

An Analysis of STEM Learning Facilitation in Informal Educational Environments

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Introduction and Context

As part of a National Science Foundation project, Wise Guys & Gals—Boys & Girls as *WISEngineering* STEM Learners (WGG)¹, we researched the effectiveness of having personnel with little or no formal teaching background facilitate middle-school level engineering design activities. WGG introduces blended learning activities. Youth begin with a design challenge that includes specifications and constraints for the solution. At key points, they are queried regarding their understanding as youth construct a model of their design and evaluate how well it meets the specifications and the constraints. *WISEngineering*² is the online learning platform used to introduce youth to each design challenge. Through this virtual platform, youth acquire the knowledge and skills needed to complete the challenge. Design challenges include such activities as “design a speaker” or “build a prosthetic leg from newspaper.” Our study took place in partnership with Boys & Girls Clubs where Learning Facilitators, the Boys & Girls Club personnel who direct the activities, guided youth through the activities. Since a key to the success of the project were the Learning Facilitators, our study focused on their role.

Currently, the WGG project is collaborating with 16 Boys & Girls Clubs in three states. Each club has a Learning Facilitator who directs the activities. Learning Facilitators engage the youth in the activity, provide relevant materials, and support learners in their designs. At any point in the activity, they may need to answer queries from youth about the design challenge. In essence, they are the teachers in this informal learning environment. However, in terms of educational background, they often have limited, if any, STEM or teaching background. Some Learning Facilitators in our study were part-time undergraduate students, others had baccalaureate degrees, none were teachers. Of the 16 Learning Facilitators who participated in this research, only 50% reported having even some STEM background (e.g., managing STEM programs at diverse institutions, web design, etc.) Further, we experienced significant staff-turnover during our study. Each year there was up to a 50% turnover among Learning Facilitators. This presented a pressing need to provide strong professional development so all Facilitators, regardless of background, could implement each activity.

To meet this need for a robust professional development experience, we created both print and virtual resources for each activity. Learning Facilitators were provided access to short video guides and written guides. Both types of guides were accessible from smart devices or computers and viewable on phones. The written guides also contained links to additional resource materials.

This report presents findings from data collected from fall 2017 through spring 2018. It builds upon four years of studying WGG. Learning Facilitators engaged youth in 15 varied activities such as designing a speaker, designing a shoe or designing slime. Our sample included 425 unique learners and 16 Learning Facilitators. Some clubs arranged for a single cohort of youth

to engage in multiple WGG activities while other clubs had different learners participating from activity to activity.

Research Questions and Design

This study examined the attributes necessary for good facilitation. The research questions are: What factors enable Learning Facilitators to successfully implement WGG activities? What factors impede Learning Facilitators implementing WGG activities?

Data for the study were collected from and about Learning Facilitators using a variety of sources.

- **WISEngineering Data**: Following each WGG activity, Learning Facilitators were asked to provide written reflections about implementation of WGG and youth outcomes. The written reflections were completed immediately following youth completion of an activity and were recorded within the *WISEngineering* program. The analyses examined data within and across activities as well as over time for indicators of growth in understanding.
- **Facilitator Survey**: Learning Facilitators of WGG activities responded to a survey about their experiences with *WISEngineering*, implementation of the WGG activities, WGG professional development and youth engagement and learning from the experience. The survey included multiple choice and open-ended questions, providing facilitators an opportunity to provide individual answers. Responses were examined by question within and across clubs. Whenever possible, questions were grouped to develop a deeper understanding of the WGG experience. Since the number of data points is small (and completion was voluntary), most data were treated descriptively, telling the story of WGG at the club.
- **Facilitator and Club Leadership Interviews**: Club leaders and facilitators participated in interviews about their club's approach to professional development, implementation and youth outcomes. Unlike the surveys that were completed individually, the interviews often include multiple people and explored topics in greater depth. The interviews were recorded transcribed, and analyzed to identify underlying themes related to the goals of WGG. Underlying common themes were explored using qualitative coding method.
- **WGG Annual Report**: Every six months the Boys and Girls Clubs submitted data about their involvement in WGG, the number of youth engaged, and other questions related to planning and delivery. These reports included both descriptions of the WGG experiences as well as quantitative data about delivery. The reports were coded and the data entered into a WGG club-level database.

In examining the data, several factors emerged about those Learning Facilitators who excelled at conducting the WGG activities. These factors fell within two major themes: 1) Facilitator Preparation and Experience and 2) Engagement of youth. These are discussed below.

Successful Facilitation: Facilitator Preparation and Experience

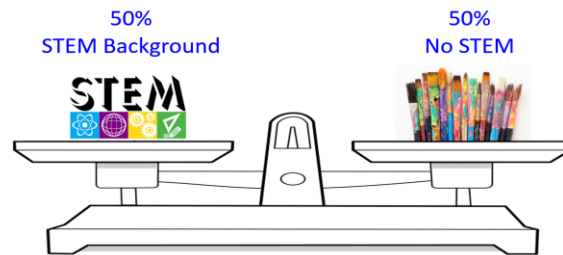
In formal education, the level of experience and training of the teacher is often a strong indicator of program or curriculum success or at least the likelihood that a program will be successfully delivered. We initially believed that a background in STEM would be very useful for implementation of WGG. However, in analyzing the data, several excellent Facilitators had no STEM background and whether the Learning Facilitator was a part-time or full-time staff member did not meaningfully contribute to success..

Of the 14 Learning Facilitators who provided information about their STEM educational background, approximately half reported minimal if any STEM background. Instead, there was a wide range of backgrounds among Facilitators including arts education, sociology, accounting, and general studies. Among the group with at least some STEM related background, most described experiences in information sciences and computer sciences. For instance, they often reported knowledge of how to use animation software and robotics. Only one of the seven had experience with engineering, a person who was pursuing an undergraduate degree in engineering. However, we found the level of experience at a club tended to shift frequently since Learning Facilitators turnover was common. Over the past four years, approximately 50% of the Facilitators were new each year. Furthermore, a STEM background did not necessarily provide an advantage. We found Learning Facilitators with and without a STEM background equally relied on the training videos and written support for implementing the activities with youth.

Facilitators vary in their STEM capability



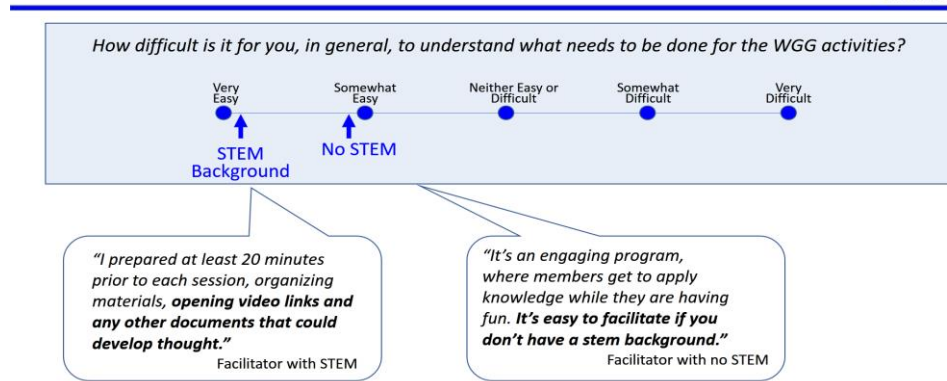
WGG Facilitator Skill Set



Note: 50+% Facilitator turn over between years

We were also interested in understanding how easy or difficult Learning Facilitators found it was to lead a WGG activity. Ratings were made on a 5-point Likert scale, where 1 was very easy, 2 somewhat easy to 5 being very difficult. Among Learning Facilitators with a STEM related background, six found the activities very easy and one found the activities somewhat easy, giving a weighted average response of 1.1. Among the Learning Facilitators who did not have a STEM background, two rated easiness as 1.0, four rated easiness as 2.0 and one rated it as 3.0. (The latter had an associate’s degree in General Studies.) The overall average for this group was 1.9, only slightly higher (i.e., indicating more difficult) than the STEM experienced group. Overall, 57% of the Learning Facilitators (8 out of 14) indicated that the activities were very easy to run; 36% (5 out of 14) indicated the activities were somewhat easy to run; and only one Facilitator, 7% ,indicated the activities were neither easy nor difficult to run. None reported the activities were difficult or very difficult. From this finding we deduced that the Facilitators could readily implement the activities.

Virtual facilitator training is effective



While a STEM background was not necessary, preparation was a key factor for successful implementation. In terms of preparation, the use of the printed Facilitator Guide was most often identified as a key to success. In particular, Learning Facilitators reported printing it out and having it available was important. The Facilitation video was more often used as a supplement rather than the main guide. Among those Learning Facilitators who struggled to implement the activities, they were more apt to rely on the video as the primary or sole source. Organization of the supplies and making sure all supplies were available was also important for success. Doing the project ahead of time, or doing elements of the project ahead of time was another key to success.

Since the WGG management team was aware that Learning Facilitators had very different STEM backgrounds it was decided to ask Facilitators to introduce easy and intriguing activities first (the order was determined based on pilot studies) and then introduce more complex ones or ones that took more time. In essence, we believed this would help scaffold Facilitators learning about how to deliver activities. This approach was expected to help Learning Facilitators to develop experience and expertise while also building youth engagement. However, several clubs examined the activities and decided on their own the order in which the activities would

be delivered. Typically, the order was different from that recommended by the project. Clubs reported a variety of reasons for shifting the order, ranging from logistical to youth interest. Surprisingly, the order in which activities were delivered did not affect how successfully they were implemented or the level of youth engagement. In hindsight, allowing clubs to select the order gave the Learning Facilitators more control and perhaps increased their motivation to run the activities well.

We also found a basic understanding of technology was important. Facilitation required the use of technology. *WISEngineering* was created for delivery on a computer. Although the Boys and Girls Clubs that we worked with claimed they had computers for WGG, this often turned out to be untrue. Therefore, we adapted the *WISEngineering* software to run on tablets using wi-fi. The project purchased tablets for clubs to use so there would be consistency across all clubs and helped each club set up the tablets. Learning Facilitators needed to be able to manage accounts, passwords, and monitor Wi-Fi strength. We developed strategies to deal with these issues, including creating videos and simplifying all instructions. The need for preparedness was a theme in this work as well. However, a series of challenges related to wi-fi strength, and tablet connectedness when left dormant for too long continued to frustrate users and project staff. Currently the project is creating a downloadable app that will run on personal smart devices. We expect this will further mitigate the technological problems by allowing Learning Facilitators and participants to use devices with which they are more familiar.

In summary, good preparation trumped a STEM background. The activities and the guides were created with this goal in mind. We found Learning Facilitators with no background in STEM or limited experience working at a Boys & Girls Clubs did just as well as those with experience. Implicit is the importance of the confidence that Learning Facilitators had in conducting the activities. Finally, we found from a project management perspective it was essential to continuously study implementation and what factors mediated success or challenges.

Engaging Youth

Building youth anticipation and interest was also a key strategy of successful Learning Facilitators. At Boys and Girls Clubs, Learning Facilitators are often tasked with engaging children in STEM activities that occur at the same time as non-academic activities such as basketball. The competition is challenging when the alternative activities are perceived as more fun and engaging. Creating interest among the youth in WGG was accomplished in a variety of ways and the approaches were often specific to individual clubs. For example, at one club, pictures related to the activity were posted on a public whiteboard. The pictures were designed to be provocative and engaging, such as showing athletes with a prosthesis in anticipation of the Prosthetic Leg design challenge. At another club, STEM professionals and their work associated with the content of the activity were featured.

Marketing the WGG activities was extremely important. Since most BGCs did not have a consistent cohort of children doing the WGG activities, this effort was on-going. Building interest in a prior activity often helped recruit youth for the next activity. Another successful

strategy often reported by the clubs was sharing highlights of upcoming activities. In essence, clubs engaged youth themselves in creating a buzz as the activity began. Some clubs at the beginning of the activity began by engaging all youth participants in a group discussion about the design challenge as a way to build interest and sometimes encouraging competition, such as teams building a structure to support the greatest number of books.

As Learning Facilitators began delivery of an activity they reported it was often a balancing act to allow youth to find their own solutions without providing the a “correct” answer or too much direction. The type of engineering design solutions that WGG introduces do not have a unique correct answer. Rather they have a correct process. Successful Learning Facilitators provided feedback and encouragement while allowing for some frustration. This was critical for engaging youth and typically led to youth being proud. The need to provide support, yet allow for frustration, sometimes contrasted with youth’s expectations developed from school experiences where a teacher helps students find the correct answer. Some successful Learning Facilitators described how as they developed confidence implementing WGG activities and allowing youth to experience some frustration, they extended the activities or adding more complexity to them. For instance, one Learning Facilitator commented about adding an additional specification to the WuGG shoe design activity. This additional specification related to walking in puddles as part of the testing and evaluation section. Another challenged the team to improve the volume of their speaker in the speaker design challenge.

Features of *WISEngineering* that Helped Engage Youth

Most of the participating clubs used the Badges and Certificates that are available with each activity as a tool for engaging youth. Each activity asks that the participant reflect on what they learned by doing the activity, and how they would improve on their design. Youth who completed this section and the majority of the other activity sections were awarded a badge for that activity. When enough badges were awarded, a STEM certificate was available that could be emailed to the youth or printed by the Learning Facilitator and awarded in person. Some clubs had ceremonies as part of their marketing strategy or a final end of the year ceremony to present these awards.



Another part of *WISEngineering* designed to help engage youth, are STEM career videos that are related to the engineering design challenge. Each challenge was introduced so the person doing the activity plays the role of an “engineer solving a problem.” A bioengineer designing a prosthetic leg, a mechanical engineer designing a rocket, or a civil engineer designing a highway are examples. We expected accompanying career videos would help engage the youth. However, time constraints meant most clubs were unable to have youth view the STEM career videos during the club period. When time permitted, (e.g., if the activity was completed more quickly than anticipated) the videos would sometimes be viewed as a whole group activity. While viewing the video was not essential to completing the activity in a timely fashion, it was considered a useful feature.

To our surprise, several clubs had the youth view the Facilitator professional development video as part of their introduction of the activity and as a way to engage youth. The videos were not created to be entertaining, but rather to be informative for the Learning Facilitator. Yet, we found some clubs effectively used them as both a motivational element and as an instructional tool for the youth. While this did not remove the need for the Learning Facilitator to be well prepared and versed in the activity (meaning they needed to review the written or video guides first), for some clubs sharing the professional video with the youth was a valuable tool for engaging and preparing youth.

Learning Facilitators stressed that they found a connection between youth engagement and ease of use. Youth did not mind, and often enjoyed, complex design challenges. However, they did not want learning about the challenge, use of the technology or answering questions to be challenging. During our pilot work, we found the amount of reading required by WGG was often an obstacle. Children, and some adults, associate reading with school and they do not like to do it. Some reading however was needed to learn about the WGG activity and to complete

the design challenge. Facilitator feedback during the first years strongly indicated the amount of reading required for the activities at that time was challenging and hindered successful implementation of the activities. Therefore, after the first year, we revised the WGG activities by decreasing the amount of reading by at least 50% and increasing the use of photos. Even with these changes, Learning Facilitators reported youth often rebelled when asked to read. A second effort was made to reduce the reading complexity and assure reading was at a level appropriate for a 10-11 year-old. Relatedly, as part of WGG, youth are asked to describe their understanding and how they would improve their design. While youth and Learning Facilitators often enthusiastically verbally discussed what they created, they were less enthusiastic when asked to write about the experiences. In response, we revised the WGG activities by reducing not only the amount of reading required but also the amount of writing. An added feature of the tablet was a voice recognition option so youth could speak their responses. We will study this tool during our final year of the project.

Conclusions

We learned that excellent facilitation of WGG activities does not require that Learning Facilitators have a STEM background or be a teacher. Excellent facilitation does require that the person be prepared. Preparation includes using the WGG Facilitator resources, having supplies ready, and often doing the activity before the youth. While success does not require that the Learning Facilitators have long-term experience working at a Boys & Girls Club, it does require the Facilitator consider what is reasonable for his or her particular club. Implicit in this finding is that the professional development materials be robust, varied, and effective. To assure our materials met these criteria, they were developed with clubs in a variety of settings, from church basements to modern buildings dedicated to a given Boys & Girls Club. Another aspect of good facilitation is finding ways to engage youth: beginning with building anticipation and excitement about partaking in the activity and continuing with coaching children as they began and completed their designs. Successful facilitation was closely aligned with engaged youth. However, our research showed engaging youth was often related to how Facilitators promoted, introduced and conducted the activity.

The factors that most often impeded successful activity implementation related to technological issues such as maintaining login information (user IDs and passwords), and making sure the wi-fi connectedness was sufficient. Learning Facilitators needed to be familiar with the WGG activity, ideally by having done it, so if youth encounter a problem the Facilitator is knowledgeable enough to help. However, once again adequate preparation coupled with materials that were understandable and easily accessible, were key.

In summary, clubs varied in what they used to effectively engage youth, but having a variety of tools was essential and allowing clubs to select the most club-specific approach led to the greatest success.

Acknowledgement

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1. <http://www.wiseguysandgals.com/> Retrieved August 5, 2018.

2. LINK-REPORT: Outcome Analysis of Informal Learning at Scale by Xiang Fu, Tyler Befferman, M. D. Burghardt, Proceedings of the Third (2016) ACM Conference on Learning @ Scale, pages 173-176. April 2016.