Intellectual Output IO5
Repository of Good Practices

Guide for Action Research

Author:
Dr. Georgios Mavromanolakis
Research & Development Department,
Ellinogermaniki Agogi, Greece
[gmavroma@ea.gr]

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1. Introduction

ARTIFEX aims to create a repository of good practices which will be publicly available to teachers and educators. The repository will consist of at least 20 good practices developed at the schools of the partner institutions at the various countries. The selection of educational practices is expected to be developed through action research by the teachers and educators participating in the project in close collaboration with teacher trainers and other relevant stakeholders. The materials developed through this process will be also of interest of and applicable by educators in other schools, educational environments and entities such as at FabLabs and makerspaces. The good practices will be linked to the STEM education competences and will be comprehensively described, in terms of aims, materials, resources, target audience, etc., and accompanied by supporting audiovisual material to exemplify their effective adoption and implementation.

It is planned that the educational good practices will be created by teachers and educators through action research. To facilitate such a process this document provides a concise guide for action research aiming at the innovation of an educational approach. The guide gives insights into the aims, process and outcomes of action research and how it can contribute to teaching and learning practices with a focus on the core competences for STEM. This guide combined with the resulting good practices, which will be available publicly and online at the end of the project, will inspire other teachers and educators to start and to implement their own action research and to improve their own competences through self-reflection and try-outs.

According to the timeline of the ARTIFEX project the development of practices by action research are planned to take place during the school year of 2018-2019 (i.e. Sep 2018 – Jun 2019). During this period 4 workshops will be organized for teachers and trainers/professionals of FabLabs or makerspaces who will be introduced and guided through 2 cycles of action research. Each cycle of action research will consist of and be developed in the following five consecutive phases:

a. introduction and selection of research question or practice,
b. planning and preparation,
c. implementation and try-outs at an educational environment,
d. observation and feedback collection,
e. and finally, reflection on findings and sharing of results

Two cycles are foreseen to enable teachers to effectively adopt and adapt the methodology of action research. At the final period of the project the developed educational practices will be selected and refined to be included in a general guide/repository of good practices and to be integrated in the online platform of ARTIFEX.

2. Action research – definition and objectives

Action research can be described as a form of inductive, practical research that focuses on gaining a better understanding of a practice problem or achieving a real change or improvement in the practice context. Action research is either research initiated to solve an immediate problem or a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems [1]. Action research involves actively participating in a change situation, often via an existing organization, whilst simultaneously conducting research. Action research can also be undertaken by larger organizations or institutions, assisted or guided by professional researchers, with the aim of improving their strategies, practices and knowledge of the environments within which they practice. As designers and stakeholders, researchers work with others to propose a new course of action to help their community improve its work practices. Therefore, in general action research could be seen as an interactive inquiry process that balances problem-solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future change.

In education, action research has emerged in recent years as a significant methodological approach for development, intervention and change. It is a form of curriculum development undertaken in partnership (e.g. aiming for a collaborative and reflective community of practice) provoking changes through both professional and school development. Furthermore, if curriculum development through action research is carried out in schools among teachers as well as between teachers and teacher educators, it can contribute to partnerships within and beyond school [2]. In this context, action research can be implemented as a cycle with planning, acting, observing and reflecting phases wherein educational practices or methods are first developed, then tried-out in real settings and finally are further improved based on reflection of observations and findings. As such action research as a process of professional development and change is particularly relevant to ARTIFEX since the project's main aim is on one hand to develop a curriculum of training modules and on the other to offer to teachers and educators a comprehensive high-quality repository of good practices in STEM education through a collaborative and reflective approach.

In conclusion, in the framework of ARTIFEX action research is aimed at furnishing the following objectives:

a. To enable teachers and educators trying new ideas in practice as a means of improvement and as a means of increasing knowledge about the curriculum, teaching, and learning.
b. To raise their level of critical thinking about teaching and learning, and in general about their practice or commonly adopted methodologies.
c. To engage them in collaborative and reflective development of practices.
d. To facilitate the adoption of innovative approaches in teaching and learning.
e. To emphasize the importance of sharing experience, expertise and valuable outcomes with other teachers in their community and beyond.
f. To strengthen their capacity and confidence to become active change agents.

g. To empower them in engaging with research independently and for their particular needs or interests.

3. Methodology and guidelines

Teachers, and in general educators, develop practices of teaching with which they feel comfortable and confident. When they mature it is usually difficult to change, or they feel insecure to adopt an innovative methodology or practice such as the educational approach proposed by ARTIFEX. However, when asked in surveys, the majority of teachers express the willingness to adopt new methods and models of STEM teaching, that have proven their effectiveness and that lead their students to better results in terms of concept and content understanding. A required condition is that they are thoroughly introduced in practicing these new methods before applying them to their everyday classroom teaching. In this respect workshops on action research not only help them to explore, adopt and improve an already made educational activity or practice but also assists them to gain confidence and experience towards developing their own ones individually or in collaboration with other educators.

In this context ARTIFEX offers to teachers dedicated workshops to help them to pre-practice by following examples, develop further and reflect on their best-practices and understandings and past experiences, collaboratively reflect on their instruction models, their main advantages and the common mistakes, etc. These workshops can be offered in parallel or within the framework of existing professional development programs, or even better in synergy with other similar projects and initiatives so that more teachers can be involved. They are grouped into two consecutive cycles where action research on an educational activity is implemented, feedback is collected, and findings are shared. As already mentioned, the goal is the use of action research as a tool for collaborative design of educational activities to foster creativity, problem-solving and inquiry-based science learning.

In general, when developing activities or curriculum in partnership it should be emphasized that alongside the process of how an activity is developed, key aspects of the activity itself like aims, learning outcomes, content, teaching and learning methods and assessment methods also need to be considered. Usually in literature (for example see [3] and [4]) an extended version of key aspects of an activity, and in general the curriculum, is shown in the shape of a spider web, thus metaphorically illustrating that placing additional focus on one of the key aspects this would inevitably influence the shape and the strength of the whole web. The key aspects of the curriculum as depicted in Figure 1 are: rationale, aims and objectives, content, learning activities, teacher role, materials and resources, grouping, location, time and assessment.

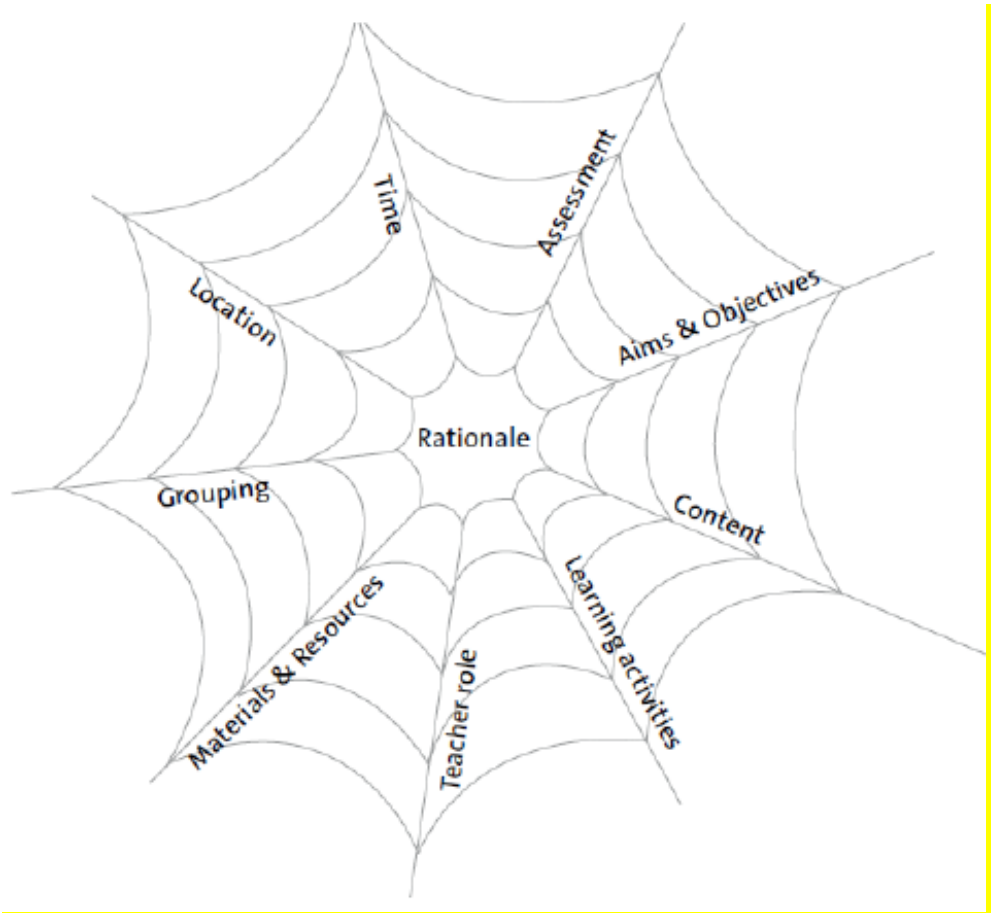

Figure 1. Curricular spider web as proposed in [4]

We adopt this spider web model, and as discussed in section 4, we devised a list of predefined statements categorized in a sequence of templated forms that address the different dimensions of the curricular spider web. This will assist and facilitate teachers' work in their action research.

Regarding the general process of educational design or development cycle of an activity we follow an approach that focuses on three phases: the analytical, the prototyping and the assessment phase [3]. In the former phase teachers are introduced to an example, they practice it taking the role of learners and analyze it in a reflective and collaborative way. In the second phase, the prototyping, they actually implement the activity with their students, taking the role of action researchers and critical observers. In the last phase, they assess their findings, collaboratively reflect on the results and outcomes. The whole process is implicitly of iterative nature and provide a well-founded overall framework for the development of a repository of best-practices.

In the framework of the ARTIFEX project, the development of practices, which are elaborated and evaluated by action research, are planned for the school year of 2018-2019 (i.e. Sep 2018 – Jun 2019). During this period, in total 2+2 workshops will be organized for teachers/educators who will be introduced and guided through 2 cycles of action research. The corresponding guidelines and proposed agendas are described in the following sections.

3.1 Guidelines for Cycle-1 workshops (Workshop-1 and 2)

In the first cycle, the corresponding two workshops are suggested to take place during the first half of the 2018-19 school year and preferably soon after (within a couple of weeks or one month) or complementary to a training event/professional development module offered to teachers within the framework of the project.

In the first workshop of the series (Workshop-1) participant teachers mainly are introduced into action research work of an example educational activity, reflect on the understanding they acquired during training and will act as being learners themselves ("teachers as learners and action researchers") or in other words experience, practice and reflect on a given activity from the learner's perspective. One of the main objectives of these workshops is also to raise awareness and clarify possible misconceptions about action research, its main objectives, their importance and relevance etc. They will also motivate participant teachers to start developing their own practice or adopt existing ones in collaboration with their fellow teachers.

A workshop of this type may consist of two main sessions. The first session, about 1-1.5 hrs. long, will have presentations of a possible example educational activity and short reminders and familiarization with the action research report templates (included in section 4 of this document), which preferably have been handed-out to teachers in advance. This session will open the discussion among the teachers so that they reflect on their own understanding but also compare with each other's approaches and views. The second session, about 1-1.5 hrs. long, can be a model practice or group work on a given example educational activity. In this session teachers are asked to identify and discuss strong and weak points, main advantages and barriers, do clarifications and develop further their understanding and confidence on assessing an activity according to the proposed templates. At the end or during the sessions of the workshop participants are encouraged to work collaboratively, to feel free to provide feedback to organizers and to fellow teachers about prior experience, effective approaches, possible challenges and barriers, etc. The workshop finishes with planning an actual activity try-out at participant schools and with a round table wrap-up discussion. Below is a proposed agenda for a workshop of this type.

Table 1. Example agenda of Workshop-1 ("teachers as learners and action researchers").

Time	Session description
9:00 - 10:00	Introduction and welcome (5 min) Presentation of an example educational scenario
10:00 - 10:30	Familiarization with the action research report templates Discussion and reflection
10:30 - 10:45	Break
10:45 - 11:45	Hands-on practice on a proposed activity or group work to develop one on a given theme
11:45 - 12:15	Assessing the activity according to templates

12:15 - 12:45	Discussion and reflection Planning an activity try-out Wrap-up presentation or round table wrap-up discussion and conclusions

The teachers' professional development approach of ARTIFEX incorporates a gradual structure to facilitate change of attitude in parallel to knowledge development. Within this structure, teachers can reflect on what they know already about inquiry-based STEM teaching and learning methodologies, how they learned or practice them, and what are the achieved results and benefits for the students. Teachers are better able to understand essential aspects of new methods of learning and teaching by discussing and thinking about their adopted instruction practice, and also share their experiences with other teachers. They basically act as critical thinkers, questioning constructively the pros and cons of introducing new learning methods in everyday science/STEM classrooms. They furthermore discuss or propose how certain learning activities may facilitate students' skills and knowledge. These discussions and reflections of teachers as thinkers, soon after they have tried-out an educational activity which they assess it by action research, can be facilitated in a dedicated practice reflection workshop. This is the main rationale of the second workshop of Cycle-1 (Workshop-2), which can be entitled "teachers as critical thinkers".

In this workshop participants discuss in deep and reflect on their tried-out or developed practices. They discuss on difficulties they foresee or expect or have experienced and propose work-arounds or methods to avoid them. The objective of the workshops of this type is not only to motivate more teachers and newcomers to adopt a new methodology or reflect on it and act as critical thinkers themselves but also to provide them with practical answers and assistance on how to break any last barriers or fears they have before an actual educational activity can be implemented in their school. Therefore, if possible, more experienced teachers that have already practiced such activities and learning approach in their teaching can be invited in these workshops to present their best-practices and collaboratively reflect on them or to act as role models and change agents.

A workshop of this type is practically a follow-up and logical sequence of a "teachers as learners and action researchers" workshop and can be organized soon after that and the corresponding try-out of activities on participants' planning request and convenience. It may consist of two main sessions. The first session, about 1-1.5 hrs. long, consists of presentations of selected best-practices or developed activities on which all participants will reflect on later based on their action research findings. The second session, about 1-1.5 hrs. long, will mainly focus on participant's discussions about difficulties, identified or expected problematic areas, and proposed solutions for improvement. The workshop finishes with round table wrap-up discussion or presentation. During the sessions of the workshop participants are reminded and encouraged on one hand to be openly reflective and critical on all aspects of their experience and on the other to think and act in a constructive and practical way towards possible improvements or needed alterations. If time permits the organizers may schedule at the end of the workshop an interviewing session with volunteer participants or selected teachers to thoroughly discuss and express their views on STEM teaching and learning and the approach of ARTIFEX in an open and critical way. Below is a proposed agenda for a workshop of this type.

Table 2. Example agenda of Workshop-2 ("teachers as critical thinkers").

Time	Session description
9:00 - 10:00	Introduction and welcome (5 min) Round table presentations of educational activities or best-practices at various levels of difficulty
10:00 - 10:30	Discussion and reflection on action research findings
10:30 - 10:45	Break
10:45 - 12:15	Discussion on difficulties, identified or expected problematic areas, and proposed solutions/improvements
12:15 - 12:30	Wrap-up

3.2 Guidelines for Cycle-2 workshops (Workshop-3 and 4)

The workshops of Cycle-2 are suggested to take place during the second half of the 2018-19 school year, and if possible, soon after (within a couple of weeks or one month) or complementary to a training event/professional development module offered to teachers within the framework of the project. The teachers have now passed from the states of "teachers as learners and action researchers" and "teachers as critical thinkers" and are now more reflective practitioners that have started developing the required skills and they are gaining confidence to assess, evaluate, adopt, but also adapt and redesign and develop authentic learning activities. Additionally, all participant teachers have practiced and implemented at least one educational activity in their classrooms. They are now more capable or in a position to assess their achieved results and so to reflect on the efficacy of the application of the method in their schools or in other schools. The purpose of Workshop-3 and 4 is to build on the experience of Cycle-1 and continue it in a refined way.

In this context Workshop-3 is similar to Workshop-1 with the addition that teachers are now elaborating and reflecting on educational activities or best-practices that have been developed in different countries. If necessary, after appropriate adaptation, possible try-outs at their schools are planned. Below is a proposed agenda for a workshop of this type.

Table 3. Example agenda of Workshop-3.

Time	Session description
9:00 - 10:00	Introduction and welcome (5 min) Presentation of a best-practice from different country(s)
10:00 - 10:30	Discussion and reflection

			Assessing the activity according to templates
10:30	-	10:45	Break
10:45	-	11:45	Hands-on practice on proposed activity or group work to redesign or develop new ones
11:45	-	12:15	Discussion and reflection Planning an activity try-out
12:15	-	12:45	Wrap-up presentation or round table wrap-up discussion and conclusions

The main focus of the final workshop (Workshop-4) is to discuss outcomes and propose improvements on the approach in a holistic way, the training offered or needed, possible prerequisites or further training material and content etc. A workshop of this type can have a more official character and be part of the teachers' conference of the project. It may consist of a session of invited speakers followed by a session where best case scenarios teachers present their work and outcomes to colleagues from other countries. The closing session will focus on proposed next-steps and improvements along with a critical perspective of the overall approach. If time permits the organizers may schedule at the end of the workshop an interviewing session with volunteer participants or selected teachers to thoroughly discuss and express their views, experiences and achievements. Below is a proposed agenda for a workshop of this type.

Table 4. Example agenda of Workshop-4.

Time			Session description
9:00	-	10:30	Introduction and welcome (5 min) Presentations of success stories, best-practices and best outcomes
10:30	-	10:45	Break
10:45	-	12:15	Discussion and reflection on outcomes achieved, methodologies practiced, experiences, proposed next-steps/future improvements
12:15	-	12:30	Closing/Wrap-up

4. Action research report templates

To facilitate teachers in their action research work we devised the following list of statements categorized in a sequence of templated forms that address the different dimensions of the curricular spider web (1. Aims and objectives, 2. Content, 3. Learning activities, 4. Teacher role, 5. Assessment, 6. Materials, 7. Time, 8. Location and 9. Grouping). Teachers can utilize them for guidance or as a preliminary list of indicative statements that can help them to characterize their observations from the action research of the educational activity they tried out. In general, teachers are also encouraged to develop their own list of statements in addition to the proposed ones. The level of agreement to each statement or potential observation is quantified by a score indicator in scale from 1 to 5 according to the following table. This is to assist teachers and project partners in the analysis of the results.

Score scale	Interpretation
5	Strongly agree
4	Agree
3	Neither agree nor disagree
2	Disagree
1	Strongly disagree

4.1 Aims and Objectives: Towards which goals are students learning?

Aims and Objectives: Towards which goals are students learning?	1	2	3	4	5
Challenge creativity and innovation					
Critical thinking and problem solving					
Communication and collaboration					
Literacy in ICT and new technologies					
Independence, initiative and self-direction					
Productivity					
Ownership of results/achievements					
Leadership and responsibility					
Exposure to real-life situations and problems					
Utilization and application of certain technical processes (e.g. 3D-printing, laser-cutting, CAD design, etc.)					
Add here any comments or remarks					

4.2 Content: What should be the content of the educational activities? What are students learning?

What should be the content of the educational activities? What are students learning?	1	2	3	4	5
Students should be able to improve or advance their critical thinking and problem-solving skills					
Students should be able to start a design process to solve a given problem					
Students should be able to advance or improve their content and concept knowledge of STEM curriculum topics					
Students should be able to initiate or follow an inquiry process and actions towards a predetermined goal					
Students should be able to reflect on or self-assess their learning progress, to gain confidence and independence on acquiring knowledge and skills					
Students should be able to improve or advance their ICT and new technologies literacy					
Students should be able to improve or advance on interdisciplinary and collaborative learning					
Add here any comments or remarks					

4.3 Learning activities: How are students learning?

Learning activities: How are students learning?	1	2	3	4	5
When educational activities are inquiry-based (e.g. including phases such as questioning, designing or planning investigations, gathering evidence, making connections, explaining evidence, communicating and reflecting on explanations)					
When activities combine or foster synergies between inquiry-based science learning and the making ideology directed at developing creativity, innovation and problem-solving					
With activities that give emphasis on collaboration, communication, collaborative project work					
With activities where students can investigate and reflect on their own prior knowledge, misconceptions, false beliefs and attitudes					
With technology-enhanced learning activities					
Add here any comments or remarks					

4.4 How is teacher/educator facilitating learning?

How is teacher/educator facilitating learning?	1	2	3	4	5
Take into consideration students' prior knowledge, skills, competences, attitudes, beliefs, learning styles and experiences and accordingly organize appropriate learning activities					
Make explicit connections between specific content knowledge and educational activities					
Be a model for inquiry- and creativity-based learning, for example by encouraging students' decision making during inquiry processes, and sharing, evaluating and reflecting on outcomes					
Provide students step-by-step guidance during the educational activity					
Foster creativity and problem-solving skills by being more like a coach instead of someone who will give all the answers					
Add here any comments or remarks					

4.5 Assessment: How to assess students' learning progress?

How to assess students' learning progress?	1	2	3	4	5
Base assessment on acquisition and development of problem-solving skills and on understanding about the process of acquiring knowledge rather than the content knowledge itself					
Assess learning progress based on students' overall development of STEM content and concept knowledge, skills and attitudes					
Measure progress based on productivity or other quantitative indicators (e.g. time-on-task, time-to-completion, etc.)					
Promote students' independence and responsibility in assessing their own progress and in identifying the areas for improvement					
Use different forms of evidence (e.g. portfolios, diary, observation lists, tests, questioning, essays, project work, teaching practice) for assessment purposes					
Add here any comments or remarks					

4.6 Materials and resources

Materials and resources	1	2	3	4	5
Emphasize the use of ICT infrastructure and related available materials and educational resources (online applications, portals or repositories)					
Facilitate and promote access to a variety of STEM curriculum materials and resources fostering STEM competences. These should include everyday materials and basic equipment for hands-on exploration					
Facilitate and promote access to everyday low-cost materials and resources					
Utilize the basic equipment of a fablab or makerspace (i.e. 3D-printers, laser-cutters etc.)					
Work only with basic materials like paper, wood, plaster, cardboard, etc.					
Add here any comments or remarks					

4.7 Time availability

Time availability	1	2	3	4	5
Educational activities that could be continued or completed at home					
Allow sufficient time for students to explore their creativity, innovation and problem-solving capabilities and to gain confidence through the process					
Provide opportunities for time-independent (distance or online) learning					
Explore various approaches encouraging interdisciplinary and project work					
Educational activities with fixed time					
Add here any comments or remarks					

4.8 Location

Location	1	2	3	4	5
Educational activities that take place in a variety of learning environments in- and out-of-school, including e.g. fablabs, makerspaces, science museums and centers, natural habitats, etc.					
Educational activities are more effective when can take place in fabLabs/makerspaces					
Educational activities are more effective when they take place in classroom or in school environment					
Activities that provide opportunities for location-independent and collaborative distance learning					
Add here any comments or remarks					

4.9 Grouping

Grouping (With whom are students learning? Are they better learning individually, in small groups, or whole-class?)	1	2	3	4	5
Provide students with flexibility to choose from a range of learning trajectories according to their preferences and working styles (individually or in groups)					
Implement the same educational activity in whole-class					
Promote team working and collaboration in small groups					
Emphasize students to work individually and independently					
Provide interaction and interdisciplinary collaboration opportunities amongst students of different skills and competences					
Add here any comments or remarks					

5. Template to document an educational activity/practice

In the following we provide a template for teachers and educators to document and report their developed educational activities. The template should be filled-in in a way that other teachers can adopt it and be able to implement a similar activity with their students. Any additional material or supplementary document may be attached at the end of the template or can be provided online through a weblink. A template for collecting basic statistical/demographic anonymous data is also provided. These are solely to be used for statistical analysis by the consortium and will facilitate the assessment of the project.

5.1 Template for teacher(s) profile

Teacher profile

Gender	Female	Male
	○	○

Teaching level	Primary	Secondary	Vocational	Post-secondary
	○	○	○	○

Teaching subject	Science or Math related (e.g. Mathematics, Physics, Chemistry, Biology, etc.)	Technology related (e.g. Informatics, Computing, Electronics, etc.)	Engineering related (e.g. Mechanical Eng., Electrical Eng., etc.)	Business related (e.g. Economics, Entrepreneur-ship, Management, etc.)
	○	○	○	○
	Please write here your specific teaching subject:			

Teaching experience	1-5 years	6-10 years	11-15 years	15-20 years	More than 20
	○	○	○	○	○

Age range of your students	10-12 years	13-15 years	16-18 years	19+ years
	○	○	○	○

Classroom size (where this project was implemented)	1-5 students	6-10 students	11-15 students	More than 16
	○	○	○	○

5.2 Template for teacher(s) to report an educational activity

  Erasmus+ Report of educational activity	
Title of activity	
Name of school and level	
Start/End Date	
Country City/Region	
Name of teacher(s) and teaching subject	
Number and age-range of students	
Working language	
Type and duration of activity	*If possible, indicate one or more of these types:* - *In-school or classroom activity* - *Out-of-school activity* - *Activity in fablab, makerspace, etc.* *If other, please describe*
Level of difficulty	*If possible, indicate the level of difficulty of the activity according to a three-level scale (i.e. low, medium, high)*
Learning objectives	*Give a short description of what are the learning objectives of the activity*

General description of activity	*Provide here a concise description of the educational activity with the students. If the activity is composed by multiple phases then describe each phase in more detail, mentioning what students planned, what they did, what they achieved etc. Mention also any difficulties or challenges*
Learning outcomes	*Give a short description of what students learned and achieved*
Materials or equipment that are required	*Give a list of materials or equipment that are needed for this activity*
Photos or other relevant material	*Attach here pictures, photos or other relevant supplementary material, such as instructions, worksheets, screenshots or web-links related to the activity*

6. Summary

ARTIFEX aims to create a repository of good practices which will be publicly available to teachers and educators. The repository will consist of at least 20 good practices developed at the schools of the partner institutions at the various countries. The selection of educational practices is expected to be developed through action research by the teachers and educators participating in the project in close collaboration with teacher trainers and other relevant stakeholders. The materials developed through this process will be also of interest of and applicable by educators in other schools, educational environments and entities such as at FabLabs and makerspaces. The good practices will be linked to the STEM education competences and will be comprehensively described, in terms of aims, materials, resources, target audience, etc., and accompanied by supporting audiovisual material to exemplify their effective adoption and implementation.

It is planned that the educational good practices will be created by teachers and educators through action research. To facilitate such a process this document provides a concise guide for action research aiming at the innovation of an educational approach. The guide gives insights into the aims, process and outcomes of action research and how it can contribute to teaching and learning practices with a focus on the core competences for STEM. This guide combined with the resulting good practices, which will be available publicly and online at the end of the project, will inspire other teachers and educators to start and to implement their own action research and to improve their own competences through self-reflection and try-outs.

7. References

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