



An evaluation framework for STEAM processes

A methodology to assess the effect and effectiveness of STEAM activities developed by the STEAM INC project

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Contents

Introduction

Development of the STEAM evaluation framework

The elements of a STEAM process

The evaluation competencies

The evaluation framework for STEAM processes

Collaboration

Communication

Exploration

Critical thinking

Civic and social skills

Sustainability

Metacognition

Wellbeing

Appendix I - the STEAM INC project

Appendix II - planning an evaluation, the tradititonal approach

References

Bibliography

01

02

02

03

04

05

06

07

08

09

10

11

12

13

15

17

17

Introduction

Welcome to the evaluation framework for STEAM processes, the third output of the STEAM INC (STEAM Innovation and Curriculum) project funded by Erasmus+. The framework has been underpinned by the reflective outlook and attitude adopted by the project partnership throughout its work. By constantly questioning methods and findings as well as considering how they may be improved for future practitioners within and beyond Higher Education, a framework has evolved that addresses the distinctive elements of a STEAM approach.

The framework builds on two previous phases: the collection of STEAM approaches across the project partnership, published as the [STEAM Approaches Handbook](#), followed by the production of new and improved [STEAM methods](#).

More details about the STEAM INC project are included in Appendix I and the project website www.steaminnovation.org

Figure 1 - the STEAM INC partnership





Development of the STEAM evaluation framework

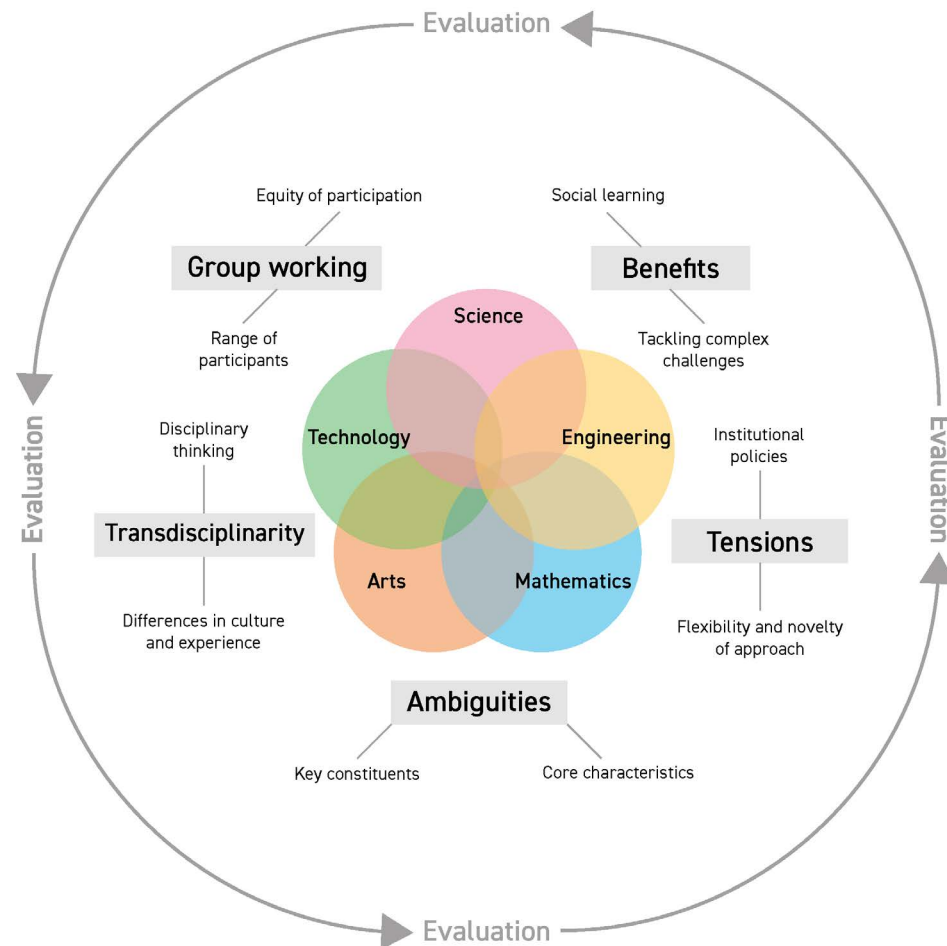
The elements of a STEAM process

STEAM (the integration of Science, Technology, Engineering and Mathematics practices with those from the Arts) is increasingly regarded as a mechanism to tackle challenges by adopting a transdisciplinary approach that embraces creative awareness. Its focus on collaboration and group working allows individuals to learn socially as well as broadening their perspectives and knowledge.

STEAM fosters group activity to engage the different disciplines and ensure that all can contribute. Processes can vary widely in length and structure. For example, it could consist of a two-hour or two-day workshop; a long-term project; a course module or a full educational programme. These may be credit or non-credit bearing, ie, formal (being assessed) or informal (being formative). Further, a broad array of participants may be involved, for example: students, academics, researchers, administrators, external partners, industry and communities. Groups may be all from one type, ie, all students, or from a mix that includes, for example, academics, students and industry practitioners.

Figure 2 shows the key aspects of a STEAM process, which are covered in more detail in Appendix I.

Figure 2 - the STEAM process





The evaluation competencies

The above (figure 2) demonstrates the many considerations that a STEAM process involves. As such, covering all aspects adds to the difficulty of evaluating a STEAM activity. Also, there is no commonly agreed methodology for appraising STEAM processes or transdisciplinary endeavours generally. Discussion in the project partnership, based on these considerations, led to the creation of a set of competencies that should be realised as part of a STEAM process.

The partnership's deliberations have been supplemented by a survey of people outside of the project team, interviews of team members and investigation of the evaluation methods used by partners during their own STEAM approaches. Additionally, academic papers resulting from the project (Carter et al, 2021; Durall et al, 2022) and previous work on embedding evaluation (eg, Selman et al, 2010) have provided inspiration and focus on considering evaluation upfront and at all stages to benefit a STEAM process from the start. Throughout, considering the measurability of a competency has also been a priority.

The eight competencies arising from this process and forming the basis of the STEAM INC framework are:

- **Collaboration** – the ability to work with others from different backgrounds, values and beliefs, disciplinary and/or cultural
- **Communication** – the ability to interact and share knowledge and views effectively, verbally, visually and through the written word
- **Exploration** – the process of investigating and examining a problem or issue

- **Critical thinking** – the analysis and assessment of information in a questioning way
- **Civic and social skills** – the consideration of the influences on and by a STEAM process, including stakeholders as well as the political, social and environmental contexts
- **Sustainability** – an equitable consideration of the outputs of the STEAM process with respect to their economic, social and environmental impacts
- **Metacognition** – the level of contemplation about one's own learning and thinking
- **Wellbeing** – the level of emotional and physical positivity resulting from participation in a STEAM process

The uniqueness of the evaluation framework lies in these competencies. All were judged to be integral in STEAM activities by the project partnership. It is important to note that, although this work is primarily geared towards a Higher Education context, it is an evaluation framework to measure the effect of a STEAM process on its participants. It is not a method of assessing coursework. While the framework may inform an assessment, an individual institution's policies and practices should be considered in developing marking criteria or similar.



The evaluation framework for STEAM processes

In the following, each competency is expanded in terms of traits and indicators for those traits. These are followed by a set of suggested questions and prompts for reflection.

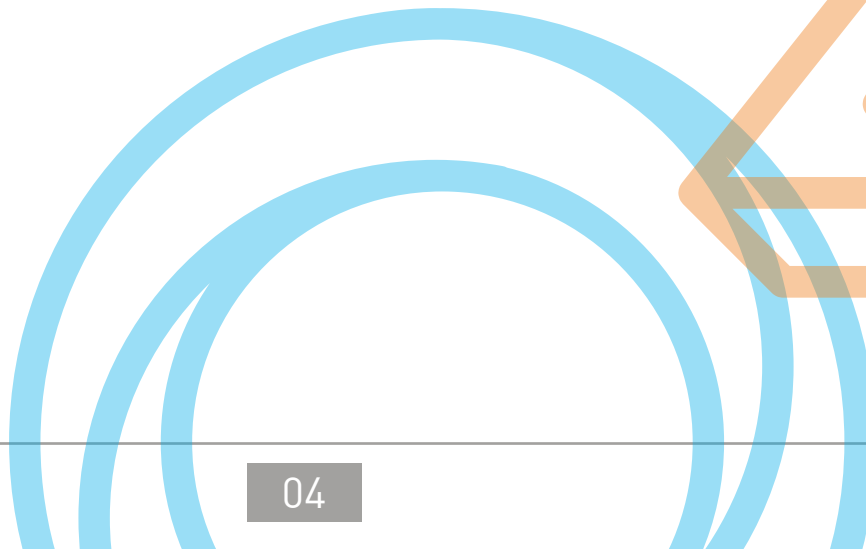
It is intended that the framework can be used by anyone involved in the STEAM process, from academics to those working with industry or other community partners to students and other participants. As such, it can be used by students as a basis of self-assessment. However, to reiterate the above, it is not intended that using this framework should necessarily or can adequately replace existing formal assessments of educational courses.

In contrast to more traditional project evaluation procedures (see Appendix II), the STEAM INC framework is intended to be flexible and fluid in line with the complexity and range of objectives of STEAM processes. Not all competencies will be developed. Nor is it necessary to ask every question. Exactly what will be covered is best decided by the project team (whatever its complexion) possibly with guidance from a STEAM

practitioner as appropriate. Also, based on its experience of STEAM processes, the STEAM INC team advises embedding evaluation throughout a STEAM process. This enables learning to be tracked and recommendations to be implemented during the process, not just at the end.

Therefore, it is very important evaluation is not seen to be an afterthought or useful add-on at the end of the process. It should be an embedded and cyclical process of critical reflection and learning leading to adaptations or adjustments at any stage of the process.

Please note that questions are written in the past tense. They can be adjusted to be expressed in the future tense (to establish the baseline competencies of participants) or present tense (to aid regular evaluation) as appropriate.





Collaboration

Definition – the ability to work with others from different backgrounds, values and beliefs, disciplinary and/or cultural.

Characteristic traits and indicators - Effective collaboration depends on the group establishing trust and respect for each other. This requires an understanding of the different knowledge and perspectives of members as well as a shared vision of the project focus and/or outcomes. Where appropriate, participants establish roles and responsibilities, but these should be flexible and may be adjusted as the project progresses. All participants should be allowed

to express their ideas, thoughts and opinions without prejudice. To maintain a healthy working relationship, participants will resolve conflicts within the group, through acknowledging differences rather than forcing agreement. Finally, participants inspire and are inspired by peers as well as making compromises when appropriate.

Prompts for reflection:

- What did the group do / what could the group do to:
 - build trust among members?
 - increase equitable participation for all members?
 - resolve conflict within the group?

- Was the outcome of the process better due to group collaboration? If so, in what way(s)? If not, why not?
- What have been the main benefits and drawbacks of collaboration in your group?
- What have you learnt about collaboration during the process?



How much do you agree with each of the following statements?

- I was aware of the knowledge and perspectives of other members in the group.
- Group member roles were clear.
- The group resolved conflicts.
- I was inspired by members of the group.
- I feel that I inspired members of the group.
- I trusted the group.
- The group established trust among members.
- Diversity, equity and inclusivity were central to group working.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Communication

Definition – the ability to interact and share knowledge and views effectively, verbally, visually and through the written word.

Characteristic traits and indicators - Participants expressing their own views and listening to those of others are key to productive communication. All participants should engage in the group’s discussions. This may necessitate adopting a shared language, by modifying a discipline’s terminology so that it is understood by a wider audience. Participants will also need to recognise and acknowledge the various social, historical and cultural perspectives represented in the

group. Methods of communication may be varied, such as visual, verbal and written, but all should be clear.

Prompts for reflection:

- What did the group do (or what could the group do) to increase:
 - the representation of audience/group members?
 - the inclusivity of participants?
 - respect for all?
- How well did the group communicate with one another? What do you feel allows for good communication?

- What barriers did you encounter when it came to communication? How did you try to overcome these barriers? Did they work? Why do you think they did or did not (as appropriate)?
- What have you learnt about communication from taking part in a STEAM process?



How much do you agree with each of the following statements?

- I engaged in group dialogue.
- All members engaged in group dialogue.
- I listened to the ideas of others in the group.
- I acknowledged the ideas of others in the group.
- I was able to express my own thoughts and ideas to the group.
- I adapted my language/communication style to interact with the group.
- Others adapted their language/communication style to interact with the group.
- Everyone had an equitable platform to communicate with the group.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Exploration

Definition – the process of investigating and examining a problem or issue.

Characteristic traits and indicators - Exploration requires participants to be open-minded and flexible. Ideally, groups will generate multiple ideas, using investigative techniques such as divergent thinking. Groups should be experimental and adventurous, trying new things and not being afraid to fail. Processes tend to be iterative with outcomes from one stage tested with those of the previous ones or the original aims.

Prompts for reflection:

- What did the group do (or what could the group do) to increase:
 - the number of ideas?
 - group flexibility?
 - the number of methods used in the STEAM process?
- Thinking about the methods used during the STEAM process, which methods worked well and why? (For example, encouraging group cohesion, trust, innovation or equity.)

- How did the project progress, particularly in terms of milestones? Did you make any changes? If yes, what were the main influences on these changes?
- Did the group operate in an iterative fashion, checking outcomes of one stage with preceding one(s) and/or objectives and adapting accordingly? If yes, what were the advantages and disadvantages of an iterative approach? If no, why do you think this is the case?



How much do you agree with each of the following statements?

- The group tried a variety of methods during the STEAM process.
- The group developed multiple ideas/solutions.
- The group was open to new ideas and suggestions.
- The group adopted a flexible approach.
- The group created several versions of its solution to the issue.





Critical thinking

Definition – the analysis and assessment of information in a questioning way.

Characteristic traits and indicators - Critical thinking is a crucial element of any STEAM process. Through describing and defining the issue under investigation (what? when? who? where?), undertaking a thorough analysis (why? how?), followed by evaluation (what if? so what? what next?), participants will test the credibility of the evidence, filter information and derive findings and conclusions that reflect on the implications of the evidence. Indicators, such as, convergent thinking, finding and cross-checking perspectives and thinking through their significance, all contribute to effective critical thinking.

Prompts for reflection:

- What did the group do / what could the group do to:
 - increase the validity of the evidence and range of sources used in the STEAM process?
 - improve decision making in the group?
 - make the solution more novel?
- How well do you think your group defined the issue? Give examples of the evidence used, how it was found and the group’s response to the what? when? who? where?
- How well do you think your group analysed the evidence? Give examples of the analysis and the group’s response to the why? how?

- How well do you think your group evaluated the analysis and drew conclusions? Give examples of the evaluation of your deliberations and response to the what if? so what? what next?
- What have you learnt about critical thinking from taking part in a STEAM process?



How much do you agree with each of the following statements?

- The group found valid evidence to support its discussions.
- The group defined the issue to be addressed.
- The group identified evidence from several data sources.
- The group considered multiple perspectives when deliberating the issue.
- The group discussed approaches from different disciplines.
- The group analysis was comprehensive.
- The group evaluation was credible.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Civic and social skills

Definition – the consideration of the influences on and by a STEAM process, including stakeholders as well as the political, social and environmental contexts.

Characteristic traits and indicators - STEAM processes contribute to civic and social skills through increasing social awareness and understanding of relevant stakeholders. Indicators include consideration of the project’s wider effects on policy, climate, society and the economy (local, national or global as applicable). This is supplemented by reflections of the impact on the wider society, local to global, and the long-term impacts, such as future generations. In terms of stakeholders, typical indicators include gaining knowledge of community aspects, such as, needs and wants, perspectives, history, resources and activities. Also important is understanding

the stakeholders who will (or will not) benefit from the project.

Prompts for reflection:

- What did the group do / what could the group do to:
 - improve the group’s knowledge of stakeholders?
 - increase understanding of the global relevance of the STEAM process?
 - make the process outcomes more beneficial to stakeholders?
- What do you think the opinions and perspectives of stakeholders might be regarding the interim and final outcomes of your STEAM process?
- Did anything about the stakeholders surprise you? If so what and why?

- What are the drawbacks and disadvantages of including stakeholders in the STEAM process? How might you improve communication with stakeholders in your next project?
- Did you (or your group) feel that your thinking was limited by external factors that restricted how valuable your solution might be to the community and stakeholders? Provide examples.
- What have you learnt about civic and social skills from taking part in a STEAM process?



How much do you agree with each of the following statements?

- I developed a better understanding of the needs of stakeholders and the local community.
- The group identified community stakeholders who may benefit from this project.
- The group identified community stakeholders who may not benefit from/be disadvantaged by the project.
- The group gained knowledge about the stakeholders and community’s history.
- The group gained knowledge about the resources available in the stakeholders and community.
- I developed an understanding of the global relevance of our project.
- The group considered the possible impacts of the project outcomes on future generations.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Sustainability

Definition – an equitable consideration of the outputs of the STEAM process with respect to their economic, social and environmental impacts.

Characteristic traits and indicators - Addressing the sustainability pillars (economic, social and environmental) in an equitable way is a fundamental aspect of any STEAM process, whatever the issue being tackled. There should be a focus on meeting the needs of the present without compromising the ability of future generations to meet their needs. Therefore, principal indicators are the ability to assess environmental, social and economic impacts, as well as the longer-term

aspects including the potential for the process outcomes, such as transferability or implementation.

Prompts for reflection:

- What did the group do / what could the group do to:
 - improve the group’s approach to sustainability?
 - decrease the negative impacts of the STEAM process on future generations and/or increase their equity?
 - make the process outcomes more transferable or likely to be implemented?
- Did the various disciplines have different approaches to tackling the sustainability pillars and/or the equity

of solutions? If yes, what were they?
What did you learn from the other approaches?

- Did you (or your group) feel that your thinking was limited by external factors that restricted how valuable your solution might be in its sustainable aspects? Provide examples.
- What have you learnt about sustainability from taking part in a STEAM process?



How much do you agree with each of the following statements?

- Sustainability issues were central to the group’s deliberations throughout the process.
- The group envisaged the project’s wider effects on global society.
- The group considered the effect of its project on environmental issues.
- The group considered the effect of its project on economic issues.
- The group considered the effect of its project on social issues.
- The group deliberated the equity of the project’s process and outcomes.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Metacognition

Definition – the level of contemplation about one’s own learning and thinking.

Characteristic traits and indicators - Metacognition traits arising during STEAM processes include participants reflecting on their own learning and thinking as well as that of the group as a whole. This will embrace recognising and learning from mistakes as well as identifying different learning and thinking styles. There may be evidence of participants reconstructing acquired knowledge, incorporating their reflections into ensuing activities and observing changes where appropriate. Participants will identify how their knowledge and experience applies in other disciplines and how they can

use learning gained in the STEAM process in current and future work, ie, ascertain transferable skills.

Prompts for reflection:

- What did the group do / what could the group do to:
 - improve reflective processes (individual and as a group)?
 - learn from mistakes or pursuing flawed ideas?
 - make the solution more novel?
- What did you think about your own thinking and learning throughout the STEAM process? Did your thoughts shift over time? If yes, in what way?
- Did you detect differences in the thinking and

learning styles of people from other disciplines in your group? If yes, what were they? What did you learn from the other approaches? Provide examples of different styles and your reaction to them.

- What did you learn about your existing skills that can be used in different disciplines? How will you use this in the future?
- What have you learnt about your way of thinking from taking part in a STEAM process?



How much do you agree with each of the following statements?

- The group learned more about itself through reflection.
- The group learned more about the project through reflection.
- The group learnt from its mistakes.
- The group was not afraid to fail.
- I regularly reflected on my thinking and learning during the process.
- The group regularly reflected on its thinking and learning during the process.
- As a result of the process, I can use my skills/knowledge/experience in another discipline.
- I will use the learning I gained in this project in future work.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Wellbeing

Definition – the level of emotional and physical positivity resulting from participation in a STEAM process.

Characteristic traits and indicators - Significant aspects of wellbeing in relation to STEAM include the level of enjoyment, confidence and comfort participants feel during the process. Further, participants should be mindful of their contributions to the group, as well as acknowledging their own strengths and shortcomings and those of the group. In line with metacognition, participants may find the process of learning illuminating and feel motivated, curious and excited during the activity.

Prompts for reflection:

- What did the group do / what could the group do to:
 - help every member to feel comfortable during the process?
 - increase motivation of the group?
 - make it easier for members to contribute?
- Did you find the STEAM process beneficial from a wellbeing perspective? If yes, in what way(s)? If not, what would you like to be different next time? What would you do differently next time?
- Did you feel confident and comfortable during the process? Do you think the rest of your group felt the same? Think through any differences – why did they occur? What have you learnt?

- What are your strengths and weaknesses with respect to wellbeing? What were the strengths and weakness of the group with respect to wellbeing? Are there examples when members tried to help others to feel better? What are they and were they effective?
- What have you learnt about your own wellbeing and that of the group from taking part in a STEAM process?



How much do you agree with each of the following statements?

- I felt confident during the process.
- I felt comfortable during the process.
- The group acknowledged its strengths and shortcomings.
- Overall, the group enjoyed the process.
- I feel better about myself because of the process.

Not applicable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
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Appendix I – the STEAM INC project

From October 2019 to January 2023, the STEAM INC team investigated STEAM approaches and methods in various European institutions, primarily Higher Education. As such, it is the first comprehensive attempt to collect and codify approaches to STEAM in Higher Education. The project had three phases as follows:

Phase 1 – defining STEAM characteristics and producing a handbook of STEAM approaches which collates and codifies Higher Education STEAM approaches as well as guidance and inspiration for those looking to develop and introduce STEAM approaches in their institution – the handbook (see Burns et al (2021)) is available at [STEAM Approaches Handbook](#).

Phase 2 – the development of new STEAM methods, through the deconstruction and rebuilding of existing methods, new STEAM tools have been produced and existing methods have been improved. The initial methods are available on the project website at [STEAM Methods](#).

Phase 3 – the creation of an evaluation framework for STEAM processes, approaches and methods.

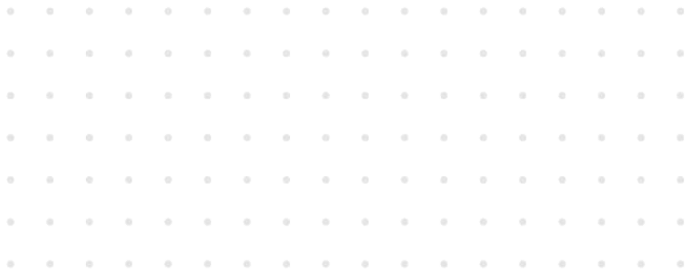
The latter aims to:

- facilitate student reflection on STEAM competencies
- encourage educator reflection on curriculum design and assessment methods based on a STEAM approach
- evaluate the benefits of existing STEAM activities to shape future projects
- foster partner reflection on the benefits of engaging with Higher Education institutions through STEAM methodologies or projects

Throughout, the project partnership has viewed STEAM in Higher Education as including attention to the customary teaching and curriculum, academic research, the internal Higher Education policies and governance

as well as external engagement with stakeholders and the public. These often become mutually supportive. For example, a university that embraces STEAM is likely to embed the concept in its curriculum, support STEAM research and innovation and adjust its policies and facilities accordingly.

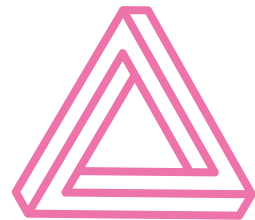
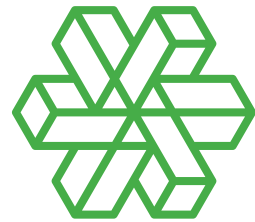
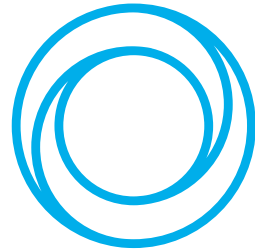
For the project partnership, arts encompasses artistic, cultural and creative practices, including design and the range of disciplines collectively referred to as humanities. Similarly, the sciences include not only the traditional natural sciences but also more contemporary ones such as the social and environmental sciences. Further, by encouraging critical thinking and intellectual curiosity, STEAM processes open routes to innovation. Issues tackled may be highly complicated problems that do not have obvious solutions due to their dynamic requirements, contradictory arguments and social complexity.



From the beginning, the STEAM INC partnership recognised that without an agreed working definition of a STEAM approach there would be little forward momentum. The box shows the agreed STEAM INC principles. For more details see Burns et al (2021).

The nature of the inter and transdisciplinary working, characteristic of STEAM processes, challenges existing organisational structures and institutions. It requires greater flexibility in operational structures and processes as well as respectful and enabling attitudes in participants. Change and challenges range beyond educational establishments. New connections and collaborations are forged across academia as well as with external organisations such as industry, business, government and society at community and individual level. For more discussion see Carter et al (2021) and Durall et al (2022).

For more information about STEAM INC see the project website www.steaminnovation.org.



The principles of a STEAM approach involves:

- a culture (or cultures) that puts the Arts and Sciences on an equal footing;
- a paradigm that is **process-driven**, student-centred, holistic and provides permission to fail alongside being comfortable with uncertain end-results;
- a pre-requisite of being **collaborative**, diverse and delivered through safe spaces;
- establishing a mindset of **radical openness**, flexibility, reflection, experimentation and curiosity;
- generating qualities that **promote learning**;
- supporting practices that are transdisciplinary and emphasise **prototyping and making** while considering modes of assessment;
- developing competencies of **critical thinking**, creativity and communication whilst investigating how these can be applied to generate solutions.

Appendix II – planning an evaluation, the traditional approach

Planning an evaluation can be considered to comprise five stages, which may be repeated or amended throughout a STEAM process based on learning arising from reflection and evaluation: The five stages are:

1. Determining purpose and scope
2. Choosing data collection methods and evaluation questions
3. Considering data analysis
4. Scheduling the evaluation
5. Presenting and learning from findings (and formulating new action points)

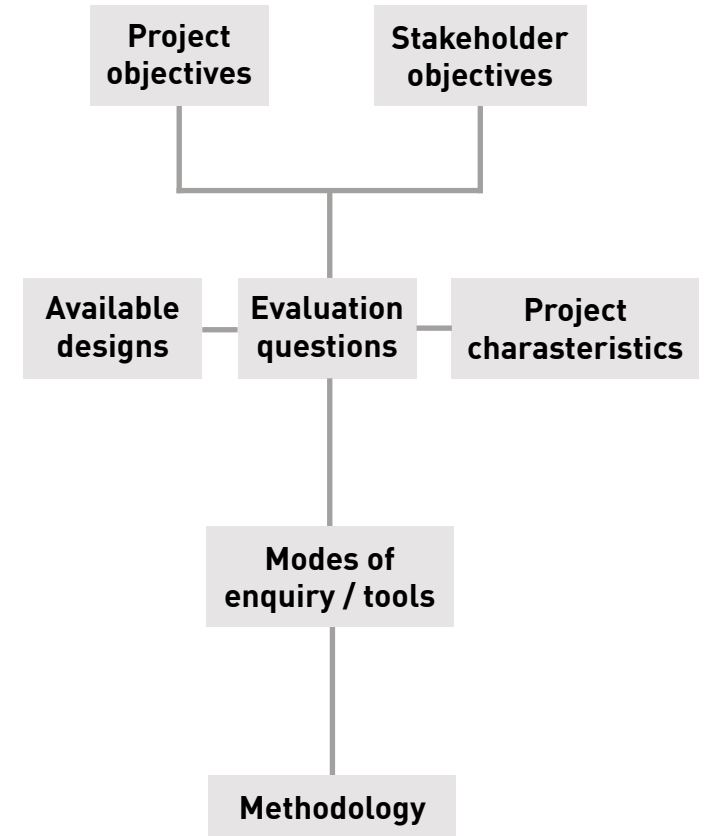
Purpose and scope

This stage includes consideration of what the evaluation is to be used for. For example, is it to build future improvements or is it to determine the effects of a process on its participants? Scope considerations could include how many people to include both within and outside of the project under investigation, eg, is it just project participants or does it include stakeholders? Defining the purpose and scope at the start of the project provides clarity to participants as well as other interested parties.

This stage should also include a definition of the audience for the evaluation as well as an understanding

of who will conduct the work. For example, in a student project, an evaluation may be a self-assessment where the participants choose what they will measure and how. Consideration of the following may be helpful at this stage.

- Project objectives: What are the main objectives of the project? These may be decided by a project team or taken from a brief at the beginning of the project.
- Stakeholder objectives: What are the needs and objectives of stakeholders? Stakeholders can be those that influence the project or those that are affected by the project.
- Project characteristics: What are the interesting elements of the project that are important to capture and assess?
- Evaluation questions: What are the questions to be answered?
- Available designs: What are the limiting factors that may hinder answering the questions, eg, time, resources, participant numbers?
- Modes of enquiry: What type of information will come from the completion of the evaluation?
- Methodologies: What methodologies will be used to capture the data?
- How will the data be analysed?





Data collection methods

As with any research or evaluation the data collection methods are primarily interviews, questionnaires (surveys) and observations. The following considers the pros and cons of each:

Interviews: can result in a large amount of data which explores the respondents' views and thoughts. For consistency, interviews should be based on the same set of questions for each respondent. Interviews can result in a lot of data that needs to be coded, based on the indicators of change being evaluated.

Surveys: comprise a set of questions that can be sent to a large population in a relatively short time. Questions can be based on a Likert scale or similar, so being relatively simple to analyse. However, results are unlikely to be as in-depth as interviews.

Observation: watching participants as they work on a project can reduce interviewee bias or provide useful data regarding the behaviour of participants. As with interviews, this method is likely to result in a large amount of qualitative data that may be time-consuming to analyse.

General project evaluation questions

The following questions are suggested to help elicit participants' views on the lessons learned during a STEAM project or process. They can be used in addition to the questions covering the specific STEAM competencies given above. Suggested questions for the project team include:

→ Has the project reached its goals and objectives?

- If yes, how? If no, what went wrong? (Remember that it is fine if a project fails – STEAM is about the process as well as the outcome.)
- What does the application of the project mean for the reach of influence / target group / the world and why is this important?
- What were the strengths and weaknesses of the project?
- What went well during the project?
- What worked less well during the project?
- What would you do next time to improve the process?
- What resources would help improve the process, how and why?
- What were the group's goals for completing this project?
- What did you want to learn or develop as a group?
- What were the desired outputs of the project?
- What did the project wish to develop or create?

Suggested questions for individuals include:

- What did you want to achieve from being a part of this project?
- What skills or competencies did you want to develop?
- What knowledge did you want to gain from this project?
- What changes did you want to result from the project?

→ Who could be affected by your project (positively or negatively)?

Data analysis: The method (or methods) used for data analysis will depend on the choices made in the previous two stages and may depend on time, skills and other resources available determining the extent, complexity and depth of analysis. The pros and cons of a detailed but time-consuming system versus a quick and easy to use option should be considered. The evaluation process does not have to be overly complex or involve statistical analysis to be meaningful and effective.

Schedule: The exact schedule will depend on the purpose and scope of the evaluation. For example, if the purpose of the evaluation is to measure the changes on participants, then a pre and post process evaluation method (eg, a survey or interview) will be needed. If the purpose is to make quick adjustments as a process evolves, then it is likely that a mid-term (or more frequent) as well as a final survey will be appropriate.

Presenting findings: The presentation of the findings will depend on all the above stages as well as the intended audience for the evaluation. It is likely to include a list of questions and their responses, some data analysis and consideration of lessons learned as well as recommendations for future activities. A sequence of 'short and sharp' results throughout the STEAM process may be more effective than a detailed report where it takes time to share results and insights. This stage and all previous stages may also be influenced by institutional requirements (for example, if a STEAM project or process is an internally or externally funded activity with reporting obligations).



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