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'STEAM success stories': refocusing the framework of intersectionality

Saima Salehjee,[1,*] Mike Watts[2]

[1] Senior Lecturer of Education, School of Social and Environmental Sustainability, University of Glasgow, UK
[2] Professor of Education, Department of Education, Brunel University London, UK
* Correspondence: saima.salehjee@glasgow.ac.uk

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Abstract

In this article, we first explore the metaphor of *wearing culture*, drawn from the work of Anne Phillips, which challenges some of the precepts underpinning theories of intersectionality. We then go on to celebrate successes rather than failures, a departure from the broad ethos of intersectionality and illustrate how wearing of STEAM culture can be enacted throughout women's 'STEAM lives', employing a pedagogy for success. We make use of phenomenographic approaches to gather and present women's 'STEAM success stories'. *Autobioracy* is the term we coin here, in contrast to autobiography, to describe our capture of these oral accounts. We use data from three cases – Fatima, Su-Li and Anna-Maria – to illustrate their adult re-engagement with elements of STEAM, having long since disengaged from early formal school-based science and technology. We finally resist a template process for the interpretation and presentation of their storied accounts

and adopt, instead, a montage approach to place instances and descriptions side by side to illuminate their complex, often contradictory and unpredictable ways of knowing.

Keywords culture; pedagogy; STEAM; success; autobioracy

Introduction

The acronyms STEM [science, technology, engineering and mathematics] and STEAM [science, technology, engineering, the arts and mathematics] are, at the same time, both underspecified and over-extended. Laura Colucci-Gray (2023), for one, points to the multiple meanings and understandings of both terms. Nevertheless, she sees virtue in developing ideas within STEAM and takes the bold step of arguing that reframing STEM as STEAM can bring a radical transdisciplinary, transformational shift to science education. Adding an arts (A) dimension to STEM, she argues, is a laudable move that enables people to 'inquire differently', to *craft* broad issues that affect communities and the ways we live together in the world (Colucci-Gray, 2023). In this article, we take a step further and explore how STEAM education can be culturally responsive. At one level, adding arts to science and engineering might be seen in itself as adding culture to academic areas that are commonly perceived to be universal, as decidedly non- or a-cultural (for example, Banks, 2008). We are far from being alone in arguing that science is very much a culture, while also then being an integral part of everyday culture, and that technology and engineering are culturally shaped in, for example, their drive for innovation and fostering entrepreneurship (Banks and Barlex, 2013). Mathematics, too, is an integral component of all cultural contexts and is influenced by the interpretation of individuals within those contexts (Gay, 2018). For the purposes of this article, we define STEAM as the integration of science, technology, engineering, the arts and mathematics around a centralised problem to be solved.

Rethinking intersectionality

Intersectionality is a key analytic framework (Cooper, 2015) through which STEAM researchers talk about multiple forms of inequity and their operation in under-represented communities. It is a broad sociological framework that has enabled investigation and interpretation of the ways in which multiple interlacing social factors, such as race, sexuality, gender, ethnicity, religion and class, aggregate and create barriers in the pursuit of STEAM education and careers (for example, Archer, 2018; Avraamidou, 2020; Dawson et al., 2020). In our own work (Salehjee and Watts, 2023), we have seen the need to rethink intersectionality and drive it down from the generalities of the sociological to the ethnographies and particularities of the personal. Along with Jennifer Nash (2008), we ask the question, 'whose intersectionality?', and stake an interest in exploring the 'complexity and messiness' of the lived experiences of multiple identities. Following Phillips (2010), there are various times and places, for example, where a woman might want to be fully immersed in a particular culture, to wear it closely and heavily, while, on other occasions, she might want to move fluidly between quite different cultural groups, and maybe wear her culture loose and light. There are occasions when she might want to be fully engrossed in her culture, revel in its rituals and practices, while, on others, she might enjoy slipping and sliding between cultural expectations, sometimes adopting other cultural norms to blend with a group, sometimes creating hybrid moments of witty duality, of clever cultural crossover. This can all be seen in the three case stories we present here.

Making intersectionality personal in this way is just one part of our rethink. A second part relates to the ethos of failure that accompanies understandings and uses of intersectionality in research. Much of the existing literature on intersectionality focuses on how multiple, intersectional forms of inequality and disadvantage accumulate to create hindrances, obstructions, blocks and barriers for society's racially minoritised people. This body of literature either completely ignores or simply hints at the existence/perceptions of opportunities, privileges and freedom that some minoritised people in developed countries can experience in their STEAM-based academic and professional lives (Salehjee and Watts, 2023). It is not our intention in any shape or form to minimise the painful struggles, the fraught frustrations or the burning injustices involved in challenging oppressive systems and power structures.

We do, though, want to recognise and acknowledge successes where they happen, and we look to illustrate some of these here through the three case studies we present below.

A third issue for us surrounds the 'so what?' of intersectionality (Salehjee and Watts, 2023). Our own backgrounds lie both within science and in education, and this engenders an actionable strand in our thinking. The STEAM success stories of our participants provide us with evidence to critique existing pedagogical practices, for example, one-off institutional outreach activities for minoritised women to promote equitable teaching and learning practices. We have outlined, instead, a pedagogy for success wherein we look to diversity as a resource, rather than simply as an endpoint objective, and seek to embed inclusivity in all aspects of teaching and learning. Therefore, our specific research question is: 'How do minority ethnic women's diverse cultures highlight the "A" of STEAM, support and transform the wearing of STEAM cultures, and impact on what and how we teach culturally responsive STEAM successfully?'

Methods and arts-based montage

Our work develops a phenomenographic approach to qualitative educational research (Marton and Saljo, 1984). For us, this involves understanding phenomena through the eyes of people, communities and cultures – in our case, capturing the lived experiences of women who engage with STEAM. Drawing on Abbott and Wilson (2015), we use the idea of lived experience to explore tacit personal, social and cultural meaning-making that continues throughout life, where women are looking to make sense of who they are, where they are, what they are doing and what is happening to them. Autobiographical approaches are widely used to capture people's lived experiences; in our work, we replace the 'graphy' (written accounts) part of the autobiography with 'oracy' (oral accounts). To avoid the clumsy form of 'autobio-oracy', we have shortened our constructed term to 'autobioracy' as a neater word, requiring 'bio' and 'oracy' to share the letter 'o'. Autobioracy, then, is the act of oral storytelling about 'oneself'. Many other questions arise from 'storying' one's life, for example: What is my working life? How does 'telling' my science life connect to my home culture and heritage?

Adopting a snowball sampling approach, the 10 participants of this small-scale study are all immigrant, middle-aged (age group 30–50) women from minority ethnic backgrounds, who are working in the STEM areas, but who have not taken conventional forms of STEAM education, that is, an academic degree in a STEAM subject area from higher education institutions. They are not doctors, engineers, biomedical scientists, architects or the like.

In this article, we present 3 (of the 10) participants because of the clear articulation of their oral accounts and the diversity in their ethnic backgrounds: Fatima, who is a British Indian; Su-Li, who is British Chinese; and Anna-Maria, who is from a South American–British background. Participants' names are all pseudonymised, and we present various biographical details and descriptions of their experiences with their written consent. We employed one-to-one, informal, semi-structured interviews for around 60 to 70 minutes. During these interviews, we sought spontaneity in what they said and discussed. Our interview questions were also relatively spontaneous, and generated with a focus on their previous formal and informal education in STEAM, their working lives and their cultural beliefs. We closed the conversations by asking about the successes they gained from the events and scenarios they had shared with us.

Our analysis adapts a montage technique to analyse, synthesise and interpret the heterogeneous data of our participants' experiences. Montage can be defined as an 'assembly of fragments constructed from complete and autonomous parts' (Aumont, 1987: 150), which nonetheless cohere in an overarching narrative. According to Thompson and Bowen (2009), one aspect of montage is the assembly of seemingly unrelated facets, images or issues that can stimulate thoughts, ideas or new emotions in the audience. That is, montage creates thoughts and ideas from combinations and contrasts that can counterpoint or even collide with each other. We base our use of montage to present the outcomes of our interviews on the belief that these counterpoints are ways of approaching the world that differ fundamentally from those of traditional 'template' research, and that these might better suit worlds that are increasingly complex, contradictory and unpredictable (Ladkin and Taylor, 2010; Weick and Sutcliffe, 2007).

In assembling and then reassembling the sequence of the oral accounts, we aim to present the meaning and associated emotions of the related but disorganised oral accounts concisely – accounts that were experienced by the participants in different spaces and at different times in their lives. In doing

so, we focus on their wearing of intersectional cultures, including their home culture, working culture and the culture of STEAM. Similar to other forms of interpretive analysis, we acknowledge that a montage approach is researcher-driven in arranging and rearranging data sequences. We used our interpretation of the different sections of the women's accounts (Mann and Warr, 2017). To mitigate our subjectivity, we sent the individual montages to the respective participants presented in the next section of the article, and any requested changes were made by them accordingly.

Three cases: Fatima, Su-Li and Anna-Maria

Fatima: a landscape artist

Fatima is a freelance landscape gardener. She is a relatively late entrant to the world of botany and plant biology, having been a company financial officer for many years, between periods of raising a family. Once her three children moved towards higher education and careers, she decided the time was then ripe for her 'to get going, do her own thing'. With full family support, she first took a relatively menial role in a local garden centre, rose to managerial level, and then embarked on different courses through the Royal Horticultural Society, eventually undertaking an online Master of Horticulture degree:

> For my final year project, I looked at the design and development of Sissinghurst Castle Gardens in Kent. It was created by Vita Sackville-West and Harold Nicolson in the early 1930s. She was a poet and writer, you know, and I loved every minute of writing it, the fascinating history it gave me, the big personalities of the characters involved, and the garden's wonderful plant collection. Especially the roses!

She now takes commissions for landscaping projects for both small and large gardens and has a team working with her to manage the 'hardcore work' of earth moving, drainage systems, brickwork, paving, digging and planting. We talked about the range of knowledge and skills she has brought to each project:

> It's everything! I have to test soil types and ground features, research appropriate plants, design and build things like water features, it's amazing! There's engineering, architecture, building, all kinds of technology and, of course, the science of plants. But it's so much more than that, I need an aesthetic touch! [laughs] I say that it is my woman's touch, the mix of colours and textures I bring to a garden. I bring the overall look.

She continued:

> I am really no expert. Not even remotely! I listen to the people who talk on *Gardeners' Question Time* on the BBC, and am amazed at their knowledge – about everything, all kinds of trees, plants, vegetables, ground conditions, crop diseases, everything! I am nowhere near that, I have to work very hard to shape the plans I make. But I made a lot of friends on the course, and I often call them up, 'Help! What should I do about this?' And they have been great, always amazing ideas.

We asked about the impact of her culture on the work she was doing:

> I really like some of the vegetables my Bangladeshi grandparents used to grow, like lablab beans and bottle gourds. The gourds are great! In one place, I built this structure so the vines could climb, and the gourds could just hang down. They taste good, too! I have tried growing taro, as well, which is very ornamental.

What about some of the difficulties she experienced?

> Well, some of them are out there, of course. People are a little surprised, shocked, I think when they make an appointment on the phone and then a middle-age Indian woman turns up to talk gardening. They are usually very polite, but I can see the wariness there until we get talking properly. My parents were very happy when I chose accounting, that sounded like a very solid career for a young woman. They had to be persuaded when I joined the garden centre that I was following a dream, but my husband has been very supportive, and they listened to him. They are happy again now I have a new degree and my own company [laughs].

And how would she describe success in this aesthetic-science world of hers? She knew the question was coming, but nevertheless took some considerable time to answer:

> So many. So very many. Getting an unusual plant to flower or to bring fruit. Getting a particular look, when a plan all comes together. Getting satisfied customers, who ask me back again and again for advice and more ideas. Getting customers by word of mouth – that's a great feeling! Being part of a network through the courses I did. Finding new plants and ideas, that's a great feeling. I get a great deal of satisfaction from researching the area, its geology, its history.

She finished by saying:

> And I was once in charge of company finances, so the bottom line really counts, too. At the end of the day, I really have to turn a profit, if only to pay the people who work with me!

We draw several threads from what Fatima is saying. First, her horticultural STEAM most certainly has an arts-aesthetic 'A' embedded firmly in what she does. She designs, crafts and creates within each garden commission she undertakes, she studies the soils, water tables and the backdrop with a mind to the environmental impact and sustainability of everything she accomplishes. Second, she brings a cultural response to her science and technology, shaping English gardens while at the same time drawing from her Indian heritage. In some cases, she says, the homeowners want something special and different and, in our terms, she 'wraps' herself quite markedly in her heritage and culture in order to conjure new designs. At other times, she moves easily within the 'Englishness' of what they want. Third, she is both formally trained and informally educated. She is a strong advocate of the Royal Horticultural Society's qualifications systems, of the skills she acquired and the networking she developed, but she also feels heavily indebted to the many friends and colleagues who help and advise her so readily. Fourth, her claims for success meet our criteria by being quite varied and multiple. We explore the nature of success in the final sections below.

Su-Li's Chinese dragon

Su-Li was born in Beijing and brought to the UK at the age of 4 years when her parents took academic posts in London. Now a UK citizen, she chose to train as a primary school teacher and, for the past three years, she has worked in a multicultural school in the East End of London. Her subject specialisms were not in science or technology, but, as a conscientious primary teacher, she has attended several professional development programmes that have given her confidence and encouragement to engage in school projects. It was she who suggested that her class should design and make a Chinese dragon for the children to 'wear' during Chinese New Year celebrations. The head of the dragon was constructed from a hard cardboard box with papier mâché additions to give it shape, and the 'body' was formed from a long section of silky satin material supported by five semi-circular plastic D-shaped hoops. The tail was a mix of coloured fabrics from the make-and-do box. The class worked in teams to build and paint their section of the dragon, and Su-Li supervised – something she had never tackled before. Lots were drawn, and children were assigned to 'dance' under the fabric, inside the highly coloured dragon, and it made its debut at a school assembly to Chinese music and wild applause. It made a further appearance at local New Year festivities in the neighbourhood:

> Oh, goodness me, it was such fun! Half the battle was keeping a lid on the excitement, the children got *sooo* exuberant! Everything about it was new for me. Oh, I have seen dragons in parades before, lots of times, but never really looked to see how they were made – they always looked so professional! I took to YouTube, of course, and followed some of their designs, and talked to lots of my Chinese friends – especially the older people, they had lots to say. Lots – believe me! It's not the sort of thing we ever did at home, my parents are not that kind of people, but other teachers helped me as I got going.

She talked about the mathematics, technology and the history brought to the project:

> It took a while to get it all together, and we had to commandeer a part of the assembly hall to lay it all out, see what we were doing, get the measurements right. We wanted it all in

> proportion, the right size and height and everything. We talked a lot about Chinese culture, and the ways dragons are a part of Chinese history. Well, not just Chinese, of course, but in lots of cultures. Saint George slayed a dragon, didn't he? And so we had to mention him, too. And the Welsh dragon.

What difficulties did she meet? She paused before answering:

> Not all of the class is Chinese, of course, we have twins from Angola, Annie is from Armenia, two Mohammeds, some new Ukrainian children and so on. I did feel a little as if I was imposing my culture on them. I wondered how the parents would react, but the school as a whole was right behind me, and we do celebrate many other cultural festivities during the year – the school is very proud of that. I needn't have worried, really, I think the parents saw it as a fun creative – technology – adventure, and got engaged with the children at that level.

What were her measures of success?

> Non-stop excitement! So much fun and energy! The children's enthusiasm was so fantastically infectious. Even while we were doing our ordinary lessons, I just knew they were thinking about it, wanting to get to the next stage and so on. And they deserved the applause they got; you've never seen a dragon swish like that one did! Oh, and a very nice pat on the back from my Head after the assembly.

Culturally responsive STEAM is most certainly evident here, with the 'M' of STEAM celebrated as a part of Chinese culture. The arts sides of the project are easily identifiable: the use of history, books, images and stories, and classroom discussions of myths and beliefs. The technology was not 'rocket science', but, nevertheless, problem-solving was required along the way to the completion of the project. For example, it was difficult at the start to attach the papier mâché to the 'head' of the dragon without soaking the cardboard box and rendering it too fragile for use. The ears, eyes and various 'bulbous bulges' had first to dry thoroughly, and then be attached, painted and coated in varnish gloss. As with Fatima above, Su-Li is both professionally trained and informally educated – she is adamant that she could not have brought the project to fruition without the help of 'a thousand people'. Her measures of success were typically self-effacing – success belonged to the children and the school, although with a small measure of approbation from her head teacher.

Anna-Maria's cake-bake

> I am Anna-Maria Tuena, and, in my country, my surname means 'perfect', and I try to live up to that! When I do something, I want it to be good – no, not just good, *very* good! My married name is Weaver, but I keep my family name to remind me always to try hard!

Anna-Maria is a homemaker and mother of three children, all now at school. She volunteers at a local food bank and is an active member of her church community. With a group of women friends, she organised a large-scale cake-bake to raise funds for charity and feed the homeless. They tackled the project on a small industrial scale, working together to agree on ingredients, quantities, baking and decorating. They were allowed to use the kitchens of a community hall, sourced the materials and equipment, organised the production line, printed the T-shirts, designed the promotional materials, and took a stall at a local town-centre craft fair to sell their wares. The women came from a variety of cultural backgrounds, and they worked together under Anna-Maria's directions:

> My children say I am naturally bossy [laughs]. Maybe I am, I am like my mother in that way. I do find myself telling people what to do. I don't always know best, but it never stops me telling them! But there was so much to do, and it needed someone to take the lead. Karina, my eldest, is doing food technology at school, and she was also giving advice. We are a very mixed group, but somehow, we manage to succeed. People in India and Pakistan cook things differently to South Americans. Dominique is from France, and she found it very hard to watch others cooking. She organised our T-shirts instead.

There was much discussion about measures, temperatures, baking time, sugar content, retaining freshness, gluten-free requirements, allergens, personal hygiene, food hygiene procedures, storage, wastage and so on, as well as learning about tried-and-tested, time-honoured, traditional ways of doing things. No one was a qualified chef, but all were experienced cake-bakers:

> We had very little money for the project, we begged most of the supplies, and so we really couldn't afford to make any mistakes – we couldn't really go back for more. We did small batches of different cakes to see what worked, and then scaled up the process. Even getting the cakes from the kitchen to the stall was a nightmare, we couldn't simply plonk them in the back seat of my car!
>
> Yes, there were difficulties. Ours is a very multicultural community, and there was some hesitation, some grumbling, at first, about doing it through my church. Our priest, Father Morris, was very good that way, he talked to everyone so nicely. And we said we would do another one for the mosque and the synagogue. We worked well together in the kitchen, but you could say that, at times, there were just too many cooks, too many languages, for it to be smooth and easy. But we got there!
>
> Success? Oh my, yes! It felt like climbing a mountain at first, and we were very happy when we got there – and we were still all friends! There was so much we didn't know, so much to learn. We sold everything, we made a great sum of money, and we were flat out tired. I know we said we would do it again for the other churches, I just hope I have the energy.

In general, food technology concerns the production, quality control and preservation of food products, in this case, cakes for consumption by the public. Anna-Maria's was a small-scale homespun enterprise, but it nevertheless illustrates the creative artistic 'T' in STEAM. It is an example of informal collaborative learning in a community setting, structured effectively, with women working on separate tasks yet contributing to shared outcomes. Not all of this was practical experiential learning; not all those concerned were conversant, for example, with various allergens and gluten-free products. Success for Anna-Maria came not just in terms of the sales revenue and sum donated to charity, but also in terms of her friendship group, and their common achievements.

A pedagogy for success

Our work (Salehjee and Watts, 2023) develops the idea of a pedagogy for success. Our sense of pedagogy is not limited, however, to structured formal teaching strategies, nor informal learning activities. We see no single instructional 'straight line' between teacher and taught. Rather, as Gert Biesta (2014) points out, pedagogy is much broader than that, and we enjoy Henri Giroux's (2004: 61) description, when he says:

> Pedagogy is not simply about the social construction of knowledge, values and experiences; it is also a performative practice embodied in the lived interactions among education, audience, texts and institutional formations. Pedagogy, at its best, implies that learning take place across a spectrum of social practice and settings.

Nor do we have a single meaning for success; instead, we see it as coming from within, through self-contentment, internal drive, external service for others and continuous informal learning (Gomez, 2020; Gotian, 2022; Goy et al., 2018). Most certainly, pedagogy plays a vital role in developing successes, in this instance in STEAM education and career choice. For our participants, a pedagogy for success involves a personal drive to achieve happiness and long-lasting contentment, directed at the goal of living a 'good STEAM life'. This is supported by strong and constructive relationships built with others. This personal drive and relationship building strengthens individual determination to overcome stereotypical norms, cultures and customs. A key ingredient in pedagogy for success is a concern for the flow of knowledge, in particular the sharing, the give and take, and the exchanges of knowledge and experience between participants. Successful learning, in our view, lies not in a singular 'teacher transmission' mode, but in the collaborative flow created by learners in action. In our three cases, this flow of knowledge is rarely unidirectional and uni-sourced from within formal educational spaces, and

one key to success is the willingness to tackle STEAM study from whichever sources the individuals see as appropriate, for example, learning from family and friends, customers, colleagues, children and media.

The five features we list for pedagogy for success are not original, but we bring them together as a basis, a platform, for promoting success in learning – and generating a sense of success from learning. First, we see the need for a *web of relations*, the interconnectivity between people and the value this brings to the learning of STEAM in our three case stories above. It is possible to see the relationships between teachers and learners, and between learners and learners, and how these are shaped. From Fatima's extended connectivity through her master's course to Anna-Maria's women's group, there exists an overall 'culture' and ethos within the learning space that enables and respects the sharing of power (Cochran-Smith and Lytle, 1999). It shapes the ways, for example, in which people work and share their learning, and it can create a sense both of individual self-determination and of communal belonging. We see positive relationships, whether at school, university or within other learning communities, as the bedrock for generating an atmosphere of STEAM success.

Second, the *learning objectives* in each situation have been different, with decisions being made as to what exactly was to be achieved in each setting. There are clear differences, for example, between Su-Li's teacher-determined objectives for the dragon-making and Anna-Maria's learner-initiated learning for the cake-baking. Our interest here relates to who exactly sets the goals, and how they are set. There is no doubt that learning objectives are generated against a sense of what exactly counts as success.

Third, we are interested in *the flow of knowledge*. This involves the directions of the flow and exchange between teachers and learners, and between learners and learners. These are decisions to be made on when to 'hold in' and teach, or to devolve responsibility and generate collaboration with and between learners, moving from teacher-telling to exchanging with 'more-knowledgeable others' (Nissen, 2006). Our three case stories illustrate opportunities for learners' voice, for expressions of culture, for responding to feedback, and for telling stories of success. These opportunities arise differently in each of the learning situations. Our participants were asked the extent to which they were able to contribute, as well as to receive, learning and understanding during exchanges of knowledge.

Fourth, the *experiential texture* asks the questions: What was the learning like for you? How well did it work out? There are sometimes questions about the setting, the organisational details, the resources and materials, the managing of learning engagement, and maximising the opportunities unique to the immediate environment. This might involve moves, for example, from serious work to play learning and back again. Again, the formal or informal context of the situation would impact upon this experiential texture. For example, Fatima's learning endeavours include formal and informal contexts – horticulture degree, landscapes as places of work and grandparents' home gardens – which strengthened her learning and artistic ability.

Finally, the *evaluative tone* relates to self and collective effectiveness and outcomes. This, too, is shaped by the situation, illustrated by all three participants presented in this article. So, there are commonly very clear criteria and expectations allied to evaluation in formal learning situations where accreditation is part of the situation, and this is often framed as formative and summative assessment. On the other hand, commendation, compliments and praise are more likely in informal contexts. Social and collaborative situations might bring approval and applause, as in Su-Li's dragon dance, while personalised situations are likely to deliver moments of self-satisfaction.

Culturally responsive STEAM and pedagogy for success

Numerous structural and cultural barriers contribute to the under-representation of minoritised participants in STEAM disciplines, and there are calls for 'cultural transformation' in STEM-based educational departments (Johnson and Elliott, 2020). Geneva Gay (2018: 36) has described culturally responsive teaching as 'using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them'. Moreover, Gloria Ladson-Billings (2014) has focused on pedagogy as needing to be culturally relevant pedagogy. Aronson and Laughter (2016: 163) write that, 'While delineating a difference between teaching and pedagogy, both strands [must] strongly embrace social justice and the classroom as a site for social change.' Consequently, the intention for STEAM educators has been, of course, to increase diverse and inclusive participation. In practising culturally relevant pedagogy in a classroom, teachers need to be aware of their own cultural beliefs, and those of others, their

self-beliefs of knowledge, and their practices to accommodate social relations and interactions in their teachings. Our three stories illustrate some of this participation, both inside and outside of classroom contexts. They also articulate a strong sense of transformation through integrated learning. Importantly, these transformative experiences have privileged the wealth of knowledge and cultural insight which the participants bring with them to these STEAM learning situations. Our stories present 'success' in culturally responsive pedagogical actions, not only by including some insights and tasks which promote the knowledge and understanding of minority ethnic cultures, but also in illustrating transformations in 'wearing' STEAM culture. We argue that formal STEM education on its own has little to offer for gains in cultural responsiveness. It becomes responsive when individuals wear STEAM culture – at home, in their neighbourhoods, in educational and non-educational institutions, and in workplaces. Moreover, a culturally responsive STEAM pedagogy is no tick-box activity – there is no simple pedagogical toolkit that can develop culturally responsive individuals and society. As we discussed earlier, the 'personalised' way that individuals wear their STEAM culture is dependent on their own intersections with social factors, such as heritage, religion, social class and nationality. And the 'strength' of these factors will vary over time, and in different contexts and situations.

The personalised wearing of STEAM culture gives flexibility to our pedagogy for success framework. For example, the 'web of relations' signals the array of relationships among people possible within STEAM activities and practices. In our stories, this has involved children, students and adults, working largely in low-resourced schools and neighbourhoods, and commonly living in 'STEAM-disadvantaged' families. Even while we rethink our intersectionality framework, it is important to articulate the social influences and practices experienced by people, young and old, in developing, for example, their web of relationships, and the ways in which these relationships are established and maintained. The impact of our stories shows that 'intersecting differences' among students' heritage, socio-economic status, gender and religion can be managed through culturally responsive STEAM education. In this sense, educators from varying educational levels, schools, colleges, universities and adult learning institutions, need to be aware of their own web of relations, and recognise intersectional make-up and differences as they work. And beyond the web of relations, learning objectives and modes of evaluation vary from person to person and from situation to situation. Achieving and evaluating these learning objectives needs to centre on the willingness of individuals to embed cultural responsiveness towards socially diverse people with varied STEAM learning needs, and the different ways they satisfy those needs, and practice various actions.

Reshaping the model of knowledge flow for educators then becomes a priority – educators need to accept the innovation and reshaping of a STEAM culture on an ongoing basis, different from traditional forms of knowledge flow. Therefore, including culture in the process of knowledge flow transforms the concept of 'knowledge transfer' from Vygotsky's (1978) 'more knowledgeable person' to receiver. The 'more knowledgeable person(s)' with respect to culturally responsive STEAM education will not always be established educators – they can often be students and people in everyday life, so learning goes beyond the subject knowledge of STEM orthodoxy to the informal learning and learners of STEAM. Moreover, 'experiential texture' cannot be the same for all. The learners' intention to see their learning outcomes through the lens of cultural responsiveness, coming together to learn and practise STEAM without assuming that any one person is more knowledgeable than others, becomes the norm. So, STEAM's success in evaluating cultural responsiveness comes from various but interlinking directions: an effective 'web of relations' among diverse groups of people, accomplishing 'learning objectives' by including people from a variety of cultural backgrounds, success in breaking the traditional barriers to the flow of knowledge, and using a variety of resources and modes of engagement to elevate cultural responsiveness. All of these interlinking routes contribute to successes in completing collaborative projects, challenge the ethos of failure, and look to generate self-satisfaction and happiness at a personal level.

In conclusion, we view intersectionality as the wearing of cultures, and as educators succeeding in practising culturally responsive pedagogy at a personal intersectional level, and being inclusive of all students from varying cultural backgrounds, as well as supporting the development of culturally responsive learners and advocates, including educators themselves and their students – heralding the way forward for STEAM education research and pedagogy.

Declarations and conflicts of interest

Research ethics statement

The authors declare that research ethics approval for this article was provided by Brunel University ethics board.

Consent for publication statement

The authors declare that research participants' informed consent to publication of findings – including photos, videos and any personal or identifiable information – was secured prior to publication.

Conflicts of interest statement

The authors declare no conflicts of interest with this work. All efforts to sufficiently anonymise the authors during peer review of this article have been made. The authors declare no further conflicts with this article.

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