

FORMAL AND INFORMAL LEARNING INTERSECTIONS

FINAL REPORT

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INTRODUCTION

STEAM (sciences, technology, engineering, the arts, humanities, and math) is an approach to education that promotes student-led explorations driven by curiosity and the application of competencies and practices across disciplines that can effectively and equitably prepare them for success in education and the 21st century workforce. The aim of the project was to investigate how STEAM can help create feelings of equity, well-being, and belonging in students. The aim of cohort 5 was, additionally, to investigate how informal and formal educators can better work together to achieve this goal and to assess where the field is lacking research, information or effectiveness.

To effectively promote the research goals of this project, cohort 5 began by assessing the current positions within the cohort participants to achieve consensus and to determine where disparities within the group may occur. As such, the cohort members were first surveyed to gain consensus on key elements to standardize essential vocabulary as well as to assess potential struggles and known successes in the research topic area. Cohort participants were asked the following questions to ascertain any discrepancies within the cohort.

- How do *you* define equity, well-being, belonging, informal education, formal education?
- What are the most effective and ineffective things you have seen in addressing equity in in/formal education?

- What do you perceive as the barriers in accessing informal education opportunities?
- What might you want quantified through additional research?
- In the intersection of equity, well-being, belonging, and in/formal education, what are you most curious about?
- In the intersection of equity, well-being, belonging, and in/formal education, what is the biggest struggle?

The results of this initial survey were notable. All cohort participants are deemed to have experience and merit in the field of informal education within a STEAM framework and yet the survey results had not provided a single standardized answer among any of the questions. Answers indicated that the participants' definitions were very much centered in a particular community, population or socio-economic group and solutions varied wildly depending on the combinations or importance of those factors. There was no "one-size-fits-all" answer and the actual work being done has to be tailored to the individuals being addressed. The results were surprising to the group as all participants had a high level of effectiveness and knowledge in their particular communities, but this would not necessarily translate across communities.

The function of the project was to help create some guidance and best practices for the informal educational community at large in regard to equity, well-being and belonging in STEAM. As such, the cohort needed to take a step back and gain some consensus on what possible overarching themes or practices might potentially benefit the project.

The results of this initial survey allowed us to understand that we had no universal agreement on any of the answers and it was determined we needed a larger sample size to provide sufficient direction for future project directions. To obtain these findings, the cohort worked with Claire Bebee, Research Analyst from the Houston Museum of Natural Science, to develop a survey tool that could be sent to both domestic and international practitioners for input on what the universally understood definitions could be, the biggest struggles they face, what they believed would be most beneficial to them in practice, what learners need help with the most, and how they believe they could most effectively work with their counterparts in formal or informal learning.

Note: During the project, Cohort 2 – STEAM for All – standardized the definition of equity and provided additional insights on implementation. The refined definitions and insights can be found in the STEAM for All report and should be used when conducting additional research or furthering the project.

KEY FINDINGS

The goal for the second, larger survey was to get feedback from 75 respondents for statistically significant findings. At the end of the survey, 116 respondents from three countries had participated - three people from Canada, one from Germany and 113 from the United States.

Survey participants were primarily middle-school educators, but there was an adequate sampling across ages to make the findings statistically significant. About 2/3 of the participants indicated they work in formal education and about 2/3 indicated they worked in informal education, indicating approximately 1/4 to 1/3 work in both fields. About half of the participants had partnerships with informal institutions/programs. These programs overwhelmingly focused on STEM and bringing kids to science.

Both formal and informal educators indicated “Collaboration/Communication” and “Impact” as the areas in most need of help to work effectively with the other side of education, but with some slight difference in order. Formal educators, unsurprisingly, wanted teacher support as their top choice. Overwhelmingly, teachers wanted support from informal educators, with almost 2/3 of all formal educators choosing this option. Formal educators specified teacher support, impact, and collaboration/communication (in that order) as the support they would like to work more effectively with informal educators in promoting STEAM education as well as making opportunities more equitable for students. In contrast, informal educators specified collaboration/communication, educational support and impact (in that order) as the support they would like in promoting STEAM education as well as making opportunities more equitable for students.

Participants indicated that there was a lack of current or usable research on how informal staff and formal classroom teachers can work to communicate better, as well as the impact on student learning during out-of-school time activities. Survey participants often had wide ranging ideas in how informal and formal educators can work together better, which is not surprising, but also part of the potential issues with communication between the two groups. Approximately one in five survey participants did not know about current literature.

To overcome barriers for informal opportunities, participants often mentioned topics of equity and building relationships, especially when it has to do with resources, like scholarships, pricing, and transportation. One participant said, "Authentic and equitable partnerships are rooted in shared collaborations between the informal science learning institution and community-serving organizations. As an informal educator, I find that

showing up and supporting community-serving organization events and programs (outside of collaborative projects), is a way to gain trust and show genuine interest in what youth and families are engaged in." Specific significant barriers to opportunities included: cost, time of participation, language access, transportation/ location, lack of accessibility, ineffective communication/ notification regarding opportunities, lack of feeling of belonging for participants, and socioeconomic issues.

In response to "How can we overcome barriers for informal opportunities," respondents indicated the most and least effective things are very dependent on your location, population, etc. There was no one-size fits all solution. Participant answers were phrased in terms of equity and building relationships, especially when it has to do with resources, like scholarships/pricing, transportation.

Participant answers indicated the least effective strategies are a fairly close tie between "Focusing on money/numbers not people" and "Assuming your average participant are homogeneous." This is notable because so many participants wanted to focus on money in the previous responses as a barrier that needs to be overcome, but then also indicated it is one of the least effective ways to address equity. This paradox came up repeatedly within the survey.

Survey participants indicated the audiences they serve, regardless of if the participant came from the informal or formal arena, need the most help with equitable access to opportunities, financial barriers, and transportation. If their biggest concern was not listed, participants were provided an open response opportunity. Those that listed a response in here often talked about understanding a community and relating to them.

Participants, however, had very different opinions on how to shift priorities for students to access equitable solutions in education although there was a slight emphasis on engaging the students through providing them agency in their choice of activity and involvement. Unsurprisingly, there was much discussion on better funding all around.

PRIORITIES FOR FUTURE WORK

In addition to asking survey participants for their feedback on the current state of and their experiences with the project topic, they were also asked for input on practical resources and methods they would like to see implemented in the future. Most survey participants indicated they wanted workshops or resources on specific, related topics as a practical resource. As mentioned above, survey participants also felt that research was lacking in how informal and formal educators can work to communicate better and

what the impact on student learning is during out-of-school time activities. Practical suggestions from the survey participants included:

- access to information on clear outreach programs and/or activities that could work onsite at the informal institution or in the classroom
- providing awareness of and/or helping with resources and/or administrative barriers like time, buses and cost of program
- helping formal educators to better understand the possibilities and/or capabilities of an informal program
- improved communication and/or relationship building opportunities, especially how or where informal education can improve or collaborate with formal education.

The most commonly requested methods for the dissemination of information or requests for resources were (in order):

- workshops, webinars or resources on specific related topics – in person when possible but potentially virtually
- activities/curriculum for informal settings that align with formal education needs
- potential funding for toolkits for both informal and formal educators to work together
- resources for inter-organization communication, such as a list of tips and resources for informal and formal educators to work together to promote equity through STEAM.

In open response questions, survey participants also requested a “justification” letter or slide deck with supporting educational research showing the value of STEAM in terms of equity and education. This could be used by both formal and informal educators to get support for STEAM initiatives, partnerships, field trip approvals and professional development opportunities.

Survey participants also recommended suggestions for further research or promotion of current research. These suggestions included expanding literature on the following:

- how informal education staff and formal classroom teachers can work to communicate and collaborate better in order to support learners with the STEAM mindset
- what impact on student learning do out-of-school time activities or programs have
- what impact do informal science education programs have on career or workforce development

- how formal educators select informal learning opportunities to incorporate into or enhance their formal instruction.

Based on the survey results, cohort participants were asked, *“If we were to hand the baton to another group to further the project, what would our recommendations be for them to pursue?”* Cohort participants were asked to keep the broader project theme in mind, in addition to how informal and formal educators can better work together to promote STEAM as an effective tool for creating equity, well-being and belonging for students.

Recommendations for the Future

Workshops and webinars, in-person, virtually or as part of a conference, appear to be the most popular and requested option for furthering the project and the item that both informal and formal educators seemed to believe had the greatest return on investment for the time on task. This is, perhaps, because during one of these events those attending have dedicated their time and attention to the topic at hand and are able to focus on the content without interruption. Due to the nature of the project, and that the issue is universal and not local, a combination of online and in- person workshops is recommended. Working with organizations such as the National Science Teaching Association (NSTA), the National Science Education Leadership Association (NSELA), and Research in Science Education (RISE) will incorporate both formal and informal educators as well as school administrators and informal educational leadership. Conferences for organizations such as the Texas Association of Museums and the American Alliance of Museums would be an excellent opportunity for formal educators to express their needs to informal educators.

A specific suggestion for workshops would be to create opportunities for educators on both sides to learn how to conduct research, write up case studies, present information, etc. For example, in many cases, informal educators do not have any actual training in education. Often, they have a passion for a subject matter or discipline and have managed to find a position at a non-profit that aligns with their interests. They may have never had to conduct a program with the aim of doing research or investigating outcomes and, even if they had, they may not know how to write up the results or where to publish the information. Conversely, formal educators have access to students and a higher probability of having had training to conduct research or investigations, but they may not have the time. Formal educators could act as the control group for informal/formal investigations with minimal time commitment on their part, but a huge savings of time for the informal educator who would otherwise have to source students for comparisons. All of this is to say that having explicit, step by step trainings – possibly

with check-ins- would help educators understand the processes and see the potential would be beneficial to both sides of the project.

Providing training or workshops to this effect would certainly help provide additional research and literature to the project as well as provide informal and formal educators opportunities to work together more frequently.

CASE STUDIES

Case Study 1: Aramco Biodiversity iExplore

The Houston Museum of Natural Science has paired with Galena Park ISD and Aramco to bring students to the Museum for a program focusing on biodiversity. The program includes a live animal presentation, a trip to the Cockrell Butterfly Center, and guided curriculum for the permanent exhibit halls. To gauge the effectiveness of the program, students are required to take a 10-question pre and post-test that indicates knowledge of science topics related to biodiversity as well as their personal science identity and comfort with science. For a majority of students, this field trip is their first visit to a museum and may be their first trip from their city. 74% of participating students were considered at risk, 39% were enrolled in bilingual and English language learning programs, and 60.8% were economically disadvantaged.

Key Outcomes:

- Ongoing results from the program demonstrate an average of ~20% increase in correct answers for questions correlated to the state standardized objectives after students attended a field trip at HMNS.
- Students who attended the program were less likely to feel nervous about science after the program and were more likely to identify science as something they could participate in.

Case Study 2: Girls Exploring Math and Science (GEMS)

GEMS is an annual festival-style event hosted by the Houston Museum of Natural Science. The event is comprised of three parts: Community Booths, Student Booths, and an overnight event. This event began as a partnership with the Girl Scouts of San Jacinto but, due to staffing turnover, HMNS has been the sole host for several years. The event begins with the overnight in which girls and their mothers participate in various STEM activities before sleeping in an exhibit hall. In the morning, they wake up, eat breakfast and are then the first participants to join the festival portion of the event. In

a public area, Community Booths interact with guests. The interactions can consist of demonstrations, activities, crafts, etc. but must be STEM-related and free to participants. These activities are intentionally in a public space to reduce a barrier to participation. Additionally, student-led booths are essentially performing the same function, but the Community Booth participants are asked to judge the student booths, and a cash prize is awarded to the top three. The primary criterion for judgement is did the students do the work themselves and how well are they able to discuss their topic with the public. The primary focus is on increasing science literacy and communication among students.

Key Outcomes:

- The event requires very minimal financial support and is one of HMNS's most well-attended events annually. Average attendance between 9 am and 1 pm is 1000+.
- Both the students and community partners have expressed true enjoyment of the event.
- The entire event signals the museum's commitment to STEM education, particularly for girls, and equity in science education.

Case Study 3: Crystal Bridges Field Trips

Researchers from the University of Arkansas College of Education and Health Professions conducted a study analyzing the impact of school field trips to Crystal Bridges Museum of American Art on students in grades K–12. In the study of 10,912 students, surveyed at 123 schools, the research team found that field trips to cultural institutions have significant benefits for students. Students participating in the program received a one-hour guided tour of the museum's permanent art collection, a discussion and activity session around a theme, and a healthy lunch. Teachers were able to choose from several themes that connected to the state standards at a variety of grade levels that included art, history, social studies, language arts and sciences. Students acting as the control group had their field trips deferred to the semester after the study. They did not have access to the program independently.

Key Outcomes:

- Students retained a great deal of factual information from their tours, recalling details about the paintings they had seen at very high rates.
- Students were able to apply the critical thinking skills they practiced during the experience at a later date to an unseen piece of artwork, demonstrating an average improvement of 9.1%. Students from high poverty schools showed a

17.9% improvement in critical thinking about art and minority students showed an 18.3% improvement.

Case Study 4: The Effect of Informal Learning Environments on Academic Achievement During Elementary School

The researcher took data from an Early Childhood longitudinal study (21,000 kids over 10 years) and looked at it across years and groups. Because of socio-economic status, race, etc. that caused differences in visitation to Museums, the researcher separated the children into subgroups matched by key characteristics, including income, race, and parental education. This approach allowed her to take a closer look at a specific group of children – those who were at risk for deficiencies in cognitive or social development that contribute to gaps in achievement. This also reduced the chance that differences in achievement scores could be due to other factors, such as the lack of resources found in low-income environments.

Key Outcomes:

- Children who visited a museum during kindergarten had higher achievement scores in reading, mathematics, and science than children who did not.
- The effects were small but significant.
- This effect was seen in the subgroup of children who are most at risk for deficits and delays in achievement.
- Evidence suggests that the influence of informal learning environments, such as those found at public libraries and museums, can have long-lasting effects on academic achievement.
- The research postulated that the visit to a museum is an indicator of a family's investment in informal learning, so the impact is likely not from a single visit, but from a relationship to out-of-school learning opportunities.

Case Study 5: MARS STEAM Project: STEAM in Gifted and Talented Elementary 5th Grade Class

Visual art-driven STEAM significantly impacts teachers and their students. Over the course of six weeks, students explored the elements of STEAM through a dynamic project focused on creating water on Mars. This immersive project not only engaged students in science and engineering principles but also sparked creativity and critical thinking as they tackled this out-of-this-world challenge. Throughout the course, the informal educator collaborated with GT staff to deepen understanding of the importance and purpose of STEAM in schools, emphasizing its role in preparing students with innovative skills for the future.

Key Outcomes:

- Student post-survey results indicated 100% of students could name at least 1 of the SMART creative/innovative thinking skills and 93% of the students could name at least two.
 - Student post-survey results indicated 100% of students indicated the project helped them understand science/TEKS better.
 - Student video assessments: 90% of students said they felt they were better at solving problems than they were before this project began.
 - One teacher pointed out that the students “were completely engaged with a conversation about the TEKS (standards) at a deeper level.”
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KEY REFERENCES

Barnum, Matt. "Wealthier Students Benefit from Art, Music over Summer While Poor Kids Miss Out." *CT Mirror*, 30 May 2018.

- In this article the author reports on the findings of several studies examining the disparities in out-of-school experiences that arise as a result of rising income inequality.

Benjamin Krause Recchia & T.J. McKenna (2024) Field Trips to Zoos and Aquariums: Solving Pedagogical Challenges Using the Next Generation Science Standards, *Connected Science Learning*, 6:1, 25-32, DOI: 10.1080/24758779.2023.2300497

- In this journal article, the authors developed a guide to introduce informal science organizations as key educational resources. The study shows they explored the meaningful connections to curricula, creation of active learning activities, differentiation and scaffolding strategies, and assessment for both students and field trips. The source is valuable for demonstrating the importance of informal and formal educators collaborating to provide dynamic learning environments.

C. Schaben, C. Cutucache, N. Grandgenett, E. Mulkerrin, R.J. Hougham (2016) Supportive Structures for Successful Science Teachers' Professional Development, *ICERI2016 Proceedings*, pp. 4653-4662.

- In this article, the authors developed a professional development model to introduce K-12 educators to informal science organizations through place-based exploration. The findings showed educators developed a better understanding of content and curriculum connections while developing scaffolding strategies for diverse learners. The source is valuable for

professional development providers to design safe training environments for educators to make content connections and develop equitable learning strategies.

Castek, J., Schira Hagerman, M., & Woodard, R. (Eds.). (2019). *Principles for Equity-centered Design of STEAM Learning-through-Making*. Tucson: University of Arizona. Retrieved from <https://circlcenter.org/events/synthesis-design-workshops>

- The text highlights key principles, such as designing for learners' diverse cultural backgrounds, promoting collaboration, and integrating reflective practices to challenge inequities in educational spaces. Additionally, it offers examples of STEAM initiatives that align with these principles and addresses barriers to implementation, such as systemic inequities and access disparities.

"Crystal Bridges Museum of American Art & University of Arkansas Department of Education Reform Announce Results of a Study on Culturally Enriching School Field Trips." *Crystal Bridges*, 16 Sept. 2013, crystalbridges.org/news-room/crystal-bridges-museum-of-american-art-university-of-arkansas-department-of-education-reform-announce-results-of-a-study-on-culturally-enriching-school-field-trips/.

- Here is a completed study where half of the students at a particular school were able to go on a field trip to Crystal Bridges as the museum opened. No students saw the space before the opening. After the field trip, all students were given a test about critical thinking and observation skills, including those who did not go to the museum. They found that the kids who went on the field trip had higher critical thinking and observation skills than those who did not, and this was even more true for rural/low-income kids.

Diane Marie Vrobel (2024) Creating Equity for Black Science Students, *Connected Science Learning*, 6:1, 2-4, DOI: 10.1080/24758779.2023.2296746

- In this journal article the author studies how Black students perceive science classes and what keeps them from enrolling in advanced science classes. The study uses the community of inquiry to identify barriers students are facing. From this work the author develops a plan on how to remove these barriers. The source is valuable because it gives us a research model to put into practice to diversify STEM programs.

Domenici, V. (2022). STEAM Project-Based Learning Activities at the Science Museum as an Effective Training for Future Chemistry Teachers. *Educ. Sci.* 2022, 12(1), 30; <https://doi.org/10.3390/educsci12010030>.

- In this journal article the authors assess a STEAM based approach to explore teaching strategies while developing STEAM lab activities to be utilized in the classroom, out-of-school programs and in science museums. The pre-service teachers take chemistry concepts and design STEAM activities based on project-based learning. The source is valuable because of the research-based STEAM based professional development model used to train pre-service teachers.

Early Learning in Museums: A Review of Literature. Smithsonian Institution's Early Learning Collaborative Network and Smithsonian Early Enrichment Center (SEEC), 2012. pp. 1-27.

- A compilation of articles regarding when and how children learn in museums. A bit out of date, but an excellent resource.

Falk, John H. *Free-Choice Science Education: How We Learn Outside of School.* Teachers College, Columbia University, 2001. pp. 3-20.

- A compilation of studies and articles about how we learn science outside school. The intro, cited here, discusses the benefits of going to science museums.

Fields, D. A., & Kafai, Y. B. (n.d.). *Supporting and Sustaining Equitable STEAM Activities in High School Classrooms: Understanding Computer Science Teachers' Needs and Practices When Implementing an E-Textiles Curriculum to Forge Connections across Communities.* Emma Eccles Jones College of Education and Human Services, Utah State University, & Graduate School of Education, University of Pennsylvania.

- This article is especially relevant for educators and curriculum designers looking to integrate STEAM principles into classroom practices. The emphasis on equity aligns well with broader goals of making STEAM education accessible to underrepresented groups. The findings offer actionable ideas for incorporating art and technology into lessons while considering students' diverse needs.

Learning Science in Informal Environments: People, Places and Pursuits. Edited by Philip Bell, et al., The National Academies Press, 2009.

- Museums and other informal learning environments have been shown to be really good at encouraging excitement about science, asking questions, testing theories, encouraging people to think of themselves as scientists, & more.

Marilyn Rowell, Megan Ennes & Brian Abramowitz (2024). Co-Development of a Museum-Based Scientist-Teacher Partnership, *Connected Science Learning*, 6:1, 8-16, DOI: 10.1080/24758779.2023.2296751

- In this journal article the authors study the importance of collaboration between formal and informal organizations to develop relevant experiences for students. The key to this model is incorporating the scientist into the program. This approach adds a third dimension creating more rigorous and relevant student opportunities. The source is valuable because it is another example of demonstrating the importance of collaboration between informal and formal education.

Mulkerrin, E.A., and Hill, J.W. (2013). Relevance, Rigor, and Relationships: Student Perceptions Following Participation in an Integrated Experiential Zoo-Based Academic High School Science Program. *Creative Education*, 4, 287-297.

- In this journal article the authors study the importance of providing opportunities for students to experience and apply science and math concepts in real world situations. The source is valuable because the research shows why formal and informal education should collaborate and provide experiential learning opportunities for all students.

Mulkerrin, E. A. (2012). The Effect of a Zoo-Based Experiential Academic Science Program on High School Students' Math and Science Achievement and Perceptions of School Climate. Doctoral Dissertation.

- This article is more evidence of the importance of collaborating.

Mulkerrin, E., Leising, A., and Sykes, T. (2018). On the Job: Job Shadowing and Internships Open Doors to STEM Careers. *The Science Teacher*, July, 2018, 31- 37.

- In this journal article, the authors talk about the importance of formal and informal science educators developing opportunities for students to apply content knowledge to real world applications in a business setting. The article explains how providing opportunities for students to apply their knowledge and learn about diverse STEM careers opens the doors to diversifying the STEM profession. The source is valuable to demonstrate formal and informal education working together to provide equitable opportunities for all students to explore STEM careers.

Mulkerrin, Elizabeth. (2016). Zoo Academy: Effective Collaboration Between Local School Districts and Omaha's Henry Doorly Zoo and Aquarium Creates Unique Opportunities for High School Students. *Connected Science Learning*, 1, 1-6.

- In this journal article the author explains the importance of formal and informal education creating a collaboration to create equitable opportunities for students to make relevant connections to STEM curriculum. The source is valuable to demonstrate formal and informal education working together to provide equitable opportunities for all students to make relevant connections to science concepts.

Musco, Miriam Ed.D. "Disparity of Informal Education Between Low- and High-Income Neighborhoods." *Theory and Practice*, vol. 1, 2018, https://articles.themuseumscholar.org/2018/06/04/tp_vol1musco/.

- A discussion of the disparity in informal education between lo-and-high income neighborhoods and attitudes about and availability of informal education spaces for low-income individuals. Includes several interesting sections about what low-income individuals thought about museums as well as expectations/reality.

Rethink Together. (2022, January 13). *What is STEAM education?*

<https://xqsuperschool.org/rethinktogether/what-is-steam-education/>

- This resource is useful for educators seeking to implement STEAM approaches in classrooms and for understanding how the arts enhance STEM learning. The examples and real-world applications discussed in the article offer practical insights into creating engaging, inclusive learning environments.

Swan, D. W. (2014, April). *The Effect of Informal Learning Environments on Academic Achievement During Elementary School*.

- Visits to museums and libraries, specifically during early childhood, indicate a correlation with higher academic achievement in later elementary.

Vergeront, Jeanne. "Creativity and Museums." *Museum Notes Blog*, 30 Mar. 2013.

<https://museumnotes.blogspot.com/2013/03/creativity-and-museums.html?m=1#:~:text=Museums%20are%20exceptionally%20well%20positioned,artists%2C%20inventors%2C%20and%20innovators.>

- Museums are uniquely positioned to infuse creativity into learning and development. Museums, however, must consciously choose to affect this role, a decision which may require a cultural shift in an organization.

Woodruff, K.A. 2022. Connecting educators through equitable and reflective practice. *Connected Science Learning* 4 (3). <https://www.nsta.org/connected-science-learning/connected-science-learning-may-june-2022/connecting-educators-through>

- Reflective practice is about being present in teaching so that we can fully understand how students are learning