STEM: Efforts to inspire more children could be entrenching educational inequalities

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Science, technology, engineering and mathematics (STEM) education is a priority for governments around the world. For example, the UK's current commitment to increasing investment in research and

development to 2.4% of GDP by 2027 means that we need to train 260,000 more researchers to carry out this work.

There has long been a perceived shortage in such skills and knowledge. And this drives policy measures in education, skills and immigration to address the situation.

In their STEM strategies, governments are increasingly focused on addressing the large disparities in participation between different social groups. For example, in the UK only 15% of scientists come from working-class households, just 7% of patents are filed by women, and among start-up founders men outnumber women four to one. The problem is often discussed in terms of a "leaky pipeline," the idea that potential STEM professionals are lost at particular points along defined pathways.

Plugging the leak

This spurs governments around the world to target activities at young people, aiming to foster STEM engagement from an early stage. "STEM inspiration" is one way to do this, by offering STEM-related activities to school-age children beyond usual subject teaching. This could take place within schools, or informally through visits to museums or in the home or community.

The Department for Business, Energy and Industrial Strategy (BEIS) funds STEM inspiration in the UK, spending £103m annually on programs delivered through bodies such as STEM Learning Ltd, the Wellcome Trust, and the British Science Association.

But is all this activity having the desired effect or could it even be doing more harm than good?

First, we know that there is just not enough provision. For example, our mapping of invention programs found that they reach just 1.5% of the UK school population annually. Overall, participation in STEM careers activities is low, with less than 30% of 11- to 14-year-olds reporting having taken part in 2017. In light of evidence that it takes around four role model encounters for effects to be seen on students' aspirations, it is likely a very small and select group that receives effective provision.

Also, provision continues to exclude students and communities who need it most—those who are traditionally less likely to take part in STEM. UCL's ASPIRES team has found that while significant proportions of the school population report never having had access to STEM inspiration, this is particularly the case among disadvantaged groups.

Competition equals inspiration?

Our own research looked in more detail at one particular type of STEM inspiration activity: competitions. STEM competitions are an increasingly popular model in the UK and internationally, challenging students individually or in teams to apply STEM skills and knowledge to hands-on projects.

There are around 50 STEM and innovation competitions in the UK. Government departments run their own—for example, the Youth Industrial Strategy Competition by BEIS, and CyberFirst by the National Cyber Security Centre. The model is also very popular in the US and China, and reflects a strategic focus on STEM for economic growth. However, in some countries, such as Finland, competitions are treated more as opportunities to collaborate and share knowledge than promote individual success; and in Singapore, there is a noticeable emphasis on creativity in STEM.

We looked at participation in STEM competitions in England and

compiled a dataset of 179 schools that had teams shortlisted, from 13 competitions in total. While two competitions, the Leaders Award and IET Faraday, provided complete lists of all participating schools, only shortlisted schools were available for other programs.

Classifying schools by type, we found that 21% were independent schools, a large over-representation (independent schools make up just 10% of all schools in England). This is probably because, while over 80% of independent schools offer STEM competitions as an extracurricular activity, only half of all state schools do.

After excluding independent schools, we added data on state schools' deprivation levels using eligibility for the pupil premium (extra funding allocated to schools to support students from disadvantaged backgrounds) as an indicator. We found that almost half (45%) were in the least deprived fifth of all state schools. In other words, there is a strong skew towards schools serving richer populations.

Other studies show that this pattern holds in different fields, too. For example, independent schools are also over-represented in enterprise competitions, and theoretical work suggests that such competitions reproduce inequalities between participants, schools and communities. Academics question the educational value of competitions, observing that such exercises emphasize the extrinsic reward of achievement, so that participants engage in tasks to win rather than to learn.

However, competitions can be designed with a commitment to equity, meaningful learning, and long-term outcomes for communities, by organizations that draw on research evidence and lessons learned through their own practice. For example, the Leaders Award run by Primary Engineer asks children, "If you were an engineer, what would you do?", challenging them to apply engineering principles to a problem of their choice. The program runs 16 distinct regional competitions, reaches

60,000 students annually, and emphasizes local community and industry links.

As ever, Finland provides an inspiring example. StarT is an international program run by the LUMA Centre, a network of Finnish universities dedicated to ensuring high-quality science, technology and mathematics teaching.

Students develop projects based on their own interests, with the requirement that projects are related to science, maths and/or technology (interdisciplinary projects, and those which incorporate other subjects such as arts, are encouraged), and that they address one of the StarT themes. These projects can then be shared at events, where children peer-assess each others' work.

A key feature of the program is the learning community: schools, kindergartens, extracurricular clubs and even families register as learning communities to support projects and are invited to share best practices within this network.

What's good practice?

From our review of STEM competitions and the research behind them, we've identified four principles of good practice.

First, equity. Competitions should be designed with those who are most excluded in mind, so that provision is practically and conceptually inclusive.

Second, congruence. The offer should relate to students' own experiences, and facilitate the move to further study.

Third, intensity. One-off experiences are rarely effective. Sustained and

joined-up support is needed for long-term outcomes.

Finally, reflection. For both participants and providers, it's important to build in opportunities for reflecting on and integrating learning into further study or further iterations of programs.

If these four foundations are put in place, STEM inspiration can better serve students, and through them, society in general.

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