How a particular STEAM model is developing primary education: lessons from the *Teach-Make* project (England)

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Abstract

Purpose – There is a lack of clarity about what constitutes Science, Technology, Engineering, Arts and Mathematics (STEAM) education and what the arts contribute. In this paper the authors discuss a distinct model, theorised from a five-year study of a particular, innovative STEAM education project (*The Imagineerium*), and developed by the researchers through working with primary school teachers in England within a second project (*Teach-Make*). The paper examines how teachers implemented this model, the Trowsdale art-making model for education (the TAME), and reflected on its value and positive impact on their planning and pedagogy.

Design/methodology/approach – The paper draws on two studies: firstly, a five-year, mixed methods, participative study of *The Imagineerium* and secondly a participative and collaborative qualitative study of *Teach-Make*.

Findings – Study of *The Imagineerium* showed strong positive educational outcomes for pupils and an appetite from teachers to translate the approach to the classroom. The *Teach-Make* project showed that with a clear curriculum model (the TAME) and professional development to improve teachers' planning and active pedagogical skills, they could design and deliver "imagineerium-like" schemes of work in their classrooms. Teachers reported a positive impact on both their own approach to supporting learning, as well as pupil progression and enjoyment.

Originality/value – The paper argues that the TAME, a consolidation of research evidence from *The Imagineerium* and developed through *Teach-Make*, offers both a distinctive and effective model for STEAM and broader education, one that is accessible to, valued by and manageable for teachers.

Keywords Primary education, Curriculum, STEAM education, Arts, Teacher development, Community of practice

Paper type Research paper

Introduction

The engagement of the arts with Science, Technology, Engineering and Mathematics (STEM) education has seen a significant rise in recent years (EASE, 2022; Tasiopoulou *et al.*, 2022), though their role, and the degree and character of their integration is diverse, highlighting a lack of clarity about what is meant by "STEAM" education and particularly how the

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contribution of the arts is enabled (see Colucci-Gray *et al.*, 2017; Mejias *et al.*, 2021; Perignat and Katz-Buonincontro, 2019). Whilst Colucci-Gray *et al.* (2017) argued that the majority of Science, Technology, Engineering, Arts and Mathematics (STEAM) projects reflect discourses of dissatisfaction with contemporary STEM education, Davies and Trowsdale (2021) and Meijas *et al.* (2021), in different ways, have sought to articulate a more positive account. By integrating the arts and STEM, these accounts move beyond instrumental uses of the arts to improve STEM outcomes and probe the character and qualities of the arts for learning. They focus on STEAM as a collective descriptor of education shaped by integrated and transdisciplinary human practices. One emerging feature is that curricula are modelled on real-world, more complex issues and their solutions.

We explore the journey from real world arts-engineering practice, through an innovative bespoke educational intervention to application in mainstream classroom practice. The journey began with a group of engineers and community arts organisations that collaborated on a number of large-scale, site-specific performances (e.g. https://imagineer-productions.co.uk/projects/godiva-awakes). The engineers and artists involved saw the possibility of using their way of working to inspire a new generation of imaginative engineers (artistically informed scientists and scientifically informed artists) (see Trowsdale, 2014, 2020). A particular, innovative arts and engineering education project, *The Imagineerium*, was developed drawing on the insights of engineers, artists, educationalists and teachers. It ran for five years, working with 20 primary schools and 641 pupils. Children and teachers explored and undertook a real-world task, *the commission*. They were supported through a range of active learning sessions, trial and error and working with experienced artists and engineers. The evaluation of the project indicated pupil progression in understanding science and design technology, greater awareness of how the arts and engineering relate, greater confidence in their creativity and in their abilities as learners *per se* including the transversal or "soft" skills of collaboration, problem-solving and resilience noted as desirable for learners by 2030 (OECD, 2018; Trowsdale, 2020; Trowsdale *et al.*, 2019; UNESCO, 2016).

The project's positive outcomes were attractive, but the approach depended on the skills of artists and engineers, and so was expensive unless funded by external grants. Teachers and their senior leaders wanted to see how an "Imagineerium-like" approach could be embedded in mainstream schools. The analysis of *The Imagineerium* identified both the value for pupils and a clear theorisation of the ways in which the real-world activities of the arts and engineers had been influential in creating that value. A professional development project for teachers, *Teach-Make*, focussing on supporting "imagineerium-like" curricula and pedagogies was developed and has given rise to two developments. The first is the construction of a distinctive approach to curriculum design (known as the TAME approach) which consolidates research evidence from *The Imagineerium* in a way that is coherent, intelligible to and manageable for teachers. The second is the identification of developmental needs of teachers in order to confidently and competently facilitate TAME schemes of work in schools.

In this paper we outline the experiences of *The Imagineerium* as a foundation for our initial theorisation of the TAME approach. The core of the paper analyses the journey we made with teachers and artists to develop a workable approach to this type of STEAM education in the teachers' schools. We conclude with an overview of the outcomes from *Teach-Make*.

From community and professional practice to educational intervention

The real-world professional relationship between these artists and the engineers is rooted in those same artists' histories in participatory, community based "making" activities which were formative in developing *The Imagineerium*. Over recent years *making* has grown in significance in contemporary educational and community practices (see for example, Bevan *et al.*, 2014; Shanahan *et al.*, 2016). This has led to an increase in makerspaces in schools internationally (Hira *et al.*, 2014; Konstantinou *et al.*, 2021; Marsh *et al.*, 2019) and in its wake

an emergence of more such spaces in the United Kingdom (UK) schools. The makerspace title covers a diverse range of projects with disparate foundations. *The Imagineerium* and *Teach-Make* developed from a focus on community arts and real-world activities. They were concerned with making and crafting generally, and in the transformation of everyday spaces, not just bringing children into distinct makerspaces. The focus on materials and materiality in these projects came from the engineers who argued that their real-world practices were dependent on their understanding of how materials feel and behave. Hence, learners need to understand the physical properties of materials. This focus, along with a focus on the aesthetic properties and potential of materials, made the term "art-making" more appropriate than simply "making". The community of artists and engineers (known as imagineers) developing *The Imagineerium* were concerned with the structural, mechanical, aesthetic and social dimensions of design and the materials they used. Educationally, this was the kind of integrated approach often seen as inherent in STEAM education (see Jia *et al.*, 2021; Perignat and Katz-Buonanincontro, 2019), but for this community also reflected their professional work in the real-world. These two principles: the community of practising adult makers into which children were inducted; and the real-world focus of the tasks they collectively undertook as a commission, were identified as core structuring principles of *The Imagineerium* (see Trowsdale, 2020) and are core to the approach used in *Teach-Make* to develop new schemes of work for schools.

Whilst we are arguing that this approach, which we have named the TAME, can be considered a form of STEAM education, we are claiming here something more. In the present literature, there is a lack of clear theorisation which encourages a "bandwagon" effect: an eclectic collection of approaches all drawing on the STEAM "moniker" (Meijas *et al.*, 2021, p. 211). So, we claim that the TAME approach is not just STEAM education, but a distinctive form with a specific theoretical foundation which has been developed from *The Imagineerium*. What characterises the TAME approach is that is starts with real-world practices which are inherently transdisciplinary and integrates subject knowledge and skills. The focus on a particular task (a commission) situates and contextualises subject knowledge. The main focus of this work has been on the obvious links afforded by engineering with design technology and science, recognising that engineering as a practice is equally dependent not just on the natural sciences but also the social sciences, arts and humanities and the "integrating" possibilities of design technology (see Bell *et al.*, 2017, p. 546).

For example, in one iteration of *The Imagineerium*, participants (adults and children) were given the task of designing mechanical, moving sculptures for a new heritage park in their local city. The sculptures had to be interactive, to reflect significant aspects of national and local history, and be suitable to be kept outdoors with limited maintenance. The best design from each of the participating schools was to be built by local engineering firms for the new park. It was therefore a real-world task with a real-world outcome. Over 10 weeks, pupils worked in groups developing their design, identifying significant moments in stories from the city's past, working out the mechanics of the movement, considering how people might interact with their sculpture, and then creating part-working models of their design. Throughout this process they were supported by adult art-makers from a range of backgrounds but most significantly the children were required to work collaboratively and learn from each other. They physicalized ideas, developed sketches, mini-models and tested different materials to enhance their design. At various times, the adults provided focussed direct teaching about the knowledge and skills necessary to complete the task – e.g. forces, cams, drawing to scale. These were taught in workshops using physical theatre, drawing and hands-on experimentation. At the end of the project the children presented their designs to a panel that made the final decision on the models that would be built for the heritage park. All involved accepted that designs might need to be modified in order to be built, it was not expected that participants would have the skills necessary to design a workable model,

and that adaption and modification reflected real-world practice in the move from design to fabrication.

Evidence from *The Imagineerium* showed a range of positive outcomes for children (see Trowsdale, 2020 for an extended discussion). It was a participatory research design of a distinct case study, where the researcher (Trowsdale) was embedded in all aspects of the project from its initial conceptualisation through the five years of delivery. The case was delineated by the project, the artists and engineers employed on it, and the classes and teachers involved (20 classes, 641 pupils, 35 teaching staff, 10 artists, 6 core and a further 8 associate engineer/scientists over five years). Fieldnotes of planning and project sessions, interviews with teachers, pupils, artists and engineers as well as reviews of pupils' personal journals formed the core data. These were supplemented by two other pupil focussed data collection methods: a whole class activity exploring what was learnt on the project, and a pre- and post-questionnaire for all pupils to access their confidence in themselves as learners (in years 3–5) (see Trowsdale *et al.*, 2019). Teachers also completed a questionnaire on pupils' confidence and progress in learning and science (see Trowsdale *et al.*, 2021). Qualitative data was thematically analysed, and quantitative data analysed using statistical package for the social sciences (SPSS). Ethical permission was granted by an ethics committee at Warwick University and all participants gave informed consent.

Data from pupil interviews and fieldnotes showed there was an increase in motivation and increased interest in science and engineering as a result of the project. One girl noted that she had not realised that engineering was both "hands-on" and "mind-on" which made it more attractive for her. Another returned to school the following year asking for more mathematics as she wanted to be an engineer in the future. Boys were also positively impacted by the project and talked of being inspired and wanting to try harder at what they do in the future. Further, data showed that children had the opportunity to practice a range of transversal skills as a result of working together and being able to direct their own activity and learning. Teachers, in interviews and more informally at design meetings, talked of historic difficulties in embedding such skills and of witnessing how *The Imagineerium* both offered opportunities to practice such skills and made the skills more meaningful. This was because the project situated learning and required children to act in these ways. Wanting to "behave like an imagineer" motivated children to support and challenge each other, to explain ideas, to apply their understanding. One teacher noted:

> They had free rein . . . [and] found out things for themselves . . .. They could investigate, find out it doesn't work and change it . . .. [It] let them take the lead . . .

Quantitative data, from the pre/post-intervention pupil questionnaire, identified that children felt more confident and capable in learning in general and specifically in those elements of the curricula covered during the project (see Trowsdale *et al.*, 2019 for more details). Teachers assessed the progress of children during the project against the science and design technology learning outcomes and judged there was strong progression for all children. Qualitative comments showed surprise at the progress of those children they typically saw as "underachieving". A reoccurring positive comment was how much the children could achieve when allowed to direct their own learning.

> The complexity level definitely went up . . . The level of difficulty . . . and the level of application was very high . . . They were able to articulate push and pull and change direction . . . by putting it into a new context and applying it to a model, they fully understood [forces].

The joint conclusion of teachers and educational researchers was that the project had enhanced children's learning and confidence in relation to education in general, motivated and driven an interest in integrated practices such as engineering and supported them in achieving the learning outcomes required by national standards.

Theorising *The Imagineerium*

The theorisation of *The Imagineerium* initially focussed on two aspects. The first was how the imagineers worked together and how this real-world practice was a model for and impacted on pupils' education. Whilst the practice was specific to this group, it was at the same time reflective of work at the interface of engineering and the arts. The culture and characteristic ways of behaving are, partly, definitive of the group but were also seen as important for education. They included more active forms of learning motivated by a desire to solve the design problem, but also an approach which emphasised relational elements such as respectful collaboration and a valuing of others' skills and insights. The second was the way this group structured and governed their collective activity; namely through a distinct, collectively understood, design task to be explored and solved. This "commission", for example the building of a moving sculpture for the park, used terminology directly lifted from professional practice. The commission was often scaffolded and explained to pupils as involving a series of interrelated tasks. Adult art-makers' professional practice in responding to a commission shaped the educational experience, including a greater focus on more active and investigative approaches to learning, greater collaboration, more use of drawing, gesture, tactile engagement with materials and co-production. These differences were reflected in pupil and teacher discussions on what made *The Imagineerium* special and educationally valuable.

The key characteristics of *The Imagineerium* reflected professional, real-work practice of imagineers and led (Trowsdale) to the primary theorisation of its efficacy as reliant on a particular art-making community of practice (CoP). Lave and Wenger's (1991) account has long been recognised as a helpful model of how learning is developed in everyday situations (see Ingold, 2013). It has been widely adopted as a social, apprenticeship model of professional development common across disciplines including education. It has been less used in relation to primary school pupils, but it provides a codification of the specific approach to learning in *The Imagineerium,* focussing as it does on content, practice and the shared tasks of the community. The CoP model was recognised by artists and engineers as articulating their experience of working on the project, and enabled researchers to foreground specific aspects of the data identified in the literature on CoP. In theorising this way, other aspects of the experience came more clearly into focus; notably pupils' potential role of "legitimate peripheral participants" (Lave and Wenger, 1991, p. 107). This reflected a bounded level of agency and autonomy that the exploratory and relational culture of *The Imagineerium* gave pupils to variously watch, support and sometimes take the lead as they felt confident with their expertise to contribute. So, pupils' engagement could shift: they did not stay on the periphery, they moved from one position to another in response to the activity. The implicit choice and freedom gave them the security to make self-directed contributions, rather than being instructed to do so (see Trowsdale, 2020 for a more detailed review of the use of CoP).

In summary, *The Imagineerium* showed that a well-designed curriculum shaped by these principles and mixing investigative work alongside direct instruction was effective in supporting learning in specific subjects *and* in developing children's motivation, enjoyment of learning, confidence and ability in transversal skills. As a result, school leaders were interested in how the approach which underpinned *The Imagineerium* could be deployed as part of regular school practice. As one teacher notes:

> I think I speak for a lot of class teachers here, in saying we would be very keen in putting imagineering at the centre of our work and designing learning around it.

The result was to pilot a two-year curriculum development project (*Teach-Make*) working with 7 primary schools in one English city whilst also clarifying a model for "Imagineerium-like" curricula useful to teachers.

Teach-make: shaping and trialling the "TAME"

14 teachers from 7 schools took part in the project supported by senior leaders from each school. The project was funded by the Paul Hamlyn Foundation. Two teachers from each school were commissioned to develop a new scheme of work that met part of their school's development plan. Although not specifically focussed on any curriculum area, all 7 schools identified design technology as the curriculum area. The teachers were identified by school leaders for their potential to support school curriculum development and because they were working within key stage 2 (7–11 year-olds). Most teachers had backgrounds in the humanities or arts, with only teacher having a degree in science. The project supported teachers in curriculum development, in developing confidence in a range of arts-based and open-ended pedagogies and supported their subject knowledge in science and engineering. Teachers undertook ten development days, eight skills workshops as well as using in-school planning time to develop their schemes of work.

The study was participatory and collaborative by design. Both authors were involved in the development sessions with teachers and artists and at least one was involved in each skills development sessions. The researchers collected fieldnotes, lesson plans, talked informally with participants and led more structured discussions on the impact of the project on teachers' planning and classroom practice, and outcomes for pupils. Semi-structured interviews (average time 40 min) were conducted with the teachers just before the project, after one year and at the end of the project. We interviewed the artists twice (average time 60 min) and kept notes on artist development meetings throughout the project. We also interviewed senior leaders from each of the 7 schools at the beginning and end of the project. Interviews were transcribed and thematically coded. All participants gave fully informed consent and ethical approval for the research was given by the University of Central Lancashire's research ethics committee. Here we report on the teachers' interviews and structured discussion comments, supplemented by reflections from fieldnotes.

A model for teachers' practice

Pre-project teacher interviews identified a lack of experience in curriculum design and a lack of confidence in science, design technology and in using art-making practices to develop learning. Teachers revealed a desire to give children freedom to express themselves, take some responsibility for and enjoy their learning, but that this was in tension with concerns to cover a packed curriculum, so these were often not realised. Whilst they recognised the educative value of "collaborative activities and projects [which] allow greater independence of thought and ownership of their own learning", they struggled to achieve it.

In the early stages teachers focussed on "pedagogical tips", for example how physical theatre, drawing and construction could be used immediately in their classes. The artists had designed ways of working that enabled more active pedagogies even in the pandemic, and these were particularly attractive to the teachers.

> [The project] has given me the confidence to use a more physical and active approach by including movement in many areas of my teaching.

Year one was a process of responding to teachers' questions and discussing their successful use of the elements of the developing TAME model in their practice. We sought to ensure the approach was faithful to the insights from the professional work of the art-makers, responsive to the needs of the mainstream classroom and attuned to the theoretical insights gleaned from *The Imagineerium*. The process was iterative and messy with the model emerging from the ongoing discussions between teachers, artists and researchers. Sometimes, as researchers, we listened into the conversations and at other times, as professional developers, we facilitated discussions. Through trialling different TAME

pedagogies, and becoming familiar with the concepts of "community of practice" and "commission", teachers' planning changed and they developed an understanding of and confidence in these approaches:

> Normally schemes of work are designed and aimed at the end product . . . [The TAME] makes you focus on the other parts of it that you wouldn't normally – like the learning behaviours and what you want the learning environment to be like.

> the community of practice is quite a unique approach of having the children think about how they're going to behave

We found that visualisations of the approach were helpful in directing teachers' attention during their planning, and these were consolidated in the second year of the project into a single visual representation of the elements and their interconnections (Figure 1). In addition to the foundational CoP and commission which structure the model, framed by the known educational benefits of practising art-making (Dewey, 1934; Eisner, 2002; Ingold, 2017), the model embeds a range of characteristics identified from the culture and practices of the art-makers, such as the active practices noted earlier.

Teachers designed their schemes of work over 18 months (albeit with interruptions due to the pandemic), trialling elements in their settings, with regular discussion and feedback from educationalists and artists. Developing their understanding of the model, its educational implications and how it could inform their classroom practice, was not an easy process. In the end of project interviews, one teacher talked about coming to a session with what they thought was a really good idea only to for it to be "picked apart by you [the educationalists]". Whilst initially such moments were disheartening, they were later acknowledged as vital to the growth of teacher understanding of the model and having the confidence to sustain such practice. A particular exercise undertaken towards the end of the project was noted in many end of project interviews as significant. Teachers were given two hours in groups to develop

Source(s): Adapted by authors from Wenger-Trayner and Wenger Trayner 2015; artwork by Andy Moore

Figure 1.
The Trowsdale art-making model for education (The TAME)

another scheme of work based on an "idea" presented by one of the artists. For many teachers this was a light bulb moment as they recognised that they understood the TAME, its concepts and characteristics, surprising themselves in producing new, exciting schemes of work.

Working with teachers and reflecting upon *The Imagineerium* enabled us to affirm the educative value of the TAME's conceptualisation as a CoP of art-makers for teachers. We expounded, and teachers tested, how the work of Lave and Wenger (1991), Wenger (2007) and Ingold (2013, 2017) related to the specific context of teachers in primary schools. CoPs identify three interrelated elements important for teachers' planning: a distinct group of people (the community); who are engaged in a specific area of activity (the domain); and who, as a result of their interest in and the character of that domain, conduct themselves and structure the community in particular ways (the practice). As noted earlier, it has long been recognised that CoPs have educative functions: the concept has been extended to analyse and develop many adult professional communities, e.g. solicitors or football players, anywhere where a community of people focus on an area of activity and develop distinctive practices as a result. Less attention has been paid to the significance of such structures for children's education, and even less to the idea of aligning a CoP involving children to an extant adult CoPs in the real world. This lack of familiarity made it initially difficult for teachers to see the educative potential of a CoP, in using the approach however they recognised its potential to inherently motivate and structure learning.

> Creating a community of practice can lead to changes in children's behaviour as they rise to the expectations of the role allocated to them.

In one school, by inducting children into a community of overseas development agents, the commission focussed on them communicating and understanding issues related to improving water supply and sanitation. The children were required to engage with issues related to the physical world and how humans engage with and understand it, requiring multiple subject knowledges, but also to think and behave like a member of this community of overseas development agents. The commission, situated in the real-world, generated a series of real-world making tasks that the community needed to undertake and through which majority of the learning occurred: learning-by-doing and/or educative conversations whilst being supervised to address the task, or at moments by direct teaching. Art-making practices of physical theatre provided a hook and a medium for exploring possible solutions to challenges; drawing and 3D making enabled children to practice their understanding of the science and technology dimensions. It required not just the development of scientific, design, geographical and communicative knowledge and understanding but the ability to empathise, listen, think critically, imagine, negotiate ideas, be responsible for particular tasks, practice particular skills, persist with ideas – in short to see themselves as a necessary and valued member of this community by practising and behaving like overseas development agents. If a teacher wants to develop particular behavioural skills that required honing, such as the ability to negotiate, then the commission and CoP can be refined to focus on opportunities to regularly practice this throughout the scheme of work. Here, as was usually the case in TAME schemes of work, children's engagement in the CoP and the particular commission was initiated through a drama-based activity to build empathy and a commitment to overseas development.

Another feature of the CoP is a horizontal structuring of relationships between members (adults and children). This apprentice-like model, foregrounding relationality, invited individual choice and legitimated a range of levels of engagement, so that watching (a common form of "peripheral participation") is recognised as a legitimate way of engaging with learning by any member. Even when observation data showed children had watched something happen, they spoke as if they had been actively involved: '*we* did X'. This suggested that watching felt like being fully involved, that they had learnt through the

process – reflecting the effect attributed to mirror neurons. Many argue it is also the root of empathising and connecting with each other (Iacobini, 2008; Lakoff, 2012). Having different levels of legitimate participation enables children to shift position dependent on their own sense of confidence, expertise and interests, so it also feeds and channels their intrinsic motivations.

In addition to the CoP and commission, the model foregrounds other elements of the integrated way of working characteristic of the art-makers. Learning was "active and embodied", firstly in the rather superficial sense that children where more physically and cognitively active than in usual classroom learning, but also in the deeper sense (drawing on, for example, Lakoff and Johnson, 1999; Ingold, 2013, 2017) that the mind is not disembodied and learning happens through and in the body. For example, children gained a better sense of (i.e. learnt about) forces through their bodies and as a result understood different kinds of forces and their effects. Physical storytelling enabled them to make sense of, for example, the role of forces in constructing an effectively engineered wildlife home. Such storytelling allows children to begin to mediate two different narratives of physical ideas, that of the real-world and the more formal narrative of the STEM classroom. So, whilst the approach draws on traditional notions of "active learning" which are common in inquiry and project-based approaches to learning (see Kokotsaki *et al.*, 2016; Leat, 2017), it also emphasises the need to move beyond these principles and take seriously the inherently educative nature of professional practice of the art-makers and all the ways in which children (and adults) learn. Learning, whether that is about science, the arts, humanities or social science, was situated as part of their pursuit of the commission. This does not mean that children just learnt "anything"; one of the key purposes of the TAME is to support teachers to structure a curriculum that focusses on specific learning outcomes. Curriculum design in this approach is as formal as other approaches, its difference lies in its seeking to improve children's "broad and balanced" learning.

The TAME also challenges the homogeneity of learning spaces. As had been the case in *The Imagineerium,* teachers were encouraged to experiment with the impact of different spaces, and configurations of furniture and resources on pupils' learning. Teachers commented that many of these changes correlated with increased conversation between children and a sense of both ownership and control over the work. Teachers recognised the limitations and affordances of the school buildings and playgrounds to which they had access. One school had already invested in a bespoke "makerspace", another used a nearby community space and another extensive outdoor space. Another school was limited to classrooms and a small multi-use hall that was in constant demand. The spaces available, the readiness to explore spaces beyond school, and to re-conceive or adapt spaces shaped the kinds of scheme of work that teachers designed. Finally, the project affirmed the importance of experts, usually teachers and art-makers but sometimes other children, in supporting learning and asked teachers to review how they view themselves and others in the classroom. The TAME encourages teachers to think about the potential learning resources that could be provided by the local community – sometimes family members but increasingly by organisations that have specific educational activities, or beyond the locality, through virtual media. Teachers drew on arts organisations, environmental groups and those working with refugees to develop the real-world aspects of their schemes of work and provide specialist support for learning. The TAME model also asks teachers to rethink their role from "experts in everything" to "co-learners with their pupils". This did not discount the inclusion of moments of more formal and direct teaching approaches; working on the TAME reframed, expanded but did not entirely replace extant habits. But in end of project interviews, teachers talked of the joy of joining pupils in learning about something they had never thought about, as well as the lack of confidence they had initially experienced in taking this approach. Significantly, the teachers saw that pupils were more motivated when they brought:

> [them]selves down to the children's level rather than being like the teacher in front of them and learning and discovering things with them

and that pupils learnt more though this joint learning.

Teach-Make*: the outcomes*

We had confidence, from research on *The Imagineerium*, in the value of the approach for children when led by artists and engineers. The primary focus in *Teach-Make* was whether this could be translated into mainstream classrooms and led by teachers. Here we report on three outcomes: teachers' understanding of the TAME; the limitations and problems they encountered in using the TAME in their schools, and teachers' perceptions of the value of this approach for their pupils. We deal with these in reverse order.

In pre-project interviews, teachers explored their beliefs about good teaching and good schemes of work which were noted as needing to be "relevant and responsive" to children's needs, to have "clear aims and objectives" and be structured to enable "progression". Teachers' reflections over the first year of the project recognised that legitimate educational concerns had led to an overly teacher dominated approach. As noted earlier, the pre-project interviews had indicated that rather than designing curriculum, teachers largely adapted pre-existing schemes of work. This limited their ability to imagine different routes to the same learning outcomes. A teacher, in the end of year one interview, noted how a content heavy, prescribed curriculum diverted them from how they wanted to teach and also reduced the opportunities for learning:

> Being 'child-led' . . . often is brushed aside in order to fulfil the crammed yearly curriculum content. But to be inventive, creative, all-encompassing, to record your ideas, and then become more discerning and analytical in actually how a project could come together, are all valuable skills – ones that the future is more likely to need . . .

The pre-project interview comments on good pedagogy also advocated active engagement, but this was often recognised as aspirational, without a clear account of what that might look like.

In the end of project interviews we returned to these themes. Teachers still noted the lack of flexibility in the school year, but realised that within the planning freedom they had they could make changes:

> In my teaching and my planning I think I may be a bit more open ended. Maybe not so scared for it to be pupil-led or for it to be led in a different way. We were focused so much on an outcome at one point that it was preventing us from planning a good journey.

> . . . we can use the arts more in the curriculum . . . or be more practical in the way we think about and deliver subjects

> I am thinking about more kinaesthetic ways of learning and trying to integrate further movement based, experimental ways to learn into our curriculum.

Testing out the TAME approach seemed to have reignited several teachers' aspirations for their pupils, and shown how to facilitate and recognise learner' capabilities:

> I now have a better understanding of what children are capable of.

> They still remember what we did . . . they can still talk about it.

It seemed to have given teachers confidence that in addition to learning just as well, children had more fun. Enjoyment was a reoccurring theme in the end of project interviews with teachers noting how they focussed more on "keeping things fun . . . trying to include opportunities for them to be hands on and experience things as much as possible". As one

teacher said: "the children's enjoyment has been brilliant". A senior leader in one school noted that the class "remembered [the scheme of work] as the best thing all year".

They recognised how the model provided the structure which:

> . . . is helping me to be more confident to hand over control to the children . . . allowing them to lead their own learning, inspired by their natural curiosity.

They spoke of 'seeing teaching from a different viewpoint" – a shift of focus from *teaching* to children's *learning,* and having "the confidence to think a bit bigger than just yourself or your classroom".

As an example of the kinds of changes that teachers made, consider this from another school. Here the teachers took the opportunity to overhaul a scheme of work which had low levels of interest from children and which, whilst historically fulfilling a design and technology curriculum requirement had given rise to minimal and low-level learning by children. The original scheme of work had required the children to build a bird-box from pre-prepared parts following instructions given them by the teacher. At the end of the scheme of work, the teacher dismantled the bird-boxes in order to use the materials the following year. The actual curriculum requirement is that children build a free-standing 3-dimensional structure, and the teachers started their planning with this as the focus of their commission. They were also keen to maintain and enhance the link to environment concerns. The teachers designed a scheme which positioned the children directly as if members of a CoP of environmentalists with a commission to enhance their school environment by providing support for wildlife. The commission was open but set to require children to survey the school for wildlife, explore the life cycle of key wildlife, then design and build something to support a chosen wild creature. The teacher, acting as an environment consultant, could layer the commission through questions and direct instruction to ensure that children produced a 3-dimensional self-standing product as required by the curriculum. They could also support children in surveying skills, understanding the life cycle of particular wildlife, the significance of properties of materials (whether both materials might decompose and whether this was a desirable property) and thereby addressing the science and design skills needed to build the final product. However, the experience of the teachers was that children were motivated to find out for themselves and quickly managed to work together in groups to fulfil the commission. The project was designed carefully to ensure that in the process of developing their products children needed to achieve the core learning outcomes required by this scheme of work. The teachers maintained control and facilitated learning but by giving agency and clear, if bounded, autonomy to the children.

There were, however, limitations and difficulties. A reoccurring theme was the time commitment required, though it was recognised that using "off the shelf" resources also took time and could be less effective or rewarding. Other comments concerned the difficulties of embedding TAME schemes of work into the wider school curriculum, especially where the teachers wanted to use space differently or alter the usual structure of the school day. These could be overcome but required support from senior leaders to make school-wide adjustments. Senior leadership support clearly enabled the delivery of the TAME schemes of work, and some school leadership teams have enthusiastically embraced the approach for at least a part of their curriculum. Whilst enthusiasm is not everything, there is clear evidence that teachers believe, and have convinced colleagues, that the approach improves children's education.

We had thought that the technical language of the TAME might prove a barrier to teachers' understanding but they rejected this idea. Certainly, their learning was incremental, taking time to recognise the significance of how the crafting of the commission and the structure of the community of practice realised desired educational outcomes, but the notions of a practising community of makers and a commission were widely adopted. As one teacher said:

> The commission. leave[s] it very much up to the children to let them decide where they're going with it. [it's] having the knowledge in there, but making it more open in terms of the knowledge they take.

They reflected that the model, emphasised in the visualisation of the TAME, displayed the relationship of parts to the whole and reflected how learning was layered: that they had been able to focus at times on particular parts but always returning to and seeing the TAME as an internally coherent model for education. A teacher spoke of the project (and the TAME model) as:

> ... inspiring, intriguing and eye-opening ... bring[ing] learning to life and ignit[ing] a flame of excitement, for teachers and learners.

Conclusion

Whilst not seeking to unnecessarily limit the scope of the term we, like many others, have noted that STEAM as a "catch all" term for adding the arts to STEM is unhelpful for the development of either practice or research. Our purpose here has been to chart and explore the development of a distinctive approach, The TAME, underpinned by evidence of effectiveness and articulated in terms of a strong theoretical framework. What is more, having tested this approach with teachers, we argue that there is clear evidence that this approach works in mainstream schools, not just as a discrete educational intervention.

Teachers valued having a structured approach which had identifiable elements and clarity about the relationships between those elements. The visualisation of the TAME showing its two primary principles, the art-making community of practice and the commission, framed teachers thinking about the process and reminded them of the key characteristics (active and embodied learning, different spaces, situated knowledge, maker-educators). Whilst it framed planning, the visualisation did not dictate; different teachers found a different balance between the elements in response to their own values and confidence, and the characteristics of their class.

The most immediate impact on teachers was an opportunity to critique and develop additional pedagogical tools as they learnt from the artists and engineers on the project. However, they also have the confidence and skills to consider and implement a different approach to planning, which they recognised improves pupils' learning, their motivation to learn, develops important transversal skills and children's enjoyment of learning. Significantly for teachers, this motivated them to allow more freedom and co-learning with their pupils. For most teachers this was at times a difficult journey as they had to engage with arts-rich activities in which they were under confident and where they engaged in a series of critical dialogues with the researchers, a process that required an extended period of time.

The initial implications of the *Teach-Make* project are the continued development of the approach in the schools involved across all teachers and across the curriculum. Funding is also in place for a second *Teach-Make* project as a component of a regional social, cultural and economic regeneration project. Further work is being developed in relation to out of school learning and in secondary education. Together these will enable evaluations of the flexibility of the model for different educational contexts. Future research needs to establish the contribution of each element of the TAME to its overall efficacy. Whilst some elements, such as embodiment are developed in the literature others, such as the use of drawing and physical theatre are less well represented. We recommend additional research in these areas. Research ought also to continue on the interrelationship between CoP and commissions, and how these are developed by teachers.

In relation to STEAM education, our argument offers a threefold challenge. Firstly, in order to progress STEAM education we need to evaluate distinctive and specific projects in addition to more generalised reviews of its value. Secondly, we need to focus on real-world, theoretically complex practices as a coherent and practically useful starting point for

curriculum design. Thirdly, learning can and should be shaped by the characteristics and culture of those particular real-world communities of practice.

Whilst we do not have evidence to claim this is the best approach to education, we do have evidence that it is better than alternatives. Perhaps most importantly for researchers, the TAME approach is transparent with a clear evidential and theoretical basis; it is therefore open for critical review by us and by others.

References

Bell, D., Wooff, D., McLain, M. and Morrison-Love, D. (2017), "Analysing design and technology as an educational construct: an investigation into its curriculum position and pedagogical identity", *The Curriculum Journal*, Vol. 28 No. 4, pp. 539-558, doi: 10.1080/09585176.2017.1286995.

Bevan, B., Gutwill, J.P., Petrich, M. and Wilkinson, K. (2014), "Learning through STEM-rich tinkering: findings from a jointly negotiated research project taken up in practice", *Science Education*, Vol. 99 No. 1, pp. 98-120, doi: 10.1002/sce.21151.

Colucci-Gray, L., Burnard, P., Cooke, C., Davies, R., Gray, D. and Trowsdale, J. (2017), *Reviewing the Potential and Challenges of Developing STEAM Education through Creative Pedagogies for C21st Century*, British Educational Research Association, London.

Davies, R. and Trowsdale, J. (2021), "The culture of disciplines: reconceptualising multi-subject curricula", *British Educational Research Journal*, Vol. 47 No. 5, pp. 1434-1446, doi: 10.1002/berj.3735.

Dewey, J. (1934), *Art as Experience*, Penguin, New York, Perigee.

EASE (2022), "1st European 1st European Summit for STEAM educators", available at: https://ease-educators.com/i-european-summit-for-steam-educators/ (accessed 20 January 2023).

Eisner, E. (2002), *The Arts and the Creation of Mind*, Yale University Press, New Haven, London.

Hira, A., Joslyn, C.H. and Hynes, M.M. (2014), "Classroom makerspaces: identifying the opportunities and challenges", *Frontiers in Education Conference (FIE) Proceedings*, Madrid, IEEE, pp. 1-5, doi: 10.1109/FIE.2014.7044263.

Iacoboni, M. (2008), *Mirroring People: the New Science of How We Connect with Others*, Farrar, Straus and Giroux, New York.

Ingold, T. (2013), *Making: Anthropology, Archeology, Art and Architecture*, Routledge, Abingdon.

Ingold, T. (2017), *Anthropology In/as Education*, Routledge, Abingdon.

Jia, Y., Zhou, B. and Zheng, X. (2021), "A curriculum integrating STEAM and maker education promotes pupils' learning motivation, self-efficacy, and interdisciplinary knowledge acquisition", *Frontiers in Psychology*, Vol. 12, 725525, doi: 10.3389/fpsyg.2021.725525.

Kokotsaki, D., Menzies, V. and Wiggins, A. (2016), "Project-based learning: a review of the literature", *Improving Schools*, Vol. 19 No. 3, pp. 267-277, doi: 10.1177/1365480216659733.

Konstantinou, D., Parmaxi, A. and Zaphiris, P. (2021), "Mapping research directions on makerspaces in education", *Educational Media International*, Vol. 58 No. 3, pp. 223-247, doi: 10.1080/09523987.2021.1976826.

Lakoff, G. (2012), "Explaining embodied cognition results", *Topics in Cognitive Science*, Vol. 4, pp. 773-785, doi: 10.1111/j.1756-8765.2012.01222.x.

Lakoff, G. and Johnson, M. (1999), *Philosophy in the Flesh: the Embodied Mind and its Challenge to Western Thought*, Basic Books, New York.

Lave, J. and Wenger, E. (1991), *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press, Cambridge.

Leat, D. (2017), *Enquiry and Project Based Learning: Students, Schools and Society*, Routledge, Abingdon.

Marsh, J., Wood, E., Chesworth, L., Nisha, B., Nutbrown, B. and Olney, B. (2019), "Makerspaces in early childhood education: Principles of pedagogy and practice", *Mind, Culture, and Activity*, Vol. 26 No. 3, pp. 221-233, doi: 10.1080/10749039.2019.1655651.

Mejias, S., Thompson, N., Sedas, R.M., Rosin, M., Soep, E., Peppler, K., Roche, J., Wong, J., Hurley, M., Bell, P. and Bevan, B. (2021), "The trouble with STEAM and why we use it anyway", *Science Education*, Vol. 105 No. 2, pp. 209-231, doi: 10.1002/sce.21605.

OECD Office for Economic Cooperation and Development (2018), *The Future of Education and Skills. Education 2030*, OECD, Pari, available at: https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf (accessed 20 January 2023).

Perignat, E. and Katz-Buonincontro, J. (2019), "STEAM in practice and research: an integrative literature review", *Thinking Skills and Creativity*, Vol. 31, pp. 31-43, doi: 10.1016/j.tsc.2018.10.002.

Shanahan, L.E., McVee, M.B., Slivestri, K.N. and Haq, K. (2016), "Disciplinary literacies in an engineering club: exploring productive communication and the engineering design process", *Literacy Research: Theory, Method, and Practice*, Vol. 65 No. 1, pp. 404-420, doi: 10.1177/2381336916661534.

Tasiopoulou, E., Gori, J.N., Grand-Meyer, E., Myrtsioti, E., Xenofontos, N., Chovardas, A., Cinganotto, L., Garista, P., Jakić, I., Kralj, L., Dasović, D., Katarina Grgec, K., Apa, M., Ljubek, A., Krikovic, N., Castro, S., Ramos, C., Cândido, E., Francone, A., Louro, A., Mandusic, B., Cipollone, C., Cesio, C., Węgrzyn, E., Ciurea, I.E., Gugić, I., Sesar, M., Pouliaou, M.C., Lunardi, L., Nikolaou, N., Bubica, N., Sophocleous, P., Gahlawat, P., Olteanu, R., Ungureanu, S., Cerqueira, S.M.G., Michael, Z.K. and Gras-Velazquez, A. (2022), *The STE(A)M IT Framework: Executive Summary*, European Schoolnet, Brussels.

Trowsdale, J. (2014), *The Imagineerium Pilot Project - with Schools. Report for Imagineer Productions*, University of Warwick, available at: https://jotrowsdale.files.wordpress.com/2015/10/imagineerium-pilot-report-full-final-july-2014.pdf (accessed 20 January 2023).

Trowsdale, J. (2020), "Art-making as a site for education", PhD thesis, University of Warwick.

Trowsdale, J. and Davies, R. (2023), "Developing Primary education through a STEAM model", *ECER 2023 Conference*, Glasgow.

Trowsdale, J., Mckenna, U. and Francis, L. (2019), "Evaluating *the imagineerium*: the trowsdale indices of confidence in competence", *Creativity and Learning, Thinking Skills and Creativity*, Vol. 32, pp. 75-81, doi: 10.1016/j.tsc.2019.04.001.

Trowsdale, J., Mckenna, U. and Francis, L. (2021), "Teacher evaluation of the impact of *the imagineerium* educational project on the creativity of individual students: the trowsdale index of teacher observation of student creativity (TITOSC)", *Research in Education*, Vol. 101 No. 1, doi: 10.1177/00345237211014559.

UNESCO (2016), "Assessment of transversal competencies: policy and practice in the Asia-Pacific region", available at: https://unesdoc.unesco.org/ark:/48223/pf0000246590

Wenger, E. (2007), "Communities of practice. A brief introduction", available at: https://wenger-trayner.com/wp-content/uploads/2015/04/07-Brief-introductionto-communities-of-practice.pdf (accessed 14 January 2019).

Further reading

Wenger-Trayner, E. and Wenger-Trayner, B. (2015), "Introduction to communities of practice: a brief overview of the concept and its uses", available at: https://www.wenger-trayner.com/introduction-to-communities-of-practice/

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