted. These teachers, once familiar with the aims and scope of the project, would be able to both select appropriate tasks for their students and suggest models that would be useful in the teaching of particular themes and concepts (Figure 7).

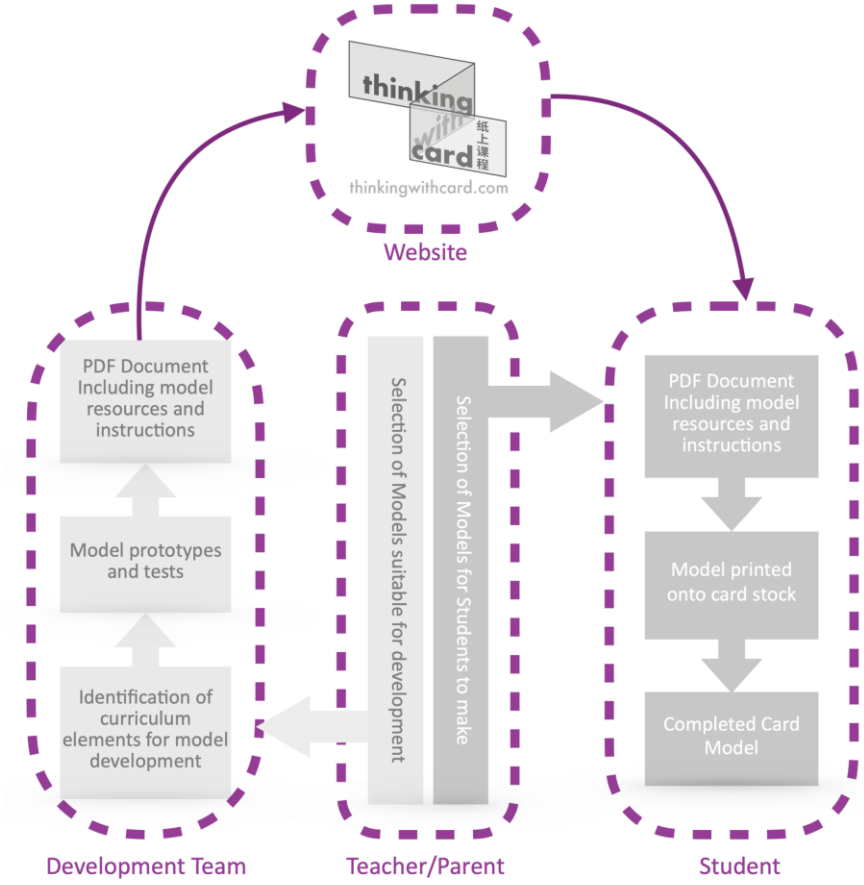

Figure 7. Representation of the different roles within the Thinking with Card ecosystem

Once a series of models had been developed, the website was promoted amongst teachers and parents who might be able to implement the tools in their own teaching. This included posting to relevant social media groups, targeting specific teachers and running workshops with students of an appropriate age where additional instruction could be given and observation could be undertaken (Figure 8).

Figure 8. Workshop conducted with students to build sample models.

The initial interest was good amongst students of the target 7-14 age bracket. They managed the tasks well and reported enjoying the experience. It is clear that this kind of making activity, despite being themed around academic subjects is considered more like 'play,' where the novelty and freedom to explore holds less status than perceived activity of accumulation of knowledge. We were therefore more interested (and apprehensive) regarding feedback from teachers and parents. In order to get as much coverage as possible, this was sought through the more formal means of a survey.

The survey was undertaken to identify areas of weakness in the strategy and as a tentative evaluation amongst the target audience. The sample was chosen through a database of families and teachers who had participated in workshops or been made familiar with the project through introduction by students and tutors in the previous 6 months. 70 respondents were canvassed through Wechat social media, accessed through smartphone. The questionnaire contains both closed-ended and open-ended questions in order that we can use the information in a numerical analysis and also accept more detailed insight where it is available. The closed-ended questions are concerned generally with opinions about the use of practical making activities for middle school students and the use of the Thinking with Card models. These questions have a Likert five-point scale choice to determine the strength of opinion (figure 9). The questionnaire was conducted in Chinese language only amongst Chinese teachers and parents. The results are published online (Hughes, 2021).

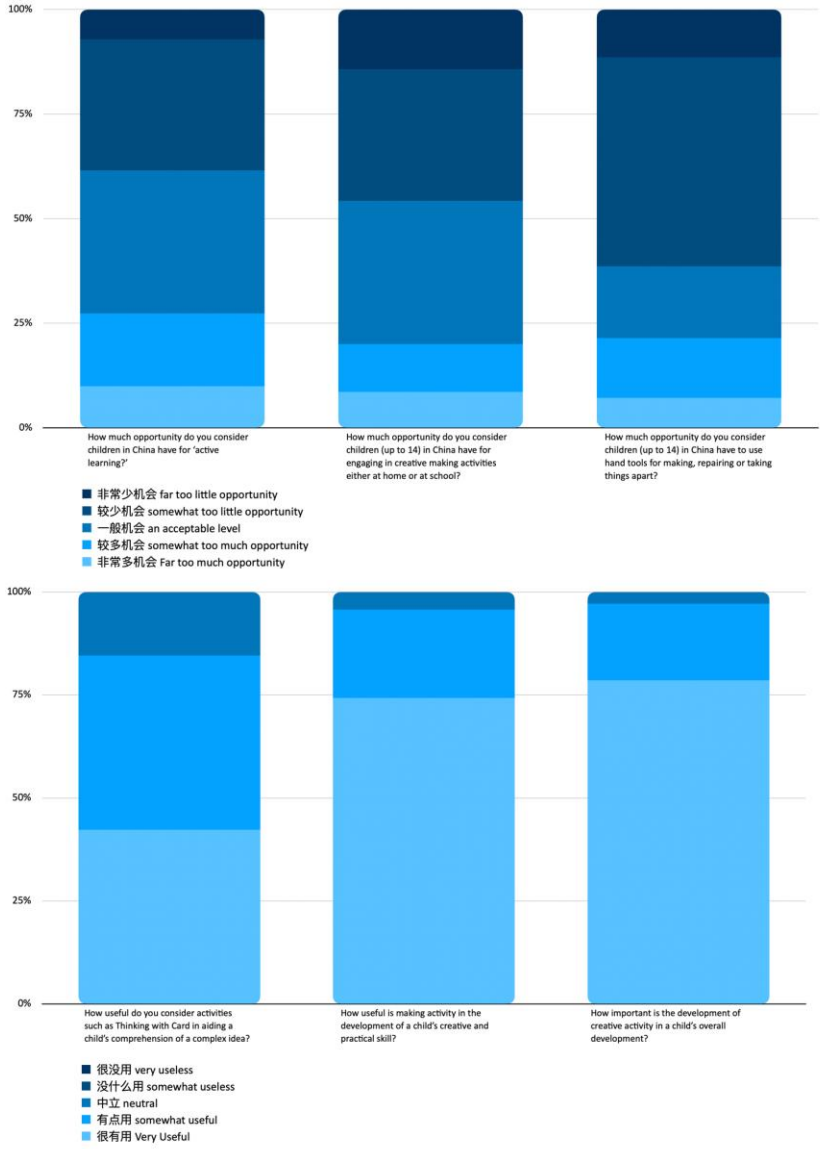

Figure 9. Selected outcomes of survey amongst parents, teachers and users of the Thinking with Card resource.

The findings demonstrated that 95% expressed a belief that 'making activity' was useful in the development of a child's creative and practical skill. The 5 most popular models in the

range were geographical terrain; historical Spring and Autumn Period; geographical climate distribution; earth orbit and seasons and biological plant photosynthesis. Of those with direct experience of using the models, only 5% found any of the models difficult to make, the reason given being that the description of the steps was not clear enough. 84% of these users considered this kind of activity useful in aiding a child's comprehension of a complex idea while 88% of all respondents consider the development of creative activity important to a child's overall development. All teachers canvassed indicated that they were willing to implement the tools in the classroom. They suggested that the content should be more extensive, so as to ensure that the knowledge is common and easy to understand, and that the instructions and operation be as straightforward as possible.

The open-ended questions garnered a good number of supportive comments as well as constructive suggestions, for example:

> "Quite necessary, Chinese children lack such hands-on opportunities. Such activities during adolescence will benefit children a lot in their growth and future life."
>
> "I strongly support the idea, but it should not be simple cut and collage – it needs a variety of materials research and application of divergent thinking."
>
> "Very good to do this kind of learning enhancement activity with children. Whether or not the material is useful, it is still a worthwhile experience."

6. Future Development

As previously described, the project relies in part on an ecosystem from which feedback may be sought from the teachers and parents of the target users. Teachers, in particular, once familiar with the aims and scope of the project, would be able to both select appropriate tasks for their students and also provide feedback to the development team regarding improvements (figure 7). Of particular relevance to design educators is the way that this development team is being configured to include undergraduate and postgraduate student projects. While initial project examples were developed by a professor with a small group of three postgraduate students, the aim in the future is to populate the project with models developed by larger numbers of students attending a course focused specifically in this area. The lack of making skills amongst design students means that tuition on basic card modelling skills are of great benefit and can yield excellent results. This starts with tuition regarding tools, safety, basic cutting and folding techniques and joining techniques. From this foundation, students can be introduced to modelling structures and mechanisms in card of increasing complexity (figure 10).

The Thinking with Card project is a good vehicle for this type of project because it provides a well-defined focus that requires students to put themselves in the position of both teacher and middle school student. Although the task appears relatively straightforward, the time and effort needed to refine a concept into a fully functional proposal is surprisingly great. On

a small scale, this gives students a good insight into the process of create and specify a design for production. Following some initial success with workshops and short courses in this area, the course is being piloted as an online MOOC course. This includes 8 sections: Basic card modelling materials and tools; Basic card modelling techniques; Sample structures in card; Sample mechanisms card; Introduction to Thinking with Card; Selection of Theme; Concept Development and Evaluation; Product communication and specification. A set of 'style guides' have been produced to ensure that models produced for the project adhere to the same basic layout and legibility.

Figure 10. Workshop with postgraduate design students to develop mechanical structures in card.

6. Conclusions

The distance-learning/home-schooling strategy described in this paper was created as a means to not only boost the understanding of complex ideas to an audience starved of rich learning experience, but also to introduce, almost by stealth, a component of making. Each of these elements, it turns out, had been implemented previously in some form or other but their conflation into a single entity became more realistic in 2020. The combining factors that facilitated this this include the penetration of internet and mobile phone usage in China, the proliferation of cheap options for printing; the desire for education reform and the Covid-19 pandemic which meant many students working from home for the first time. The first challenge was to prove that the strategy was feasible - that the DIY construction of physical learning tools was achievable and engaging to the core audience (7-12 Year old middle school students in China); the second was to gain acceptance amongst the gate-keepers of education in China - parents and teachers. The first challenge took time and seemingly endless permutations of model development in the early stages, but our

workshop activity demonstrated early enthusiasm for the concept. The second challenge is ongoing. The Chinese education system is founded on a broad acceptance of the teach-to-examine model which dates back centuries. The legally guaranteed 9 years of education has proved difficult to standardise in terms of quality given that China is such a vast country with huge disparities in income and lifestyle (Postiglione, 2006). It is not unreasonable that initiatives generated outside of the Ministry of Education would be treated with some suspicion. Follow-up projects and further engagement with teaching staff is seen as crucial to the future success of the project. Thinking with Card is a pilot initiative that provides access to a richer and more practical learning experiences (Dewey, 1938). The hope is that it can provide an example of how experiential learning can be integrated into a system that is less informed by exploration and active learning. An elective course for undergraduate and postgraduate students is being developed which will help produce further models for the project; improving and enlarging the content in the next stage.

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