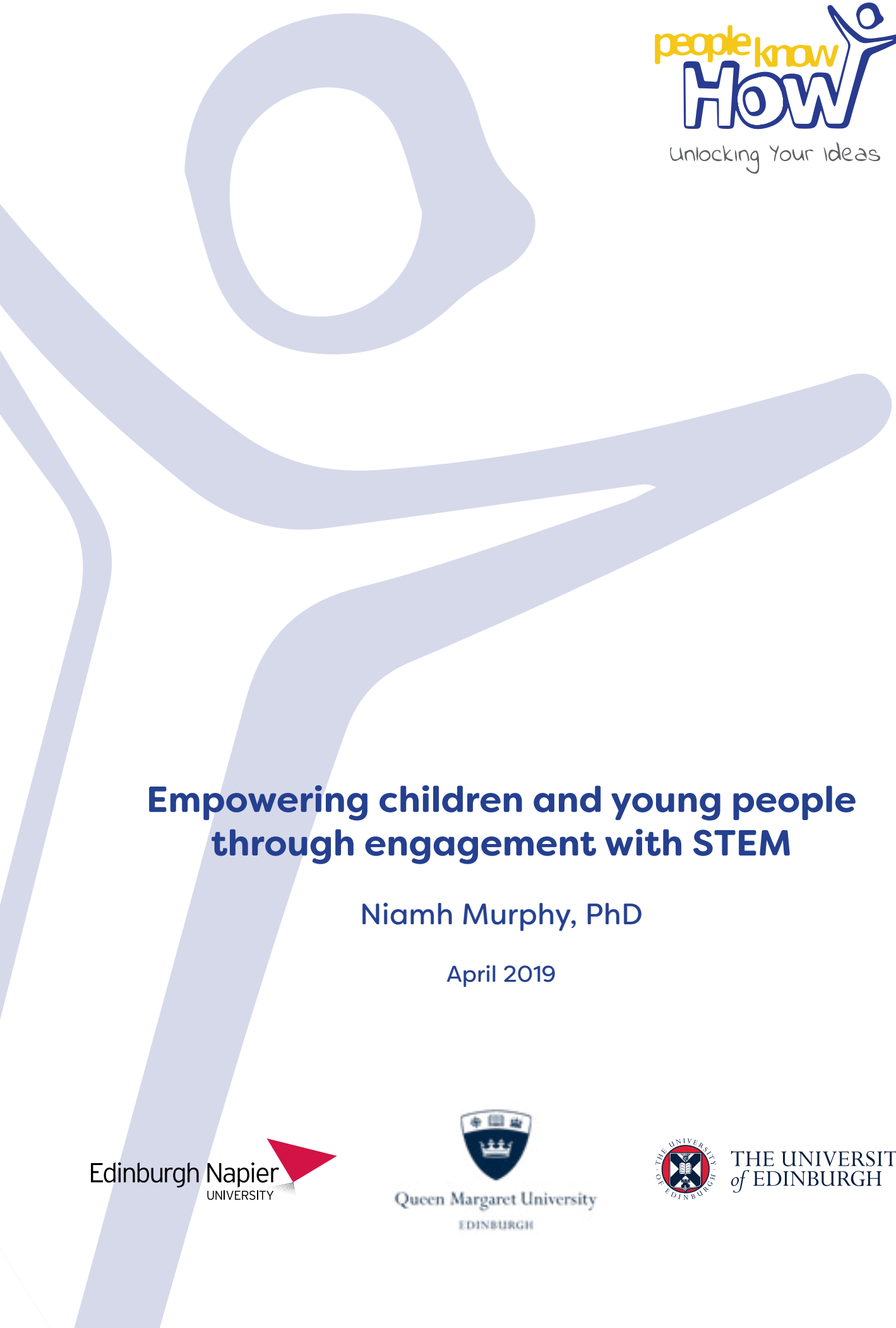

Empowering children and young people through engagement with STEM

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Abstract

As children develop toward adolescence, neurological changes occur in the brain that heighten their inherent curiosity and ability to think critically. In order to utilise these new abilities effectively, young adults must be internally motivated. They must learn because it feels good, not just because they want to get an A or get accepted to a good university.

Curiosity, creativity and innovation are at the core of Science, Technology, Engineering and Mathematics (STEM) education. STEM enable us to make sense of the world around us, to understand public policy issues (e.g. climate change) and subsequently make informed decisions. However, most day-to-day classroom environments discourage or neglect curiosity and instead focus on rote learning practices. Teachers have to show that students are achieving learning goals "that are obvious, measurable and explicit" and so, students are evaluated on mandated tests, teachers are evaluated on their students' exam results. However, a new school of thought (pardon the pun) is beginning to emerge. Scientists now believe that the most important factor in a child's success is NOT their IQ but rather qualities like persistence, curiosity, conscientiousness, optimism, and self-control. In fact, some policy-makers in the United States believe that only by reinventing STEM education to attract, support, and sustain the participation of students from all walks of life can the needs of science and technology innovation, economic prosperity, and social well-being be recognised.

Keywords

Curiosity, STEM, STEM clubs, Education, Creativity, Innovation

Key Points

- Informal, community-based activity clubs offer an easy way to introduce a broad range of activities into out of school settings at relatively low cost and in ways that were almost universally enjoyable to young people.
- STEM clubs have a clear potential to broaden the views and curiosity of young people about science.
- Future funding of STEM activities should evaluate whether the frameworks introduced by various projects are widely applicable and whether a change in the skills, attitudes and perceptions of young people can be demonstrated analytically.
- STEM clubs need to work in partnership with CYP to achieve the best educational outcome for their participants and to determine how best to engage their particular set of activities.

Background

"Tell me and I forget, teach me and I may remember, involve me and I learn." – Benjamin Franklin

As children develop toward adolescence, neurological changes occur in the brain that heighten their inherent curiosity and ability to think critically. In order to utilise these new abilities effectively, young adults must be internally motivated. They must learn because it feels good, not just because they want to get an A or get accepted to a good university (1).

Curiosity, creativity and innovation are at the core of Science, Technology, Engineering and Mathematics (STEM) education. STEM enable us to make sense of the world around us, to understand public policy issues (e.g. climate change) and subsequently make informed decisions (2). However, as argued in "The Hungry Mind", most day-to-day classroom environments discourage or neglect curiosity and instead focus on rote learning practices (3). Teachers have to show that students are achieving learning goals "that are obvious, measurable and explicit" and so, students are evaluated on mandated tests, teachers are evaluated on their students' exam results (4). However, a new school of thought (pardon the pun) is beginning to emerge. Scientists now believe that the most important factor in a child's success is NOT their IQ but rather qualities like persistence, curiosity, conscientiousness, optimism, and self-control (5). In fact, some policy-makers in the United States believe that only by reinventing STEM education to attract, support, and sustain the participation of students from all walks of life can the needs of science and technology innovation, economic prosperity, and social well-being be recognised (6).

An ASPIRES report recently identified a disproportionate number of Children and Young Persons (CYP) from disadvantaged family backgrounds as being put off STEM subjects and careers because they are perceived as being "middle class" (7). However, these CYP are often just as capable as their "middle-class" compatriots. A joint venture by researchers at the University of Michigan C.S. Mott Children's Hospital and the Center for Human Growth and Development analysed data from 6,200 kindergartners. They found that children with lower socioeconomic status characterised as "curious" performed similarly on math and reading assessments to children from higher-income families (8). Another study found that the CYP who experienced science activities connected to physical expression demonstrated superior creativity to those of the control group (9). Therefore, STEM activities may be an important, under-recognised way of promoting curiosity and creativity in children, especially those from environments of economic hardship.

Traditionally, youth workers have used sports, arts and crafts, or outdoor activities to engage with disadvantaged CYP (10) because these informal environments can be organised in such a way that allows CYP to create and follow their own learning agenda (11)(12). Therefore, community-based STEM clubs may offer a great opportunity for young people to develop an appreciation of STEM subjects, particularly given that young people spend up to 80 per cent of their time outside of school (13). Research

has shown that informal science learning may be particularly beneficial for young people from disadvantaged backgrounds, who are more likely to find science subjects challenging and unengaging at school due to significant personal roadblocks, including overworked or absent parents, emotional problems, and drug and alcohol abuse (14,15). All young people deserve to be inspired by science and to see its significance to them in everyday life.

Examples of STEM clubs

The Curiosity Club

The Curiosity Club was a project developed in partnership with People Know How and Science Ceilidh, with funding provided through a £2m scheme between the Wellcome Trust and BBC Children in Need (http://www.scienceceilidh.com/curiosity). The project helped youth organisations develop and deliver inspiring science activities for disadvantaged CYP in 15% of the most deprived zones in NE Edinburgh (16). The project succeeded in three key areas: 1) raising the confidence of 60% of CYP participants by encouraging them to share and develop their ideas through presentation to their peers, 2) raising the aspirations of 76% of CYP participants about their future and what they could achieve (by 76%), and 3) helping 64% of CYP participants to relate better with their families and role-models (64%) by relaying what they had achieve at each STEM club session.

The Prince's Trust Fairbridge programme

The Prince's Trust has a long history in helping disadvantaged young people across the UK to change their lives and get into work, education, training or volunteering. Recent partnerships have focused on using STEM activities to engage with disadvantaged youths. These include but are not limited to the engagement of CYP in the exploration of rivers so that they may gain a better understanding of the state of their surrounding environment, inviting CYP to solve a murder mystery using techniques and principles of Forensic Science akin to those used on TV shows like CSI, and encouraging CYP to work together to come up with a working car race track, including bridges and tunnels, and solving mathematical problems to work out average lap times (10).

Examples of STEM clubs

The Wellcome Trust recently commissioned Platypus Research to explore what activities STEM Club participants engaged with best and how their engagement with STEM might be improved in the future. They identified the following as some of the most important factors:

Collaboration

Research indicates that CYP involvement from conception to completion of a STEM club project is highly important. CYP representatives should be involved in the planning, design and execution of STEM activities as this encourages them to take ownership of their learning and provide leadership for other students. Student mentoring is also a great way of helping CYP to develop their social skills and ensure a successful Club in which students will want to take part.

Oriented tasks, small-group learning, use of technology, and student-driven inquiry projects have been shown to effectively help students remember scientific facts, understand how the facts are connected, and apply what they have learned to new situations (17). For example, an Engineering challenge held at a Liverpool STEM Club aimed to create a tower built from spaghetti and marshmallows. To make a successful tower, the young people needed to communicate effectively and work as part of a team to tease out the weaknesses and strengths of different shapes as well as the varying properties of the different building materials. Volunteer engineers were on hand to discuss the importance of foundations and the impact of the different weights and strengths of the materials on the tower (10).

Variety

Variety in any activity helps to sustain engagement but equally a narrower focus can make it easier to decide on appropriate activities, enable intensive study of a particular subject, minimise resources and equipment required for a STEM club activity (10). For example, many activities popular amongst young people are sport-based, therefore establishing links between STEM and sports may prove effective. Alternatively, TV can be used as a tool of engagement. To coincide with the Manchester Science Festival 2015, the North Manchester's Seriously Scientific! initiative invited under 16's CYP to solve a murder mystery using techniques and principles of Forensic Science akin to those used on TV shows like CSI. Students often don't see how knowledge or techniques learned in one subject could have an impact or affect another. Therefore, combining knowledge and identifying links between STEM subjects can only benefit the success of a STEM Club (10).

Planning

Successful STEM club activities need to be well planned and well managed, with careful consideration given to group composition, leadership, goals and regularity of interaction (10). For example, steps were taken in a number of high-achieving, high-poverty schools in the United States to involve all students in some kind of extracurricular programme. Those schools that participated found that such extra-curricular activities incentivised students to remain in school rather than dropping out (18).

Practicalities

STEM club activities need to be accessible and held in a safe environment. Common barriers to extracurricular engagement include lack of resources, the role of parents, lack of role models and location. Finding a base near to friends/parents/guardians and with easy access in the locality is often most impactful for continued engagement (10,19). It's about involving everyone in conversations that matter, and collaborating to raise and educate CYP to embrace lifelong learning and who succeed in school and life (1).

Showcase achievements

Rewarding achievements and providing opportunities for young people to share and be proud of their accomplishment is important for CYP (20). For example, CYP were encouraged to help rebuild fishing platforms at a Nature Reserve and complete water quality surveys,

bug surveys and a bat surveys with the Tees Valley Wildlife Trust, Middlesbrough. The outcome of the initiative saw that all CYP were given the opportunity to showcase their work and were recognised for their efforts with the John Muir Award (Discovery Level) by the Tees Valley Wildlife Trust. Similarly, giving students roles of responsibility within a STEM Club can give them a sense of pride in the Club and help with recruitment of other members. For example, student leadership at Knightswood Secondary School, Glasgow School uses student representatives to support the running of their STEM Club. As Junior STEM Ambassadors, these CYP are responsible for supporting other pupils, helping to demonstrate experiments and leading sessions (16).

Conclusion

longitudinal research on this topic at present, it remains to be seen whether these approaches will make real changes to the aspirations of young people about science. Future funding of such activities should evaluate whether the frameworks introduced by various projects are widely applicable and whether a change in the skills, attitudes and perceptions of young people can be demonstrated analytically (15). What is clear, however, is that STEM clubs need to work in partnership with CYP to achieve the best educational outcome for their participants and to determine how best to engage their particular set of activities. Luckily, STEM clubs can draw on schools in their locality for indications of where gaps are perceived in the educational provision and this can help clubs decide how best to target their resources. STEM Learning's guide (www.stem.org.uk) to running successful Clubs related to science, technology, engineering and mathematics (STEM) is highly useful tool for developing and implementing a STEM club in disadvantaged areas (16).

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