THE SUSTAINABILITY OF STEM EDUCATION PROJECTS

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Abstract

As many STEM education projects rely on short-term funding periods, achieving sustainability can be a challenging aim for project coordinators. Sustainability of a STEM education project can be described as the project's ability to maintain all or some activity once funding has ended. Scientix, the community for science education in Europe, organised the 15th Science Projects Networking Event (SPNE15) in collaboration with Cell EXPLORERS and the National University of Ireland Galway. At this event, 26 experts in STEM education came together to discuss the sustainability of projects and to propose recommendations for best practice. This observatory report outlines the key discussion points raised by the attending experts and identifies six key aspects relating to sustainability and their related challenges: continuation of activities, sustaining impact, community engagement and collaboration, leadership, planning and evaluation, and finances. The paper concludes by proposing concrete actions that coordinators could undertake to maximise the sustainability of their projects.

Keywords: sustainability, projects, STEM, education, barriers, opportunities, planning, leadership

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Introduction

Science, Technology, Engineering and Mathematics (STEM) education projects carry out activities aimed at supporting teaching and learning of STEM subjects. Seen as a whole, their scope and target groups can be broad. These initiatives seek to advance STEM education research, encourage partnerships between different educational stakeholders, offer resources, materials, training and support to different groups, raise awareness of STEM issues and encourage stakeholder involvement, support professional communities, and reward and disseminate good practices or policy change. The aims of STEM education projects usually align with the social, educational and economical issues at different levels, whether they be local, regional, national or international (e.g. European projects).

STEM education projects can target a wide range of participants, which may also be divided along geographical, political or socio-economic lines. Examples of participants and how they can be involved include students who can be targeted through student competitions, workshops, online training, student forums or other types of community-building actions; teachers who can be offered resources, materials and continuous professional development; policy-makers who can be reached at strategic conferences, meetings or high level consultation groups.

STEM education projects can be coordinated by a diverse range of organisation types, including universities, teacher training organisations, non-governmental organisations, private companies or science museums, among others. Projects can also be run according to different operational models, whether they be institution-based or community-led.

Regardless of their target audience, or their operational model, STEM education projects tend to rely on networks of support in order to achieve their aims. Networks may involve other projects or organisations with similar or balancing aims, teacher, parent or researcher communities, teacher organisations, non-governmental organisations or private associations.

Most STEM education projects have a defined lifetime of two to three years. This restriction is often due to the limited period funding. Amongst others, this is one of the contributing factors that threatens the sustainability of STEM education projects. Broadly, the sustainability of a project can refer to extending the activities, impacts or coordinating organisations beyond the funding period.

To discuss issues regarding the sustainability of STEM education projects, Scientix, the community for science education in Europe, organised the 15th Science Projects Networking Event (SPNE15) in collaboration with Cell EXPLORERS and National University of Ireland

Galway. At this event, 26 participants from 18 STEM education projects and organisations came together to discuss what happens to STEM education projects and their results once their funding has ended.

The event took place at the National University of Ireland Galway on the 29th of May 2019, under the topic of 'Sustainability of Projects'. Participants met to discuss what is meant by sustainability in the context of STEM education projects and to offer a set of recommendations for follow-up actions which could help achieve the sustainability of STEM education projects. The present observatory paper draws on their discussions, supported by existing literature to present (1) a discussion of the meaning of sustainability in the context of STEM education projects, (2) the identification of six key aspects of sustainability in the context of STEM education projects and their associated challenges and (3) what actions can be taken by coordinators to enhance these aspects to maximise the sustainability of their projects.

Defining sustainability for STEM education projects

Sustainability refers to the ability of coordinating organisations to continue their projects once funding has ended. Depending on the nature of the project, this continuation could refer to a sustained facilitation of the project, or the further dissemination and or application of the project results.

Attempts at defining sustainability in this context have led researchers to argue that the term needs to be reclaimed, as it "…has increasingly come to mean many things to many different people" (Johnston et.al. 2007, p.60). The meaning of sustainability is different depending on whether you look at the maintenance of the project itself or of the capacity building of communities at the local level. Adding to this complexity, as Harvey and Hurworth (2006) note, the term 'sustainability' has been used alongside a range of related terminology, such as 'institutionalisation' or 'routinisation'.

Continuity is key to sustainability, but sustainability does not necessarily imply that all activities and outputs of projects must be pursued indefinitely. Reflecting on the sustainability of natural systems, Costanza & Patten (1994, p.193) note that systems have a "necessarily finite life span", meaning that, in practical terms, their sustainability cannot be accurately understood without first considering: (1) What exactly should be maintained? (2) For how long? (3) When can it be said that a system has persisted? This finite life span makes sustainability more a matter of "prediction of what will last, and of achieving consensus on what we want to last". Wiley (2007) goes further to point out that regarding the continuity aspect of sustainability, organisations should consider the ability of a project to carry on meeting its goals after the end of the funding period.

It is also important to acknowledge that not all programmes should endure (Glaser 1981). As Glaser (1981, p.167) rightly notes:

> *When a validated, more efficacious, more suitable, or more cost-effective means for meeting a given problem comes to light, the former modus operandi very appropriately may be supplanted. Or the problem the given innovation was designed to address may have changed or disappeared.*

There is a strong case, however, for sustaining projects or programmes which have achieved proven impacts. Commenting on the sustainability of health programmes, Shediac-Rizkallah & Bone (1998) observe that the discontinuation of a programme can be counterproductive when the issue the programme was looking to address continues to persist or would resurface after the end of the programme, or the programme activities are discontinued before achieving full fruition. A history of abruptly or inappropriately ended programmes can also impact communities, who could become resistant in offering support to new initiatives.

Six identified aspects of sustainability

During the SPNE15 event, the 26 participants were invited to make submissions to a word cloud on the key aspects of sustainability of STEM education projects. Their answers, presented in Figure 1, reflect the complexity of the endeavour and the diversity of STEM education programmes represented in the room.

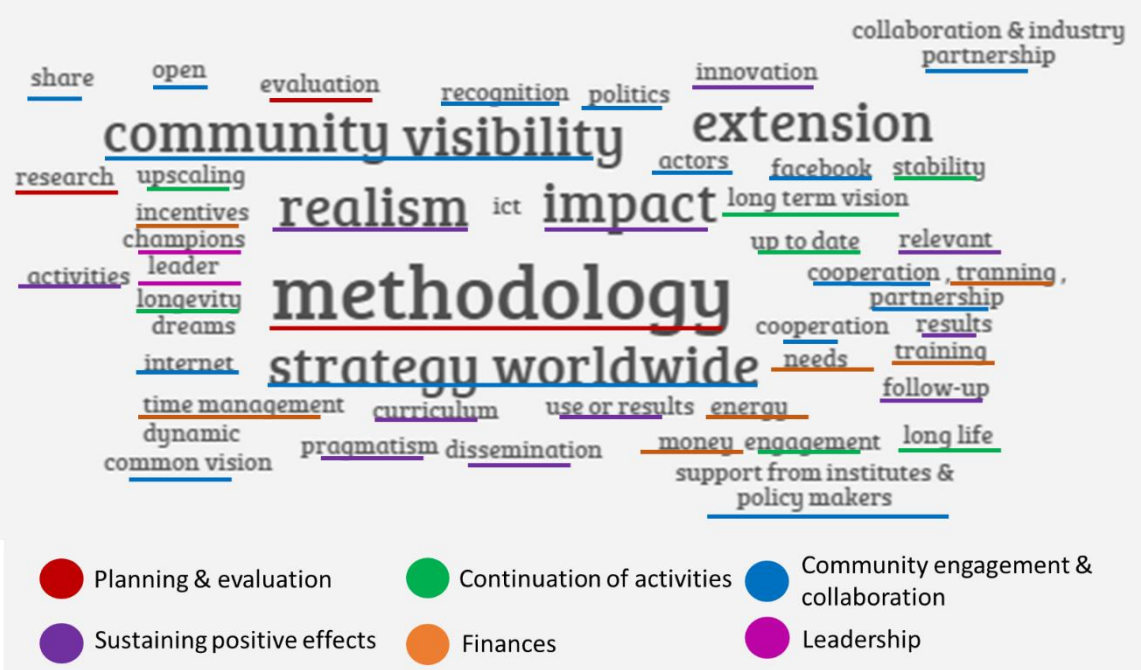

Figure 1: The six aspects of sustainability in a STEM education project. This word cloud was generated from asking the SPNE15 participants 'Which aspects should be considered to define a sustainable STEM education project?'

The terminology used was subsequently grouped through thematic analysis, resulting in six overarching categories:

(a) Continuation of activities e.g. *stability*, *longevity*, *activities*, *engagement*, *extension*,

(b) Sustaining positive effects or impacts e.g. *impact, visibility, (use of) results, open dissemination*

(c) Community engagement and collaboration e.g. *community*, *collaboration and industry partnership, support from institutes and policy makers*

(d) Leadership e.g. l*eader*, *champions*, *long term vision*

(e) Planning and evaluation e.g. *methodology, strategy, evaluation, research*

(f) Finances e.g. *money*, *needs*, *time management*, *energy*

These categories can be separated into project inputs and outputs. Sustained positive effects, continuation of activities and community engagement and collaboration can be considered as the desired outcomes of a STEM education project, whilst leadership, finances and planning & evaluation are the factors that drive the project itself (Figure 2). Each category, along with their associated challenges, is outlined further in the following section.

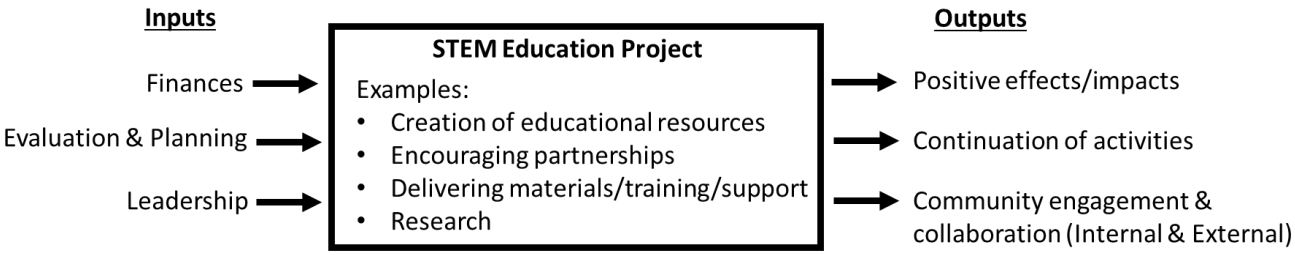

Figure 2:The inputs and desired outputs of a sustainable STEM education project.

(a) Sustainability of activities

Deciding on *what activities should be maintained* after the end of the funding period is part of an evaluation and monitoring process that must be considered throughout the duration of the project. Activities should be evaluated to ascertain whether they are successful in achieving their goals and are available to interested users. This evaluation is dependent on the nature of the project. For example, for a small-scale STEM education research project, the project activity may be a defined piece of research. To sustain this activity, the research should be robust and there should be somebody available to continue the research. Whereas, with the example of the creation of new pedagogical resources for education practitioners, the resources should have been shown to effectively deliver their associated learning outcomes. In this instance, the sustainability of this project's activities would involve the continued use of these resources.

An additional consideration that impacts the sustainability of STEM education project activities is who delivers them. In the case of pedagogical resources for teachers, this does not pose a significant problem once the resources have been disseminated. However, it does for projects that involve a complex facilitation of informal STEM education activities.

Approaches to project coordination can be categorised into three groups: (i) highly centralised where production, review and provision of materials are offered by project staff, (ii) purely self-organising, where activities are carried out by volunteers, and (iii) a hybrid model between the two, where project activities are carried out by volunteer participants, with support from a limited number of key project staff (Wiley 2007). In the self-organising model which relies on volunteer contributions and peer feedback, the cost of producing new resources can be evaluated as low as 0 USD (Wiley 2007). It should be noted, however, that this cost estimation looks only at the human-capital associated cost of the production of resources and does not consider very real operational costs such as those related to purchasing, maintaining or upgrading equipment.

Furthermore, failure to reward volunteers' contributions (whether in the purely self-organising or hybrid model) can lead to their disengagement from the project and compromise its sustainability. Therefore, projects which rely on the participation of volunteers may, at face value, reduce operational costs related to the implementation of activities, but in practice part of these costs are effectively transferred to staff, whose efforts are directed to motivating volunteer participation. Moreover, symbolic rewards (such as public acknowledgement of volunteer efforts like offering participation certificates, or articles in project newsletters) may be sufficient to motivate an additional cohort of volunteers. More significant efforts require more costly rewards such as professional development opportunities, or even small stipends for travel or participation in conference or events. This is particularly relevant for STEM education projects who often rely on the voluntary participation of teachers, who are already facing the pressure of increasing work assignments and more hectic workdays (Skaalvik & Skaalvik 2011).

In the case of self-organising initiatives, community empowerment can be an efficient way of ensuring sustainability. More centralised projects can also ensure that some activities endure through institutionalisation, that is, by including at least part of the project activities in the routine organisational processes of different stakeholders. In the specific case of STEM education projects, institutionalisation happens, for instance, when a teacher training institute uses the educational resources developed by a project in their teacher training programmes or when a school adopts the novel teaching practice as part of their everyday teaching (Hargreaves & Fink 2003). It is important to note that, when institutionalisation implies a

process of organisational change, it can often encounter resistance. It tends to be time-demanding, to require follow-up processes and necessitates a high level of alignment between the project activities and the interests of the stakeholders involved.

(b) Sustainability of project impacts

Certainly, different approaches are required if the intention is to sustain project outputs, services or the project brand, or depending on the scope of the project. Project coordinators should prioritize actions related to ensuring visibility to relevant audiences. Some of the actions required (e.g. publishing results on established online platforms, offering open access to data or participating in relevant networks of exchange), can be implemented early in the project and with relatively little costs. However, overcoming more complex challenges (e.g. maintaining and updating educational content) will be more difficult to achieve without stable financial support. These costs will likely be larger for more ambitious, larger-scale projects, such as those aiming to achieve organisational or policy change, which would require a larger set of activities to persist, particularly if they are 'ahead' of policy and may need to emphasise awareness at the level of multiple stakeholders and policy change (OECD 2000).

Aligning goals and needs to ensure the persistence of benefits

Alignment between the project goals and the needs or constraints of the community is an important aspect in achieving sustainability (Okorley & Nkrumah 2012). If project goals reflect or anticipate the real needs of its key stakeholders, it will be more likely to be eventually integrated into institutions, to continue as a result of voluntary effort of its members, or to benefit from alternative funding streams.

Research highlights the need for programmes to adapt and respond to changes in their environment. Therefore, an initial assessment of the community needs may not be enough to guide the project actions over time, as this does not account for any change in needs or their importance. The initial evaluation should be continued over the duration of the project through a monitoring process, to ensure the activities and changes it proposes remain relevant and that projects are using the appropriate actions to respond to the needs of their communities (Gruen et al. 2008).

Resistance to change

Projects that aim to affect behavioural change face additional challenges in securing their sustainability post funding. Behavioural change is "slowly achieved through education and social change" (Rizkallah and Bone 1998). To maximise long-term behavioural change (for instance, changes in STEM teachers' teaching practices) STEM education projects could

consider securing resources which could be used towards organising follow-up activities and refresher sessions with key stakeholders. These activities could help identify roadblocks in the uptake of novel practices and ensure that key stakeholders remain active in supporting the projects' goals.

(c) Sustained engagement & collaboration with the community

The community of a project means both the internal community directly involved in the project (the project team) and the extended community engaging with project activities or availing of its resources (e.g. schools, teachers, industry, community groups or other indirect contributors).

Sustainability of the external community engaging in the project

Community engagement is a complex and resource-demanding endeavour. Concerning the communication with the external community, the project's audience should be clearly identified to maximise the opportunities for dissemination and outreach. On-site events such as conferences or workshops provide important opportunities for community engagement.

Community engagement is also important in ensuring that the resources produced within projects are benefitting their intended audiences. Best practice has shown that this is achieved by listening to the associated stakeholders and evaluating their needs. Similarly, a good reflexive practice is also advised to collect feedback from the communities throughout the project. This will allow project staff to continuously adapt their relationship with their identified community and keep them engaged with the project.

One possible answer to ensuring the continuity of the community is for initiatives to allocate time and resources to build the capacity of local stakeholders, with the view that the project goals will be continued at the local level. Indeed, for many researchers, the concepts of sustainability and community capacity building are interlinked (Hacker et al. 2012, Hawe 1997). Some argue that sustainability is achieved when project coordinators have managed to "work themselves out of a job" (Hacker et al 2012), as the programme beneficiaries eventually take over the programme's key activities and the coordinating institution moves on to different priorities. Thorough assessment and monitoring of community needs, as well as an understanding of the community structures and of how to encourage the participation of different target audiences, are required in order to ensure that the changes permeate to the level of stakeholders (Merzel & D'Afflitti 2003).

In addition to the above, the 'external championship of community leaders" has been identified as a driving factor which affects the sustainability of the engaged community. Influential

stakeholders, such as school principals, can affect the support that STEM education projects receive. Projects which are championed by external authorities such as academic institutions have a greater chance of gaining public support and of raising awareness that the project "…provides services that are a critical solution to the problem" (Stevens & Peikes 2006, p.153).

Sustainability of the internal community driving the project (project team)

In terms of internal community (project team), the project coordination can be completely controlled by staff (highly centralised), facilitated solely by volunteers and the engaged community (purely self-organising) or a hybrid of the two where activities are delivered by volunteers which are supported by staff.

During the SPNE15 meeting, three barriers were identified which could generate a negative impact on the project team: (i) miscommunication (ii) unclear team structure and (iii) inefficient task delegation. To minimise conflict, project members should be able to communicate with each other. All communications should be clear and precise and engaged with in a timely manner. The project team should have a shared, known vision and project expectations should be explicit. In addition, project members should be able to know who to approach for help or guidance in different aspects of their roles. For this, the management structure of the project team should be established at the beginning of the project. Leading on from this, task delegation should be distributed equally amongst members, once expertise and capability has been accounted for. This task distribution within the team will create more engagement and ownership among the project members.

It was pointed out by some STEM education project coordinators that projects hosted by larger organisations or institutions (e.g. a university hosting an outreach programme or a school hosting a teacher-training workshop) face additional obstacles to the sustainability of their internal community (project team). For such projects, receiving recognition from the hosting organisation that the project is valued is key to maintaining the drive and motivation of the project staff. If project staff do not feel valued by their host organisation, they may be less motivated to seek out ways to continue aspects of the project once funding ends. A host organisation that recognises the value of a project may be more inclined to provide support; e.g. additional financial support, space, materials, resources, administration or staff time. To maximise recognition from hosting organisations, project coordinators should demonstrate tangible ways in which these organisations benefit from the project. However, the process of programme 'institutionalisation' is often political, dependent upon the ability of internal leaders to generate goodwill at the level of the organisation (Shediac-Rizkallah & Bone 1998).

(d) The role of leadership

Combined with community and organisation, leadership forms an important triad that underpins the sustainability of projects (Rugman et al. 2006). The leadership sustainability of a project refers to the necessity of having a project with a strong vision and a capable leader that embodies the project and engages the community surrounding it. Previous analyses on the sustainability of sponsored programmes highlight the important role played by leadership in ensuring the continuation of programmes (Hargreaves & Fink 2003, Okorley & Nkrumah 2012).

Unfortunately, finding effective leadership can prove to be challenging. There is a balance between having too few or too many leaders in a project. If the succession of a project leader has not been planned, the risk of knowledge loss is greatly raised in the event of those leaders leaving the project. Efficient knowledge transfer is often correlated with the idea of sustainability (Hacker et.al. 2012). Conversely, too many leaders can hinder the efficiency of project management, which is another indication of the importance of a clear internal structure.

In their cross-disciplinary review, Greenhalgh et al. (2004) note the important role played by 'organisational champions' in the adoption of an innovation by individuals in an organisation, but also the difficulties in understanding how to identify and systematically harness the energy of organisational champions.

(e) Planning and evaluation for sustainability

To avoid repetition, this section only discusses aspects of planning and evaluation which have not yet been mentioned. Planning, evaluation and revision of what should be sustained after the funding period, as well as a thorough assessment of how sustainability goals can be achieved, are important in ensuring that programme outcomes do not disappear after the discontinuation of funding. Planning refers to "formulating sustainability goals and objectives, as well as implementing strategies specifically designed to foster sustainability" (Shediac-Rizkallah & Bone 1998, p. 91). Through evaluation, the planned objectives and strategies are monitored and revised as the project unfolds.

Sridharan & Nakaima (2010) highlight the role played by evaluation and programme planning in informing projects on how to adapt and respond to changes in their environments (Sridharan & Nakaima, 2010). Moreover, George-Jackson & Rincon (2012) argue that evaluation results are used to make improvements to programmes, but also to gain legitimacy with stakeholders, which in turn increases the human and financial resources available to STEM intervention programmes.

However, while evaluation instruments are often embedded in education projects, their most common use is for providing evidence to funders that the project or programme is unfolding as agreed. A specific challenge for projects is to redesign evaluation instruments for monitoring sustainability goals and processes, rather than short term impacts and outcomes (Hashimoto et.al. 2010).

(f) Finances

The resources of a project can include financial resources, human resources and material equipment (European Commission 2006). Among these, financing is probably the most prominent factor in a project's sustainability (Shediac-Rizkallah & Bone 1998), as ensuring that project activities, goals, or the engagement of the community usually require real human resources and operational costs. However, it is important to bear in mind that not all outputs of the project may need to be actively financed to be maintained past the funding period.

The continuation of projects is dependent on whether funders or funding are available in the community environment of the programme (Scheirer & Dearing 2011), as well as on the ability of programme coordinators to identify and appropriately engage with alternative funders, over the programme's lifetime. Indeed, Gruen et al. (2008) highlight the impact of context-level factors on the mobilisation of resources; donor funds can be influenced by changes in the economy or by political factors, such as changes in priorities. To ensure stability, programmes are advised to carefully plan and monitor these changes in order to be prepared in eventual cutbacks in funding. Gruen et al. (2008) also point to the bidirectional relationship between the priorities of stakeholders and the programme activities, suggesting that programmes can affect the mobilisation of resources through the demonstration of positive results.

Projects should pro-actively look to diversify their sources of funding in order to gain financial stability and resilience. One way of achieving this is by engaging an expanded network of stakeholders who benefit from the project activities and who could support the project. For STEM education projects relying on governmental funding, for example, this expansion may translate into engaging with private industries who may benefit from improved STEM education by having access to a STEM-skilled workforce. Similarly, national programmes may look to form partnerships with similar international initiatives in order to enlarge their stakeholders base. New technologies can also open alternative sources of funding who can complement more generous and stable subsidies. An example is crowdfunding, which is essentially "a form of microfinancing which mobilises individuals from some large community, the 'crowd', to give away small amounts of money to other persons' ventures and initiatives they find attractive" (Hemer 2011, p.16).

Shediac-Rizkallah & Bone (1998) note that a common strategy for financial sustainability in health programmes following the withdrawal of external sources was an increase in client fees, which in most cases led to the reduction of the number of clients and a change in their profile (with poorer clients significantly reduced). It is likely that STEM education projects would see a similar effect with respect to the engagement of vulnerable groups, which raises important ethical concerns, particularly regarding the equity of resource distribution in schools (Hunter 2007). Alternatively, projects may investigate adopting blended models, whereby the commercialisation of part of their services can help sustain and allow free access to educational resources and materials for all.

Action points to maximise project sustainability

The following section outlines practical recommendations for STEM education project coordinators aiming to achieve some aspect of sustainability.

(a) Sustained activities

- Conduct a thorough assessment of what should be sustained, for how long, and who should deliver the activities past the end of project funding.
- Outline the project goals clearly. Project goals should serve the needs of the target communities.
- Identify how the activities can continue to be delivered beyond the project funding term. Possible solutions are:
    - Activities are delivered by existing team. For this, further funding needs to be obtained (see action points under Finances).
    - Activities are delivered by other practitioners. Consider disseminating the activities to others to be used independent of the project team. For pedagogical resources, consider uploading them onto Scientix's repository (http://www.scientix.eu/resources)
    - Activities are delivered by volunteers. Consider training volunteers to deliver the activities. Rewarding and recognizing the volunteer contribution is key to this (practical advice on running such programmes can be found at https://www.volunteer.ie/resources/factsheets-and-guides/).

(b) Sustained impacts

- Allocate sufficient time and resources to aspects related to sustainability to ensure that the initial investment in initiatives continues to yield benefits for target groups past the exhaustion of initial funding.
- Identify the positive impacts of the programme you would like to see sustained (e.g. findings of research, pedagogical tools, organisational model).

- Present the findings of the project evaluation at a conference, network meeting or teacher Continuous Professional Development (CPD) course. Grey-literature alternatives include blogs or newsletters to stakeholders.
- Deliver CPD to other practitioners to further disseminate your resources and expertise.
- Share your educational tools by uploading them onto an open access resource.
- Release your educational resources under Creative Commons licenses, allowing derivatives to increase reuse. In this way, even if the original authors can no longer maintain the project products, they can be taken forward by others, enhanced and used and reused for as long as they remain relevant to education.

(c) Sustained community

- Avoid conflict within your project team and its community by establishing a clear communication structure, defining roles, actions and task distribution.
- Clearly identify your target audience/community.
- Evaluate the interests of your target audience/community at the beginning and throughout the project. Maintain a reflexive practice to ensure that you remain engaged with your target audience (see evaluation & planning).

(d) Leadership

- Encourage and support leadership within your organisation, as well as in the wider community, to secure the continuation of your programme.
- Plan for leadership succession and the training of personnel to ensure that there is no knowledge loss if a leader leaves a project (Okorley & Nkrumah 2012).
- Organise train-the-trainer workshops so that those trained can continue to provide programme benefits and train others to do so. Programmes with training components are more likely to endure than those without (Shediac-Rizkallah & Bone 1998).
- Consider “distributed leadership”, to allow innovation to stem from across the coordination team by creating a “culture of initiative and opportunity, where [project managers] of all kinds propose new directions and start innovations” (Hargreaves and Fink, 2003).

(e) Evaluation & Planning

- Include a realistic evaluation methodology in the initial project proposal (see practical guide on evaluation here: https://www.ukri.org/files/legacy/publications/evaluationguide-pdf/). Any associated costs (e.g. design of evaluation tools, data analysis) should be included in the budget, in particular if the evaluation plan is ambitious.

- Evaluate the needs of all stakeholders at the beginning and the end of a project to see whether the project should be adapted accordingly. It will also allow you to measure your impact more accurately.
- Be critical in your evaluation and consider the needs of the project, the funders and the engaged community.
- Embed evaluation and monitoring activities specifically designed to measure aspects related to the sustainability of STEM programmes and not just the short-term impacts of the project.
- Consider using the same evaluation tools used by similar STEM education projects to allow for ease of comparison of results.
- Use evaluation results to inform future project planning.

(f) Finances

- Identify any further grants that could sustain specific aspects of the project e.g. a small grant to help disseminate research findings at a conference.
- Diversify the project donor base by engaging with an extended pool of stakeholders and ensure that their benefits are appropriately communicated to target groups.
- Look for alternative sources of funding, such as crowd funding, or the commercialisation of project results and services.
- Split the task of looking for funding support between the different actors involved in the project. This may be easier to obtain than a large grant to fund the project as a whole.
- Seek industry/private company support.
- Combine with existing, similar (or complementary) initiatives.
- Integrate the project into the functioning of an existing institution, which can absorb the project maintenance costs; e.g. integrating a volunteering project into a curricular module at a university.
- Delegate tasks to trained volunteers, which can be a cost-effective method of sustaining activities.

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