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# STEAM professional development Recommendations

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DOSE
DEVELOPMENT OF STEAM EDUCATION

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*The recommendations, formulated by each project partner, are rooted in the outcomes of PDP piloting, insights gleaned from educators, feedback offered by teachers and other pedagogical staff, as well as input received from interested parties and stakeholders.*

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DEVELOPMENT OF STEAM EDUCATION

## Recommendations for teachers:

- To organize a successful STEAM activity, collaboration with other teachers is necessary. The best ideas often emerge when we expand beyond our own expertise. Collaboration also extends the time available for activities; typically, 45 minutes are insufficient for a complete STEAM endeavor.

- STEAM encompasses diverse subject areas that frequently intersect. A pervasive aspect across society is technology, including hardware, software, applications, and more. While programming is commonly included in curricula globally, students also require guidance in comprehending and utilizing technology. Computational thinking empowers students to grasp and employ technology more effectively, making its integration into tasks and projects a worthwhile proposition for their future.

- Leverage online resources, including national and international lesson plans. Forge partnerships with fellow educators to establish a local professional learning community, ideally spanning various school subjects. Invest time in familiarizing yourself with both technical and pedagogical tools linked to integrated STEAM learning activities. Your school is likely inclined to support STEAM development and potentially allocate extra time as needed.

- Upon integrating STEAM activities into classes, educators should prioritize assessing students' level of engagement rather than solely focusing on the final product. Also, contemplate the inclusion of simpler or briefer STEAM activities within lessons, fostering a dynamic learning process and diverse perspectives on the topic.

- Successful STEAM activities in schools necessitate collaboration among teachers from different subjects (2-3 distinct subjects). Collaboration can extend beyond the school to encompass educational or cultural institutions. Global ideas and real-life issues offer prime inspiration for STEAM projects (consider aligning with Sustainable Development Goals). Due to the time-intensive nature of STEAM activities (a single lesson or 45 minutes is insufficient), adjustments to the timetable for extra learning time and attention to student reflection (for assessing learning outcomes) are essential.

- STEAM embodies an integrated, multidisciplinary approach that employs STEAM concepts and higher-order thinking to resolve intricate real-world problems, fostering the development of new knowledge and skills. However, operationalizing the incorporation of this

knowledge and skills as measurable outcomes remains a significant challenge. Nonetheless, assessment serves as a potent tool to enhance teaching and learning quality.

- In STEAM education, formative evaluation holds more significance than summative assessment. Students are central to their own learning process within STEAM education. As a teacher, your pivotal role involves guiding and supporting this learning journey. Consequently, formative evaluation revolves around teacher-student interaction. Ideally, evaluation becomes an integral part of classroom instruction, guidance, and assessment—forming a unified process where information is continually gathered and interpreted alongside students. This reflective dialogue embodies effective STEM pedagogy.
- Embrace Failure as a Learning Opportunity: Encourage students to view failures as stepping stones to success. In STEAM education, experimentation and iteration are essential components of the learning process. Foster a classroom environment where mistakes are seen as valuable learning experiences.
- Encourage Cross-Disciplinary Exploration: Encourage students to explore connections between different subject areas within STEAM. Help them see how concepts from one field can be applied creatively to solve problems in another. This promotes a holistic understanding of the interconnectedness of knowledge.
- Incorporate Real-World Context: Whenever possible, anchor STEAM activities in real-world contexts and issues. Connecting learning to authentic problems makes the content more engaging and relevant for students, fostering a deeper understanding of the concepts.
- Promote Diverse Perspectives: Encourage diversity and inclusivity in STEAM projects. Different backgrounds and perspectives can lead to more innovative solutions. Ensure that students from various backgrounds feel welcome and valued in the STEAM learning environment.
- Provide Open-Ended Challenges: Present students with open-ended challenges that allow for multiple solutions and interpretations. This cultivates critical thinking skills and encourages students to explore a variety of approaches to problem-solving.
- Integrate Arts Creatively: Incorporate the arts in imaginative ways within STEAM activities. Artistic expression can help students visualize complex concepts, communicate their ideas, and enhance the overall creative thinking process.
- Foster Student Ownership: Empower students to take ownership of their learning journey. Allow them to choose projects that align with their interests, and give them autonomy to make decisions about their learning paths.
- Seek External Partnerships: Collaborate with local businesses, research institutions, or professionals in relevant fields. External partnerships can provide students with access to real-world expertise, resources, and hands-on experiences.

- Continuous Professional Development: Keep abreast of new technologies, teaching strategies, and interdisciplinary approaches in STEAM education. Participate in workshops, conferences, and online courses to stay updated and enhance your teaching skills.
- Celebrate Achievements: Celebrate and showcase students' achievements in STEAM projects. Organize exhibitions, presentations, or competitions where students can display their work to peers, parents, and the community, fostering a sense of accomplishment and pride.
- Assessment Beyond Grades: Move beyond traditional grades and consider using rubrics that assess creativity, collaboration, critical thinking, and problem-solving skills. This shift highlights the broader skills developed through STEAM education.
- Cultivate Curiosity: Encourage curiosity-driven learning by allowing students to ask their own questions and guiding them in researching and finding answers. This instills a lifelong love for learning.
- Stay Adaptable: Flexibility is key in STEAM education. Be open to adapting your lesson plans based on student interests, unexpected discoveries, and evolving technologies.
- Model Curiosity and Learning: Show your own enthusiasm for learning, exploring, and trying new things. Your own curiosity can be infectious and inspire students to adopt a similar mindset.
- Create a Maker Space: Establish a dedicated physical space where students can experiment, create prototypes, and collaborate on hands-on projects. A well-equipped maker space can be a hub for STEAM creativity.

## Recommendation for school administers:

• To foster collaboration among teachers, organize activities where educators can exchange ideas and initiate interdisciplinary projects with their colleagues.

• The everyday concerns of teachers typically revolve around students' well-being and lesson planning, spanning current and upcoming lessons. In designing personal development programs, prioritize offerings that can be directly applied to teaching. This might encompass lesson plans, project concepts, or even detailed project instructions. The aim is to equip teachers with comprehensive background information to effectively teach a subject while offering practical guidance.

• Facilitate the cultivation of interdisciplinary and multidisciplinary activities. This can be achieved through diverse means, including stimulating projects involving teachers from

multiple subjects, establishing in-school professional learning communities (PLCs) potentially partnered with local university researchers, and investing in infrastructure such as rooms and technology to enable students to collaborate on interdisciplinary projects.

• School administrators should both permit and actively encourage teachers from various STEAM subjects (such as Computer Science and Art) to conceive and execute projects within the context of these subjects. This approach enhances student engagement in interdisciplinary tasks. By extending beyond their individual subject domains and considering curricular recommendations, teachers provide students with opportunities to apply acquired skills in innovative ways.

• To ensure fruitful teacher collaboration, create avenues for teachers to collectively develop integrated activities. These agreed-upon initiatives can subsequently be integrated into the curriculum, with the allocation of requisite time and resources. Establish a clear vision and expectations for STEAM activities within the school. Maintain an updated and expanding roster of institutions available for collaborative STEAM efforts, while promptly furnishing teachers with necessary educational resources.

• The bedrock of sustainable STEAM integration at a school is the commitment of the entire teaching team. Achieving enduring STEAM implementation hinges on active involvement from all educators. Once this support is established, a team can chart its unique course for sustainable STEAM integration within its specific school context. Consequently, a pivotal facet is enlisting school administrators and several teachers from one institution in a STEAM professionalization trajectory, such as the DOSE PDP.

• Allocate Dedicated Resources: Set aside budgetary resources for acquiring STEAM-related materials, tools, and technology. Adequate funding ensures that teachers and students have access to the necessary equipment and supplies to effectively implement STEAM activities.

• Promote Cross-Grade Collaboration: Encourage collaboration among teachers from different grade levels. Cross-grade partnerships can facilitate the sharing of ideas, teaching strategies, and projects, promoting a seamless progression of STEAM skills throughout the students' academic journey.

• Leverage Community Partnerships: Forge partnerships with local businesses, research institutions, museums, and community organizations. These external collaborators can offer

expertise, mentorship, and real-world context to STEAM projects, enriching the learning experience.

- Provide Professional Development: Offer ongoing professional development opportunities for teachers to enhance their STEAM expertise. Workshops, seminars, and training sessions can equip educators with the latest pedagogical approaches and technological advancements in the field.

- Create Showcase Opportunities: Organize events, exhibitions, or showcases where students can present their STEAM projects to parents, peers, and the community. Such platforms celebrate students' achievements, fostering pride and motivation in their learning journey.

- Encourage Interdisciplinary Evaluation: Develop assessment methods that reflect the interdisciplinary nature of STEAM education. Encourage teachers to collaborate on assessment criteria that assess not only subject-specific knowledge but also critical thinking, collaboration, and creativity.

- Support Risk-Taking: Create a supportive environment where teachers are encouraged to take risks and experiment with innovative teaching methods. Acknowledge and celebrate the efforts of educators who are pushing the boundaries of traditional teaching.

- Build a STEAM Culture: Foster a school culture that embraces STEAM education as a core component of learning. This involves aligning school mission statements, policies, and communication efforts to reflect the importance of STEAM skills in students' holistic development.

- Establish Long-Term Goals: Develop a comprehensive STEAM education strategy with long-term goals. Outline how STEAM integration aligns with the school's vision and how it contributes to students' academic and personal growth.

- Seek Student Feedback: Regularly gather feedback from students about their STEAM experiences. Their insights can provide valuable perspectives on what is working well and areas that may need improvement.

- Recognize and Reward Innovation: Implement a system to acknowledge and reward teachers who demonstrate exceptional innovation and excellence in STEAM education.

Recognition can include accolades, professional development opportunities, or additional resources for their classrooms.

- Promote Equity and Inclusion: Ensure that STEAM opportunities are accessible to all students, regardless of their background or abilities. Address potential barriers to participation and implement strategies to create an inclusive learning environment.

- Stay Current with Research: Stay informed about the latest research and trends in STEAM education. This knowledge can guide decision-making and support the school's efforts to provide a cutting-edge education.

- Monitor and Evaluate Progress: Regularly assess the effectiveness of your school's STEAM initiatives. Gather data on student engagement, learning outcomes, and teacher collaboration to make informed adjustments and improvements.

- Celebrate Success Stories: Share success stories of students who have excelled in STEAM education. Highlighting these achievements can inspire other students to explore their interests in STEAM subjects.

By incorporating these recommendations into your school's approach to STEAM education, you can create a vibrant and impactful learning environment that prepares students for the challenges and opportunities of the modern world.

## Recommendation for policy makers:

- Teachers should be granted the authority and autonomy to plan their lessons in the manner they deem most effective for supporting students in STEAM activities. Training, collaborative projects involving teachers from various schools and organizations, could facilitate the initiation or advancement of new STEAM endeavors within schools.

- Since the primary goal of education is to instruct students, and teachers are the daily drivers of this mission, it is imperative to engage with both teachers and students, as well as school administrators, when crafting curricula and educational policies.

- Revise documents and frameworks related to curriculum development and teacher competencies to encompass the content, learning objectives, and teaching skills essential for

the integration of contemporary and sustainable STEAM education. Utilize your influence to establish teacher training activities that cultivate these new competencies.

- To seamlessly integrate STEAM activities into classes, educators require greater creative freedom, which can be facilitated by loosening curricular boundaries. Similarly, students need reduced pressure to nurture creativity. This can be achieved by earmarking specific time slots for projects within the school calendar or by introducing an interdisciplinary subject (e.g., simply titled "STEAM") into the weekly schedule. The objective of such a subject should be individualized, and assessment-free, focusing on amalgamating diverse STEAM skills to address real-world questions, explore pertinent fields, or express creativity in diverse forms.
- Empower teachers and school administrators to strategize and implement integrated teaching and learning approaches. Extend support in devising teaching and learning resources. Encourage collaboration between school communities, research and study centers, and educational facilities, broadening the geographical scope of school-based STEAM activities. Arrange systematic and continual training, national events, and projects to motivate teachers in exploring and orchestrating STEAM education within their schools.
- Sustaining the implementation of STEAM education mandates ongoing efforts beyond the initial phase. This entails consistently expanding and enriching the educational offerings. The introduction of educational innovation invariably raises new questions. Coaching for initiating innovative pilot projects can foster professional growth that transcends acquiring novel insights, potentially evolving schools into exemplars of good practice. Schools participating in the PDP have gained preliminary insights into STEAM, yet require continued coaching to firmly embed STEAM education in a sustainable manner. Teacher design teams (TDTs) provide an excellent mechanism to afford educators time and space for ongoing professional growth through collaboration, exchange, and reflective practices across schools.
- Support Research and Innovation: Invest in research initiatives that explore the effectiveness of STEAM education methods and approaches. Foster partnerships between educational institutions and research centers to drive innovation in STEAM pedagogy.
- Foster Inclusivity: Develop policies that ensure equitable access to STEAM education for all students, regardless of socioeconomic background, gender, ethnicity, or ability. Provide targeted resources and support to underrepresented groups in STEAM fields.
- Recognize Informal Learning: Acknowledge the value of informal STEAM learning experiences, such as extracurricular clubs, maker spaces, and online resources. Encourage policies that facilitate collaboration between formal and informal learning environments.

- Promote Interdisciplinary Credentials: Develop certification pathways or endorsements for educators who specialize in interdisciplinary teaching, recognizing their expertise in integrating STEAM concepts across subjects.
- Engage Industry Partners: Establish partnerships with industries relevant to STEAM fields to provide students with exposure to real-world applications. Encourage internships, apprenticeships, and mentorship programs that bridge the gap between education and industry.
- Leverage Technology: Develop policies that enable schools to effectively integrate technology into STEAM education. This includes providing access to cutting-edge tools, software, and platforms that enhance learning and problem-solving.
- Promote Continuous Assessment: Encourage the use of continuous assessment methods that reflect the iterative and dynamic nature of STEAM learning. Policies should emphasize formative assessment, reflection, and growth-oriented feedback.
- Facilitate Teacher Collaboration Time: Recognize the importance of collaboration among educators for successful STEAM implementation. Allocate time for teachers to collaborate, share best practices, and jointly design interdisciplinary projects.
- Provide Flexibility in Scheduling: Develop flexible scheduling policies that accommodate longer project-based learning periods. This enables students to engage deeply in STEAM activities without feeling rushed.
- Support Teacher Professional Growth: Establish funding mechanisms for teachers to attend STEAM-related workshops, conferences, and courses. Policies should encourage lifelong learning and the continuous enhancement of educators' skills.
- Encourage Parent and Community Involvement: Develop strategies to involve parents and the local community in STEAM education. This could include workshops, open houses, and events that showcase student projects.
- Align with National and Global Goals: Ensure that STEAM education aligns with national educational goals, as well as international initiatives like the Sustainable Development Goals (SDGs). This connects students' learning to broader societal challenges.
- Provide Grants and Funding: Offer grants and funding opportunities specifically for schools and educators focusing on STEAM education. This financial support can facilitate the implementation of innovative projects and initiatives.
- Promote Cultural and Artistic Integration: Encourage the integration of cultural and artistic elements within STEAM education to promote creativity, diversity, and a well-rounded approach to problem-solving.
- Regular Policy Review: Establish a framework for regular policy review and adaptation in response to advancements in technology, pedagogy, and the evolving needs of the job market. This ensures that STEAM education remains relevant and effective.

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By incorporating these additional recommendations into policy frameworks, you can foster a robust and holistic approach to STEAM education that prepares students for a rapidly changing world.

## Observations

Teachers were very interested in the Personal Development Program, especially those who have received equipment through different projects beforehand (3D printers, LEGO robots, Arduinos, etc.), and were not sure how to use them and integrate them into the classes according to the curriculum. They found the PDP very useful and inspiring for their everyday practice. This was also evident in the way they designed the STEAM resources for the challenge, as most of the resources included the abovementioned equipment. Furthermore, another indicator that the PDP was successful is shown through the quality of the resources produced for the collection of best practice examples. Out of 36 resources that were sent to us, 20 were chosen by our team to be included in the Handbook. Out of the chosen resources, the majority included ideas on working with 3D printers, Arduinos, and Micro:bits.

**1. STEAM school projects should be designed in such a way that they can be implemented in the regular class curriculum**

Teacher are often overwhelmed by the everyday work in school, and they might be resistant to involving more STEAM school projects in their practice if they perceive it as more work. The STEAM projects should thus be designed to follow to school curriculum of multiple subjects, so that e.g. a Chemistry teacher and a Math teacher can both implement the project during their regular school hours. If the projects are designed this way, the teachers are far less resistant to harbouring STEAM education.

**2. Teachers are most inspired when they are provided concrete examples**

Teachers are often told about the benefits of STEAM education and how they should theoretically implement it, but they are seldom provided with practical examples of how they can bring STEAM education to their classroom. During the PDP, we tried to provide as many examples as possible, especially those that the teachers can relate to. When they understood how STEAM projects could be realized with the resources they have, they were more likely to provide a variety of ideas on how to implement STEAM education in their teaching practice.

**3. Teachers need more resources that can help them understand how to use modern technologies in education**

Teacher are sometimes provided the educational tools, e.g. 3D printer or Adruino sets, but they don't know how to use them in their classroom setting. Although teachers are provided the tools, they are rarely given instructions or didactical directions to put them to practice. We

realized during the PDP that the teachers would use the resources they have, if they were properly trained to use them. Thus, STEAM resources should include detailed instructions on how to use the tools that are necessary for the realization of the project.

## Recommended ICT tools:

Here are some ICT (Information and Communication Technology) tools that can be used to enhance STEAM (Science, Technology, Engineering, Arts, Mathematics) education.

1. Arduino - An open-source electronics platform with a range of hardware and software tools for creating interactive projects.
2. Bloxels - Combines physical and digital elements, allowing students to create video games by designing characters and environments.
3. Canva - A versatile graphic design tool that can be used to create visuals, posters, infographics, and more.
4. Code.org - Offers a range of coding activities and courses suitable for different age groups to introduce students to programming concepts.
5. CoSpaces Edu - Enables students to create virtual reality experiences and 3D content, fostering creativity and storytelling.
6. Edpuzzle - Allows teachers to create interactive video lessons by adding questions, comments, and quizzes to videos.
7. Flipgrid - A platform for video discussions, where students can record short videos to express their thoughts and ideas on different subjects (https://auth.flipgrid.com/signup)
8. GeoGebra - Provides interactive mathematics and geometry software that can be used to visualize mathematical concepts.
9. Google Suite for Education - Includes tools like Google Docs, Sheets, Slides, and Forms, which can be used for collaborative projects and data analysis.
10. Kahoot - a game-based learning platform that allows educators to create interactive quizzes and surveys
11. LEGO Mindstorms - Combines LEGO building blocks with robotics to engage students in designing and programming robots.
12. Mentimeter - a platform for interactive presentations, quizzes, polls, and interactive Q&As that can help teachers present the topic and data.
13. Merge Cube - A physical cube that can be used with augmented reality apps to explore various educational topics in an interactive way.
14. Micro:bit - A pocket-sized computer designed to introduce coding and electronics to young learners through interactive projects.

15. Minecraft: Education Edition - An educational version of the popular game that allows educators to create interactive lessons and activities.
16. Nearpod - Offers interactive lessons, quizzes, polls, and collaborative activities that can be delivered to students' devices.
17. Padlet - an online collaborative platform where students can create boards to share ideas, resources, and multimedia content.
18. Plickers - a platform with flash cards for quick knowledge checks
19. Prezi - a platform for online presentations that enables presenters to organize the space for presenting more creatively that PowerPoint
20. Scratch - A beginner-friendly programming language and online community where students can create interactive stories, games, and animations.
21. Socrative - a platform designed for fun, effective engagement and on-the-fly assessments
22. Tinkercad - An easy-to-use 3D design tool for creating digital prototypes and models that can be 3D printed.
23. VEX VR - Offers virtual robotics challenges and simulations to help students learn programming and robotics concepts.
24. Wolfram Alpha - A computational knowledge engine that can help students solve complex math problems and explore scientific concepts.