



## **Transformation of STEM to STEAM – How a traditionally run STEM camp successfully incorporated the ARTS into its framework resulting in a successful STEAM Camp (Work in Progress)**

**Dr. Arthur D. Kney, Lafayette College**

Arthur D. Kney received his doctorate of philosophy (Ph.D.) in Environmental Engineering from Lehigh University in 1999 and his professional engineering license in 2007. He is currently serving as an Associate Professor and Department Head in the Department of Civil and Environmental Engineering at Lafayette College.

Throughout Kney's career he has been active in the community, at the local, state and national level. He has served as chair of the Pennsylvania Water Environment Association (PWEA) research committee, chair of the Bethlehem Environmental Advisory Committee, vice president of Lehigh Valley Section of the American Society of Civil Engineers (ASCE), secretary of ASCE/Environmental and Water Resources Institute (EWRI) Water Supply Engineering Committee and been a member of the AWWA/ASCE WTP Design 4th Edition Steering Committee. He currently serves on the states PWEA Research Committee and Water Works Operators' Association of Pennsylvania (WWOAP) scholarship committee, and locally on the Bethlehem Backyards for Wildlife committee, the Bushkill Stream Conservancy board, the Wildlands Conservancy's Education Advisory Team as well as a number of Lafayette College committees. Recognition for his work have been provided through a number of awards; most recently the PA Water Environmental Association (PWEA) 2010 Professional Research Award and the 2010 Delta Upsilon Distinguished Mentoring and Teaching Award; 2010 Aaron O. Hoff Award.

Kney's areas of interests include water/wastewater treatment (including industrial wastewater treatment) and sustainable engineering focusing on urban sprawl and its environmental effects on watersheds. Most recently he has begun to explore methods to integrate undergraduate and K-12 education in innovative ways.

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## ***(Work in Progress)***

### *Introduction*

Summer 2014 marked a transition from STEM (Science, Technology, Engineering, and Math) to STEAM (Science, Technology, Engineering, **ARTS**, and Math) with the incorporation of the Arts into an existing informal educational model used to enhance K-12 education in an out-of-school program – a day camp experience for 60 children. This camp infused Art into engaging activities and pointed educational modules designed to teach 4<sup>th</sup> - 6<sup>th</sup> grade campers how the STEAM fields work together to create “Our Beautiful World” (the 2014 camp theme) and how these fields can influence the movement towards a more sustainable lifestyle. The modules spanned over four days and the themes were integrated into a final group project where each group created a balanced, self-sustaining community on the template of an island that was provided. Our long-term goal includes working to better understand how to improve the efficacy of informal environmental education for students through after-school activities and summer camps such as the one outlined in this paper.

### *Objectives, Goals and Outcomes*

Growing from previous years’ STEM camps, the Lafayette College STEAM camp incorporated the Arts into its model of education. Our short-term goal for this camp is to develop a template from which to present fun and engaging activities alongside pointed modules to teach 4<sup>th</sup> - 6<sup>th</sup> grade campers how the STEAM fields work together to create “Our Beautiful World” and how they influence the movement towards a more sustainable lifestyle. We operated under the Brundtland Report’s definition of sustainability: “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (Keeble, 1988).

Intended learning outcomes included:

- An increased cognizance of the environment and sustainability
- The role of the Arts in the STEAM fields and how they can enhance practices
- Understanding how an individual can change their behavior to live more sustainability
- Understanding how society can change present behaviors to help maintain the planet’s limited supply of resources for future generations.

### *Long Term Goal*

Our long-term goal was to better understand how to improve the efficacy of informal environmental education for students through after school activities and summer camps such as the highlighted in this paper.

Informal environmental education practices, focused on sustainability with an intent to expose students to critical environmental issues, will ultimately influence society’s future economic, social, and ecological dimensions (Committee on Learning Science in Informal Environments, 2009; Falk & Dierking, 2000; Bartels & Parker, 2012; Munier, 2005). By exposing students to the concept of sustainability, which is not formally taught in standard school curricula (The

Commonwealth of Pennsylvania, 2014), students will be more knowledgeable of one of the most pressing concerns facing our planet's future: how to sustainably use our resources now, in order to ensure that future generations will have access to these same resources, without compromising standards of living (The World Commission on Environment and Development, 1987; Committee on Incorporating Sustainability in the U.S. Environmental Protection Agency, 2011).

Informal sustainability-themed modules are developed to support what is taught in a typical classroom setting and to enhance standardized curricula. Students should be able to take the core science concepts communicated in school and apply these concepts to the ideas presented in sustainability-focused activities (The Commonwealth of Pennsylvania, 2014). Informal education describes education that takes place outside of the standard classroom-learning environment, in a less structured setting that shifts the management of learning from the teacher to the student (Eshach, 2007; Gerber et al., 2001). Traditional public education follows teacher centered learning methodologies, whereas informal education modules, such as those developed in this case study, encourage learners to be more motivated and responsive towards experiential, individualized learning.

The framework used to develop informal sustainability modules is based on experiential learning methodology. Research has shown that students better grasp and connect with topics presented, and develop critical thinking skills, when experiential learning techniques are utilized (Brophy et al., 2008, Falk & Dierking, 2000, Barriault & Pearson, 2010; Committee on Learning Science in Informal Environments, 2009). Assessment tools were developed to quantify the extent to which students achieved the identified learning outcomes.

#### *Leadership Team*

Two Lafayette faculty members, one from Humanities and one from Science/Engineering, supervised the entire project. Faculty members were responsible for mentoring student leaders, one from the Humanities and one from Science/Engineering, and guiding the production of the overall event. Two Lafayette student leader positions were selected from a group of 15 applicants through a rigorous interview process. Chosen student leaders were responsible for all aspects of the event; advertising the event, working with parents and children, pulling together the final team of 25+ volunteers (comprised of faculty, students, and community members), creating the learning modules, etc. Midway through the summer, an opportunity to include two K-12 professional teachers came about. Their support turned out to be quite valuable. This past year, we also pulled together a group made up of past student leaders and invested community members to oversee program, acting as Board Members in order to better manage it as we move forward.

#### *Benefits to Participating Volunteers - College/High School Students and Faculty*

The premise behind volunteers' benefits comes from the idea that "teachers know that you never really learn a subject until you teach it" (Lancor and Schiebel, 2008). With this in mind, an additional objective of the overall camp is to have college and high school students put the knowledge they have gained in their precollege and undergraduate career into active practice. Over the last three years, faculty leads have witnessed the value of this program in many ways, the most important, from an academic perspective, being the excitement and academic confidence that comes as the students take responsibility for the design and outcome of the camp

modules. This unfolds as the students draw on their education and translate it into lessons for the kids. In addition to the academic connection to our students' growth, they also have the opportunity to develop leadership, communication, community relations, and organizational skills.

Benefits to faculty come from the opportunity to work with students they normally would not work with. With the current framework of the camp, faculty members now have the opportunity to work in a multidisciplinary framework. They are also presented an ideal opportunity to connect with community members, and in-turn providing a valuable community service by helping educate future college students - an opportunity all faculty should strive to seize. Lastly, this experience provides students opportunities to take part in educational scholarship.

*Profiles of Camp Participants*

The camp was designed for students ranging from 4<sup>th</sup> to 6<sup>th</sup> grade. The summer 2014 STEAM camp had 60 children between 3<sup>rd</sup> and 7<sup>th</sup> grade participate (Table 1). Out of all campers, 29 were female, and 31 were male. Campers were charged a fee of \$50. Three full scholarships and two partial (half-priced) scholarships were given. Out of the 40 campers who provided their schools districts, eight known school districts were represented (Table 2). Donations from local Lehigh Valley businesses helped to fund scholarships. The camp roster was filled on a rolling admission basis; campers registered with a basic registration form via mail or email attachment. Registration forms were distributed through an email list of previous attendees and community partners.

Grade	Frequency	Percent (%)
3 <sup>rd</sup>	1	1.6
4 <sup>th</sup>	8	13.3
5 <sup>th</sup>	19	31.7
6 <sup>th</sup>	29	48.3
7 <sup>th</sup>	3	5.0

Note: 3<sup>rd</sup> and 7<sup>th</sup> graders were accepted upon early request of parents.

School District	Frequency	Percent (%)
Allentown	1	2.5
Bangor	4	10
Bethlehem Area	3	7.5
Easton Area	26	65
Lehigh Valley Academy	3	7.5
NCEA	1	2.5
Salisbury Township*	1	2.5
Southern Lehigh	1	2.5

Note: Only 40 campers provided this information.  
\*NCEA = National Catholic Education Association

### *Cost of Camp*

The final cost of this event was about \$15,000. The following groups supported the cost for this event:

- Mellon Foundation (\$10,000 – Student lead summer salaries and K-12 teacher support)
- College Organization, CBLR (\$1,000 – Various colored T-Shirts for student and group leaders)
- Application Fees and Community Support (about \$3,000 was raised through application fees and professional sponsors)
- College Student Club (the remaining \$1,000 for materials)

Housing for student leads was provided through college support. Faculty leads provided support voluntarily.

### *General Procedure*

Module presenters, counselors, and other helpers were recruited chiefly on a volunteer basis from Lafayette College faculty and summer research students, local high schools, community partners, and family friends. All adults completed a background check in order to work with children.

Campers were split into six groups of 10; stratified by age. Each group was assigned a color: Red, Orange, Yellow, Green, Blue, and Purple with 1-2 camp counselors per group. Counselors led their group through each day with a provided daily schedule, broken up by time, room number, and module. Camp started Monday, August 4<sup>th</sup> and ended Thursday, August 7<sup>th</sup>, 2014. Campers arrived around 9 AM and were picked up around 4 PM. Campers progressed through three modules a day, filling out worksheets on each module in their own “Lab Notebook.” At the end of each day, campers had around an hour to work on a final group project. The project was to create a sustainable community on a small, isolated island provided. Campers had to provide enough food and energy for each house they placed on the island, along with incorporating three other aspects of a community (schools, police station, shopping malls, etc.) while maintaining certain features of the island, like wetlands. Campers were to use the lessons of each module to shape their community. The template was a geographical map of Mitiaro Island, part of the Cook Islands, located in the South Pacific Ocean.

### *Education Modules*

Each module developed was to have one focus rooted in one part of STEAM. However, at least one other aspect of STEAM was also incorporated to facilitate the interdisciplinary nature of the camp. With the new introduction of the Arts into the camp model, we strived to incorporate a humanities aspect into each activity, hoping to broaden the appeal to students with varied interests.

Below is a summary of each of the modules executed during the summer 2014 Lafayette STEAM Camp.

**Hitting Our Stride: The Mathematics of Percussion:** Using college-owned Djembes, campers heard and played drum rhythms from their own and foreign countries. Campers not only learned

about different ways to combine different time signatures mathematically, but also how they feel and sound.

**Weather or Not, Here it Comes: The Facts about Climate Change:** This module explained the water cycle and how climate change affects the natural patterns of weather and climate. Campers modeled rain formations and see how glacier melting and sea ice melting effect water levels.

**Flipping Out: Lenses and Perspectives:** This module modeled and engaged campers in the fluidity of vision. Students were shown how lenses can twist our interpretation of the world and how different perspectives can influence our visual and mental perceptions. This module intended to show campers that there is not a singular, all-objective way to view a problem or the world.

**Lights, Camera, ACTION! The Science of Color:** Using college theater equipment, campers saw how colors, in both pigments and light, could be manipulated by lighting. Campers sorted M&Ms® under different stage lights, seeing how adding and subtracting light waves change our perception of color and that our eyes are not as objective as we think.

**Alphabet Soup: The Moving Parts of Poetry:** By drawing off poetry's connection with music and rhythm, this module aimed to reconstruct pre-existing notions of poetry as "boring." Instead, we hoped to show campers how poetry is a tool for learning, along with expression.

**Connecting the Dots: Polymers:** With a wide variety of take-home recipes, this module aimed to teach kids the basics of plastic technology and how this science can be applied for environmental purposes.

**Moving on Up: Alternative Energy:** Working with a community education partner, campers saw various engines and the different fuels that move them. With the aid of an actual wind turbine and several functioning solar panels, campers witnessed and engaged in the application of different models of harnessing energy.

**Breaking it Down: Composters:** After explaining the importance of a closed food loop, campers actively participated in sustainable practices by painting composters that were raffled off to parents on the last day of camp.

**Green Apple Day Activity: Landfills:** Working with a community partner in the Green Buildings Council, as a kick-start for GBC Green Apple Day of Service, this activity demonstrates landfills and recycling. Campers created personal landfills to take home and bury for a month to see how different products breakdown.

**Bridging the Gap: Toothpick Bridges:** After seeing current and historical bridges, campers will use cost analysis to buy supplies and build their own bridges. Bridges were judged on their ability to hold a certain amount of weights and the amount of materials used.

**Food for Thought: Where does your food comes from? :** Explaining the difference between artificial, organic, and local food, this module taught the journey our food takes from the ground

to the grocery store. Campers tasted the difference in select store bought, organic and local foods (peaches, honey, maple syrup, and yogurt) in a blind tasting activity.

**Out with a Bang! Chemical Reactions:** Going out with a bang, this module demonstrated to campers various indicators of chemical reactions. With explosive examples, campers saw reactions between household items in a scientific setting.

### *Showcase Event*

All of the modules, which spanned over four days, were integrated into a final *community showcase event*: each student group created a balanced community on the template of Mitiaro Island. Parents and community members were invited to attend the event, which lasted about two hours. Each group presented their models in a professional manner to invited parents and Lehigh Valley community members.

### *Surveys*

Empirical assessment of the academic success of the camp was measured. Campers were given a pre- and post- survey to be completed to track student development. Parents and campers gave informed consent with a Lafayette College IRB-approved form that was collected and kept in a secure location. Campers were assigned a number to write in lieu of their name of their pre- and post- surveys. Pre surveys were given to all groups at the start of camp before any modules or activities were completed - with the exception of the Green group, which completed their pre-survey at the start of Day 2. Post surveys were given to campers after all modules and activities were completed, before the final group project presentation. The campers were also asked to draw a picture of their “Beautiful World” in relation to STEAM fields during pre- surveys, to be added onto during post surveys in a different color.

Results were analyzed with a statistical software package using paired samples t-tests for ten questions. Questions were quantified as followed. Open-ended questions were graded on a 3-point scale:

- 1 Point - Question left blank or sloppily answered (few or no words).
- 2 Points - Answered partially answered, not clearly thought out and/or incorrect defined.
- 3 Points - Meaningfully and thoughtfully answered and/or correctly defined.

Question 1: What does each letter of STEAM mean?

- Campers could earn up to 5 points.
- Pre: Campers were given 1 point for each letter of STEAM they correctly identified.
- Post: Along with identifying the letters of STEAM, campers were also asked to give an example of how each letter can change the environment.

Question 2: The theme of our camp is “Our Beautiful World.” How do the letters of STEAM work together to make “Our Beautiful World”?

- Campers could earn between 1 and 3 points.

Question 3: Put the Steps of the Scientific Method in order. Number 1 - 6 on the correct line.

- Campers could earn up to 6 points.
- Campers earned one point for each correctly labelled line.

Question 4: What do you think the word *organic* means?

- Campers could earn between 1 and 3 points.

Question 5:

- a) What do you think the word sustainability means?
- b) What does it mean to live sustainably?
  - Both parts of this question were awarded between 1 and 3 points.
  - Scores were compounded for a maximum of 6 points on this question.

Question 6: Fill in the bubble of the best answer.

- a) When buying peaches, which option is more sustainable?
- b) It is most sustainable to put my leftovers:
- c) About how long does it take a plastic water bottle to break down in a landfill?
  - There were two options provide for each question.
  - Campers were given 1 point for a correct answer, 0 points for incorrect answers.
  - Scores were compounded for a maximum of 3 points.

Question 7: Match the correct letter to the type of energy it is. You can use the answers more than once.

- There were eight different types of energy to be categorized.
- Lines labelled correctly were given 1 point and lines labelled incorrectly or as “I don’t know” were given 0 points.
- Scores were compounded for a maximum of 8 points.

Question 8: I think about where my fruits and vegetables are grown.

- Answers were on a 4-point Likert-type scale.
  - 1- Always, 2- Sometimes, 3- Rarely, and 4- Never.

Question 9: I believe that I live in a sustainable world.

- Answers were on a 4-point Likert-type scale.
  - 1- Completely Agree, 2- Agree, 3- Disagree, and 4- Completely Disagree.

Question 10: I believe that my actions can change the environment.

- Answers were on a 4-point Likert-type scale.
  - 1- Completely Agree, 2- Agree, 3- Disagree, and 4- Completely Disagree.

“Our Beautiful World” Picture:

- The picture was quantified with the number of sustainable aspects or STEAM aspects that the campers added at the end of camp.

### *Results*

Examples of the student pre- and post-tests are provided as an addendum to this paper. They are provided simply for academic curiosity and therefore are not ranked in any particular order. As we develop our education strategy, we are considering qualitative and quantitative metrics to measure overall outcomes. The following provides a quantitative review based strictly on our Pre- and Post-tests.

- **Question 1** was disregarded because the pre- and post- survey questions were not statistically comparable.
- Campers showed a significant change in **Question Two**, where the post survey scores ( $M = 2.45$ ,  $SD = .68$ ) were significantly higher than the pre survey answers ( $M = 2.1$ ,  $SD = .69$ ),  $t(59) = -3.29$ , and  $p < .05$ .
- Campers showed a significant change in **Question Three**, where the post survey scores ( $M = 3.43$ ,  $SD = 1.71$ ) were significantly higher than the pre survey scores ( $M = 2.77$ ,  $SD = 1.75$ ),  $t(59) = -2.92$ , and  $p < .05$ .
- Campers showed a significant change in **Question Six**, where post survey scores ( $M = 2.23$ ,  $SD = .77$ ) were significantly higher than pre survey scores ( $M = 1.8$ ,  $SD = .78$ ),  $t(59) = -4.99$ , and  $p < .05$ .
- Campers also showed a significant change in **Question Seven**, where post survey scores ( $M = 6.12$ ,  $SD = 1.58$ ) were significantly higher than pre survey scores ( $M = 5.7$ ,  $SD = 1.65$ ),  $t(59) = -2.28$ , and  $p < .05$ .
- There was no significant change between pre and post surveys on any other quantified questions.
- Campers added an average of 2.56 new components to their picture between pre and post surveys ( $SD = 1.96$ ,  $N = 50$ ).

### *Discussion and Analysis*

Although no change occurred between surveys on the Likert-type questions, it is interesting to note the average feelings of the campers on issues of sustainability and their own ability for change. In general, campers noted that they believed their own actions are important for environmental change. They also generally noted that they thought about where their food comes from, showing that the younger generation can be environmentally conscious.

Due to the nature of the camp, environmentally and academically minded parents are more likely to pay for their children to attend this type of camp. Therefore, the campers who attended do not necessarily reflect the beliefs of the younger generation as a whole. Regardless, the campers all indicated that they had fun and liked most activities, indicating that the activities successfully incorporated a component of sustainability and the STEAM fields in an enjoyable manor.

There are a few possible reasons for a lack of change of answers. The surveys could have been too long, especially for the younger groups, explained by the fatigue affect. Because the organizers did not teach the modules that they wrote, there could have been a disconnect between the specific wording of the questions and the information taught during the modules. The module presenters did not “teach to the test.” Presenters focused on engaging the campers while helping them understand the desired topics of each module. It is also possible that four days is not enough time to change the beliefs of 3<sup>rd</sup> - 7<sup>th</sup> graders.

Because there was a goal to create new modules and because the amount of modules increased from previous years, consistency between module topic and theme was not as strong as previous years. There are a few ways to approach this issue for future camps. If sustainability is to remain a focus in most/all modules, then future camps may want to rotate through previously used modules on a 3-4 year basis. Assuming the age range goal stays between 4<sup>th</sup> and 6<sup>th</sup> grade, in three years, most campers should have aged out of camp eligibility.

STEAM Camp 2014 was organized mostly over the course of a ten-week research experience between two students. Student leaders were hired near the end of the spring semester, and had a few pre-summer brainstorming meetings before the summer work began. If the camp is to be sustained at its present length and attendance, the 2015 team suggests starting earlier, mainly for the following time-sensitive issues that were encountered.

- Firstly, distributing registration forms to all eligible students; most schools have an approval process they need to go through before they can give their students outside handouts. We were able to reach five school districts because of personal connections. The earlier date also allows for a more even distribution to all of the students, creating uniform accessibility to all students and families.
- Secondly, help was needed for the daily running of STEAM camp, therefore it is strongly suggested that volunteer recruitment start around the same time of camper registration. Counsellors and modules presenters were recruited on a volunteer basis. Student leaders were unable to rely wholly on other Lafayette College summer research students (i.e., students housed on campus throughout the summer) and needed to recruit volunteers from local high schools and family friends. The 2014 student leaders encourage such community involvement for future camps, especially high school aged volunteers. However,
- Lastly, permission forms that the parents sign need more detail. There was a situation where we had to send a camper to the hospital and incomplete guardian contact was obtained. On future forms, it may be necessary to include an *\*in case of emergency\** clause and insist that the emergency contact number be different from the parent/guardian number.

### *Student Leader Perspectives*

Comments from Student, Nicole Bauer '16:

From a personal perspective, I found that organizing this camp has been one of the most rewarding experiences of my lifetime thus far. I was astounded by the creativity of all the campers I interacted with. They asked brilliant questions, and, although the group projects were never objectively quantified, I believe that they were a wonderful example of the STEAM model of education. This is a program whose merit I firmly believe in, and I sincerely hope to see it continue.

Comments from Student, Emily McGonigle '15:

When I was younger, I was introduced to the STEM fields through a camp put on by a local college. Being able to provide a similar opportunity to the children in the area is one of the most fulfilling experiences I have had the opportunity to participate in. I was able to watch the children dive into the activities and, not only come out understanding the material, having a great time. I believe that introducing the STEM fields through a stress-free, fun environment, helped through the incorporation of art, will help kids become more interested in ideas that can normally be seen as “difficult.”

### *Moving Forward*

We continue to believe that informal education activities, such as summer camps and after school programs, can be beneficial for K-12 students. However, the delivery of educational

modules, presented in a manner that students can capture important learning point while staying engaged, can be challenging. We have begun to address this by improving our survey process and collaborating with professional K-12 teachers. The addition of the Arts into the STEM framework proved to be a tremendous success, as evident by comments and behavior of our young campers and through feedback from parents. The actual cost of putting on such an event is high, currently about \$250 per child; therefore, as we move forward, we will consider ways to make the event more cost effective. When considering other events we have done, sixty 4<sup>th</sup> through 6<sup>th</sup> graders is about the maximum number of campers that the current framework can admit without reducing effectiveness. When considering the educational modules are tied together through the showcase event, we feel a duration of four days is most beneficial for the campers; in the past, we have found that three days has infringed on the quality of the experience.

As this is a “work in progress,” future plans include:

- Continuation of the STEM camp as a STEAM Camp
- Continued effort to improve the efficacy of our assessment process
  - Use of past data to establish a database to aid in iterative improvements
- Better understand how the introduction of “Arts” into STEM improves learning outcomes and/or general framework of the education modules
- Establish a website where our developed education modules will be made available to others
- Integrate the support of K-12 teachers into the program with the intent to inform/collaborate on how to improve the efficacy of the delivery and messages presented through STEAM Camp informal environmental education program
  - Although difficult, considering efficacy of the STEAM camp programing, determine how we might track students as they move through their formal education programs following a summer camp experience
- Better understand how our volunteers and students leaders benefit from their involvement in this event

In conclusion, our team believes that the introduction of the Arts’ into the STEM model was beneficial to the intellectual development of the campers. With our developed template, our key short-term goals were satisfied. We continue to our address the long-term goal, as highlighted above. Overall, the STEAM camp event has been a very positive experience for all involved and we will continue to develop it into what we believe to be a valuable community asset.

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