Michigan State University's World Building on Mars

Teacher Focus Group Report

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Introduction

World Building on Mars was a pilot program implemented by Michigan State University's (MSU) Talbert and Leota Abrams Planetarium and the MSU Museum and funded by NASA. This pilot program is a STEM education curriculum providing a new immersive augmented reality (AR) Mars environment and collaborative learning experience to 5th through 12th graders. Students worked with their teachers and peers to develop structure and system plans rendered within the virtual environment. The collaborative environment offered a problem-based experience for students, challenging them to integrate knowledge about Mars, the history of the NASA Mars program, urban planning, and multiple grade-level STEM skills.

Three teachers overseeing four sessions of students received the World Building on Mars curriculum to implement during the second semester of the 2020-2021 School Year. Of the four sessions, three sessions were considered traditional classroom settings and one session was an extracurricular science club. Teachers received a stipend of 1,400 dollars to implement the curriculum and to take part in the evaluation of the curriculum. Due to COVID-19 pandemic restrictions, the curriculum was delivered virtual at times, and the focus group was conducted virtually. This report highlights the teacher focus group portion of the evaluation.

Methods: Three teachers overseeing nine classes of grades ranging from 5th grade to 12th grade took part in a virtual focus group conducted by SPEC Associates on June 7th, 2021. See Table 1 for the breakdown of the classes that teachers conducted with the corresponding grades. The focus group was conducted via Zoom. Teachers were provided a consent form and were also read their participant rights. The focus group was one hour and 15 minutes in total.

Table 1: Program Class Grade Levels

School	Grade level of students	# of classes	# of students
Holt Lutheran School	5th-6th	1	18
Holt Lutheran School	7th-8th	1	18
Eastern High School	8th	6	77
St. Johns High School	9th-12th	1	14

The focus group script had 11 questions with probes that focused on whether the curriculum met expectations of NASA objectives and 21st century skills objectives. Literature on STEM education was reviewed, and an article from the International Journal of STEM Education, *From quality to outcomes: a national study of afterschool STEM programming* (Allen, Chang, Gorrall et al., 2019) was used as a guide to develop the focus group script. The focus group script can be found in the Appendix.

The focus group inquired about the following 12 items:

1. Levels of interest and excitement displayed by students during the curriculum
2. Types of attitudes displayed by students during the curriculum
3. Influence the curriculum had on student STEM identity
4. Opportunities for students to use spatial skills during the curriculum
5. Changes in knowledge by students during the curriculum
6. Types of peer interactions (21st century skills) displayed during the curriculum
7. Displays of perseverance and persistence during the curriculum
8. Levels of engagement and participation displayed by students during the curriculum
9. Opportunities for youth to voice their thoughts and ideas during the curriculum
10. Teachers' gains in new approaches or methods for teaching astronomy
11. Appropriateness of content to stage of life
12. Types of improvements that could be made to the curriculum

Focus group findings

Summary

Overall, the World Building on Mars program was very well received by the teachers. Teachers reported observing a number of 21st century skills displayed by students, such as peer interactions, and also noted a variety of different students showcasing STEM identity, such as students who excel in the arts or students who have an interest in gaming. Teachers reported changes in knowledge and high levels of engagement. Furthermore, teachers reported an interest in using this curriculum again and in expanding the curriculum to other subject areas, such as art and social studies. Strengths that stand out with this curriculum are the way in which the curriculum engaged a wide range of grade levels, achievement levels, and student interests.

> *"I could tell that there was a lot of time, thought, effort, and very thoughtful consideration that went into planning the lessons …they did a really nice job of organizing and I feel like preparing us to deliver the lessons."*

Interest and excitement

Two strengths stand out for the curriculum that led to high interest and excitement as observed by the teachers. These included the depth of thought required to design and build on Mars, and students' ability to apply knowledge from their own lived experiences.

- Students displayed excitement at different points in the curriculum, and seemed most excited about getting to the building process. As one teacher noted *"…once we got to the end and started to actually design their buildings and their city, they seemed more excited to actually [do] the building process."*

> *"I think people just kind of say, 'Well, pick a spot on Mars and build.' And then it was like, 'No, before we even design anything, we got to think about our location.' …they seemed to be excited for what was coming next. I think they thought it was just going to be sit down and design a building. And I don't think that they realized a lot of the work that was involved with getting ready to go to that stage of the project. Definitely got them thinking."*

- Teachers agreed the progression of the curriculum promoted student thinking. For example, one teacher reported, *"They seem to be having the most creative thoughts about what you have to do before they can even live there. So that was good."*
- Teachers reported that a small number of external factors contributed to reduced excitement at different points in the curriculum. These external factors are: 1) Transfer or new students who have come in part way through the curriculum (i.e., disrupting group dynamic) due to COVID-19, and 2) Outside responsibilities for the older youth (i.e., college test taking) that took precedence over their participation in the extracurricular science club.

Attitudes

Teachers reported observing positive attitudes. Interestingly, when asked about negative attitudes, observations were noted as positive. For example, students questioned the purpose of going to Mars, which led to thought-provoking conversations amongst the class.

- Teachers reported observing a number of positive attitudes displayed by students. Primarily, students worked well together in groups, displayed a sense of pride in their final products *("I could see the ones who really put a lot of time and effort into the drawings that they were making.*"), and had deep conversations about the ethics of going to Mars.
- The curriculum allowed for only a certain amount of buildings to be built by the students. In other words, students had to work together in groups to design a single building. Although some students voiced wanting to build their own building at first, all teachers were able to guide students toward working together and into a role they were interested and comfortable with.
- When asked if students displayed negative attitudes, all teachers were hard-pressed to report such observations—though all agreed that the purpose and ethical considerations of going to Mars appeared as negative, yet elicited deep conversations within the class. "*That's the only negative I heard was some of the kids, especially the older ones would say, 'Why would we have to do this? Why can't we just go to the moon or, you know, spend money on earth?' And things like that and not really negative, but trying to see the purpose of doing it as more theoretical than just a project to do."*

> *"So that was a positive. Here was this challenge and they were able to see and get excited about some of the ways to overcome these challenges and the new challenges that came with it. I think it was positive that different students seem to be motivated by different things. And in that group environment, we were somewhat able to let people pursue their passions a little bit... So that was fun to see them with things that were making their passion, their interest levels. And I thought that was a big-time positive. We'd seem to do a pretty good job of getting people in the right sub-projects. The little groups worked well."*

STEM identity

The strengths of the curriculum as it relates to building STEM identity centers around the ability to reach students of varying interests and passions. Interestingly, this curriculum not only fostered STEM identity for youth who may already be strong in science and math, but also reached students who identify more with other subject areas such as art and interests such as video gaming.

- All teachers noted the curriculum was an excellent motivator for those students who have strengths in art, architecture and drafting. As one teacher aptly noted, "*STEM is gaining STEAM*." Teachers noted that those students with an interest in art realized there is a place for them in the field of science.
- All teachers noted the youth who are "*gamers*" and enjoy video gaming were able to relate greatly to the curriculum through the activities related to simulations and animations.
- All teachers noted the group work was a benefit for the students in that they drew upon the strengths of their peers. For example, some students were highly engaged in the artistic aspect of the curriculum while others were unable to draw a 3D block which led to a "*nice mix*" of interaction among the students.

"Not only the science and math students who typically already have their STEM sort of somewhat defined, or they're kind of familiar with being a STEM person. For those youth who are more art-based or architecture-based, or video gamers, this curriculum did help to reach those youth as well."

"I think the science and the math component, anybody that really likes science and math kind of has a feel for their STEM identity, but when you start to get kids to realize like, one thing that COVID has definitely brought to light has been the number of simulations and animations that you need to do. And we have some nice simulations in this sequence of lessons as well. So now you take kids that like gaming and want to be video gamers that, hey, you can be a simulator, an animator, and connect that to the STEM approach or identity."

Spatial skills

Spatial skills are another important component for youth to have in order to be successful in STEM fields. Although this curriculum provided opportunities to work on spatial skills, this aspect of the curriculum may have been the most challenging to complete, primarily due to the hindrances caused by the COVID-19 pandemic, such as time constraints and limitations due to virtual instruction.

- All teachers noted students preferred "*paper and pencil*" option for drawing 3D objects.
- Teachers agreed that time constraints due to the COVID-19 pandemic had an impact on learning and conducting 3D drawing on the computer.
- Teachers felt learning computerized drawing before the curriculum, or prior to the building portion of the curriculum, with appropriate software that is "*easy for a beginner to navigate through*" would be helpful for working more in-depth on spatial skills with students on the computer.

"I think the ones who chose the paper and pencil option was just because it was easier for them than learning how to do a Google drawing, using those new tools to them…they knew how to use paper and pencil. They went with what they knew."

- Although teachers indicated their own preference, and students' preference for using pen and paper to draw 3D Models, they all acknowledged the essential nature of the need to learn and use technology as a skill to be successful in STEM.

Changes in knowledge

Teachers reported observing "*light bulb moments*" and changes in knowledge related to STEM concepts as a result of the curriculum. The strengths of the curriculum that led to changes in knowledge stemmed from the rich discussions around choosing a spot to build on Mars and the resources that could be transported to Mars.

- Teachers noted that students talked about their own lived experiences, for example bringing in conversations about what their experience is like in their own communities (such as school campus) or other communities they have visited (such as Alaska).
- Teachers observed students comparing and contrasting aspects of Mars and Earth. Identifying the pros and cons spurred new ideas in their designing and building process.
- Teachers noted many lightbulb moments. As one teacher noted, "*I would say certainly the thought of time to transport resources from earth and the obstacles of taking large amounts of resources on rocket ships. I can see them having to realize, 'Oh wow, we have to work with what is already there. We're not going to be able to take a lot of stuff with us'. And I thought that was interesting for them to make that connection*."

> *"So it's interesting when they were looking at the different sites. They figured out, 'well, this temperature is really cold all the time, or this place is really hot or this place is really dark all the time.' So they were comparing all these different things and trying to figure out, well, what would we like here on earth? And somebody said, 'well, I know somebody in Alaska, that's really dark a lot in the winter time and it's terrible. So let's not go there.'"*

Peer interactions

Peer interactions are a 21st century skill important for STEM careers. Teachers were asked what observations they had of students interacting with each other in new, interesting, or innovative ways.

- All teachers strongly agreed that the students interacted with each other. The class format of having one building to build with a group contributed to the interactions. "*Well, they definitely interacted. They definitely interacted. Not real negatively, but more positively. And they shared ideas. And I'd hear once in a while 'You stole my idea'. No, you're not stealing, you're sharing. So, that kind of thing*."

> *"And it was, I think, beneficial even though maybe not optimal for them to have that process of having [Virtual Experience] ... Being on a team where you're in different locations, you have one document you're working on together and everybody's trying to contribute. I think that, while that maybe isn't the best way to interact, I think that was useful for their learning."*

- All teachers agreed, virtual instruction was more challenging for encouraging peer interactions. One teacher noted, "*Virtual hindered the interactions a little bit, because if the student was camera off, walked away from their computer, there's really nothing we could do to pull them back into the group work. Whereas I feel like if they were working in person, it'd be a little bit more obvious that they're just zoned out somewhere else that I can encourage them and their group members to…be more to be interactive*."
- Although teachers noted the curriculum was more challenging to teach virtually, they all agreed the virtual environment is beneficial in that it reflected reality, is the way of the future, and is a 21st century skill.

Perseverance and persistence

The opportunity to solve problems and overcome obstacles is a critical component to achieving success in STEM. When it comes to perseverance and persistence, the strength of this curriculum includes the ability to reach a wide range of achievement levels and span grades 5th through 12th.

- Teachers agreed the curriculum was "*about right*" for all students, allowing low to high level achieving students to participate together.
- Teachers observed students with different abilities working together to solve problems. As one teacher noted, *"…my kids encouraged each other all along the way*."
- Teachers agreed the curriculum was accessible in that there were many different types of opportunities to solve problems for different levels of performers—in other words, there were a lot of different pathways to engage with the content.
- All teachers agreed that there were no demographic characteristic differences observed in students' display of perseverance and persistence during this curriculum.

> *"…lower levels just could focus on some of the basic needs and the lower level problem-solving and then the more advanced students would... In my mind are the ones who keep in the observatory. You're having those other things that some other students wouldn't even think of and then they can work on solving those more difficult problems that... kind of keep them engaged."*

Engagement and participation

The curriculum led to a high level of engagement and participation among youth that met teacher expectations. As mentioned earlier, a primary factor that contributed to engagement for students was the ways in which students were able to tie in their own life experiences to the curriculum.

- The curriculum has the ability to tie current and real life events happening in the world and in students' own communities. For example, all teachers noted a tie in with the Mars Rover landing (February 18, 2021).

> *"It was right after the latest Mars Rover had landed. So they'd already been hearing about Mars in the news and things so it was already kind of in their mind. So that kind of helped to tie them into what we were doing…But also with the unit, the urban planning lessons, it tied right into kind of like looking at their own community of 'Okay, how is their community layout?' So kind of what they see every day, pulling that in, I think helped a lot of them really realize what goes into this process."*

- Teachers reported watching the Mars Rover landing with the students, and engaging in dialogue about the Mars Rover landing as it applies to their own life. As one teacher noted to their students, *"You're at the right age where if you plan it right, you could possibly be involved in a project like this.*"
- Teachers reported student engagement during the design of buildings and the urban planning process as notably high. Students talked about lay-outs of their own communities and discussed personal stories of how their own and other communities are planned—what they like and what they would do differently.
- Teacher noted there were some barriers (mentioned earlier) to engagement that are unrelated to the curriculum itself. These barriers stem from the COVID-19 pandemic and include time constraints, learning new software, interruptions with outside testing, or transfer students.

Youth voice

Youth voice is a component of STEM education that is critical for developing skills important for STEM careers. Teachers were asked what observations they had of students having the opportunity to feel heard and to express their own opinions and ideas. All teachers strongly and positively agreed this curriculum allowed for expression of youth voice.

"So, my goal is to have them always be respectful with each other, which hopefully, they are most of the times. So they talked with each other a lot during the class time and they shared ideas. You could hear somebody across the room, 'Hey, that was our idea.' Well, you can all have the same idea. It's what you do with it. So they did talk and they were heard."

- Youth voice was enhanced when students could draw on their previous knowledge. It was noted that the curriculum was tied into earlier lessons already taught which allowed for increased comfort and familiarity with the content for students to have discussions.
- Teachers observed students felt a sense of belonging and involvement due to the varied number of unique roles and responsibilities required to build a city. In other words, students could find their own "*niche*" and contribute their own expertise.
- Having limited buildings to design appeared to encourage youth voice. For example, students expressed curiosity in others' ideas and designs. As one teacher mentioned, *"…it was interesting to hear groups that might not get the building that they wanted, interact with the other groups or give them ideas for what they were doing. So that was a great thing to see. And they ran with it. So, they didn't complain.*"

Teacher skill development

Teachers reported having a positive experience learning the curriculum, gained skills, and would feel comfortable incorporating the curriculum in the future.

- All teachers agreed that they will incorporate the curriculum in the future. Some teachers noted they are able to be flexible and teach the entire curriculum while others may only be able to take parts of the curriculum due to their level of flexibility.
- Teachers are interested in independently implementing the lessons without the need of help from MSU (i.e., rendering the designs).
- Teachers reported that they gained skills in teaching astronomy, and moreover, that connecting with other teachers who are (or have) taught the curriculum would be an asset in strengthening their skills and ability to implement the curriculum.
- All teachers highly recommend the curriculum for teachers outside of STEM, for example other subjects such as social studies. As one teacher summed up, "*I think it's conducive to cross-curricular. [Earlier teacher] mentioned the computer teacher coming in and teaching 3D drawing. Certainly, I think there are other ways that you could bring in a math teacher, an architecture, or drafting teacher. I mean, for sure*." And another teacher added, "*The social studies with the designing and government…*" and "*Urban planning.*"

> *"...Whenever it fits into my schedule without doing the prerecorded lesson parts of it. So if there's a way I can kind of adapt it a little bit to fit in wherever I might need it. And then also... I know there's plenty of virtual reality building sites that the students can design it themselves in that virtual space versus waiting for MSU to have time to build it for us. And so students could see what those look like… I've seen examples where students did a similar [project]. Built a 3D model on the computer themselves versus just the sketch of it to then can be uploaded from MSU. So just getting them that immediate feedback of what that drawing looks like in a 3D space."*

Stage of life skills

A strength of the curriculum was the observation that this curriculum is relevant for students in a wide range of life stages. This pilot project reached 5th through 12th graders and all teachers agreed this was a relevant curriculum for their students, in particular it provided hands-on opportunities to learn skills and allowed for youth to discuss their own lived experiences in ways that are relevant to them.

- All teachers reported that hands-on experience was the strongest aspect of this curriculum as their students do "*really well*" with hands on activities and "*really love hands-on, building things, and figuring out how things work*."

> *"So even if they might not see the connection or place, that if the teacher can make a connection of, okay, how could this tie in with kids who love playing basketball? Well, you could set up a gym or some kind of exercise. Making that connection so it ties in with their interests is very beneficial."*

- All teachers reported that the second strongest aspect of the curriculum was students' ability to tie in their lived experiences, for example bringing in their interests in the design of their city.
- All teachers noted the strength of the curriculum working for all age ranges, "*And to think that, I had fifth graders, sixth, seventh and eighth graders, and what [another teacher] had high school and then more middle school that it appealed and was workable for all of those age groups. This is just very good, very nice*."
- For high school students, the tie in with applying to colleges and thinking about careers was highly relevant and valuable, as one teacher expressed, *"…And for them to hopefully see their place in that field. All the varying types of engineering to bring in—all those things that we've talked about with our technology, simulation, animation, modeling, things like that. There's a place for those kids if they go after it*."

Suggestions for improvement

Overall, teachers were positive about the curriculum. Teachers indicated they wanted to teach the curriculum again and felt over time they would continue to improve in implementing the curriculum in the classroom. There were few improvements suggested by teachers.

> *"So almost kind of having different level of supports through this curriculum. So like if you're teaching this, especially for the first time…we have, those prerecorded lessons…But the more I teach it, the more I'm going to remember, I'll be able to kind of create the lessons for my students. So kind of like different levels of support. Okay. First time teaching here is your pack of resources. Okay. You've done these three semesters in a row. Maybe you don't need so much from us. Here's kind of the skeletal work."*

- Teachers indicated interest in implementing the curriculum again. Identifying ways to support teachers who are interested in how to incorporate the curriculum without the aid of MSU will be helpful, such as offering ways to take smaller parts of the lessons to incorporate throughout the year or offering suggestions for online platforms that teachers can use to build the 3D Models without the aid of MSU.
- Although teachers indicated in-person instruction seems more ideal to teach this curriculum, all teachers acknowledged the benefits of having pieces of the curriculum be virtual. As mentioned earlier, one teacher nicely summed up, this was a real life experience, "*Being on a team where you're in different locations, you have one document you're working on together and everybody's trying to contribute. I think that, while that maybe isn't the best way to interact, I think that was useful for their learning."*
- Offering suggestions for ways to incorporate different subjects or instructors would be an asset. All teachers indicated interest in how other instructors could guest teach, for example, or how they could bring in other subjects. One teacher summed this up well, "*I think I would be more interested in doing some of the cross-curricular things. Like I didn't even think about a couple of the ways it could connect to maybe social studies or government. That is interesting to me. I think it would be awesome to whether it's not a Mars Lander, that's a Rover Lander that's occurring, but bring in an engineer to speak to your class or a Zoom or something like that. I know there's lots of those opportunities*

available just even on a regular basis, let alone scheduling something special for your students."

- Identifying ways to incorporate spatial skills or the computerized drawing aspect of the class in more detail may be of help, such as providing resources to online platforms for students and teachers to learn the 3D modeling process ahead of the curriculum.
- All teachers acknowledged they would get better at teaching the curriculum over time, and added some suggestions to aide their improvement. Having different levels of support and different levels of pre-recorded videos for new and seasoned teachers was suggested. In addition, having opportunities to meet with other teachers to share resources and discuss what is working could be of support to the teachers. In this regard, working with other teachers to find what is working and what is not working would be a benefit.
- As mentioned earlier, teachers acknowledged that a small number of external factors contributed to reduced excitement at different points in the curriculum. These external factors included: 1) Transfer or new students who came in part way through the curriculum (i.e., disrupting group dynamic) due to COVID-19 pandemic, and 2) Outside responsibilities for the older youth (i.e., college test taking) taking precedence over participation in the curriculum, especially in that participation was in an extracurricular science club.

Appendix

World Building on Mars
TEACHER FOCUS GROUP GUIDE
(Rev. 02-25-2021)

Welcome and thank you for being here today. My name is _____ and I will be conducting this focus group. The purpose of the focus group is to learn about your experiences, and your perceptions of your students' experiences, with the World Building on Mars curriculum. During the group, we'll be asking you questions about:

- What you observed about your students' engagement with the curriculum
- If there were any differences in student engagement and what may contribute to the differences
- Whether and how various aspects of the curriculum are or are not aligned with meeting the goals of 21st century learning
- How the curriculum might be improved so as to have greater impact on youth's interest in STEM fields

The discussion today is confidential. On our end, we will assure that no names are affiliated with any comments made in the summary report that we prepare. To the extent possible, every effort will be made to anonymize the comments that are made. However, there are only a small number of you participating in this group. It is possible that someone reading our report may accurately recognize a comment as coming from you, even with our redactions. Therefore, I am encouraging you to word your responses to the question carefully.

We are audio recording this interview. Only the team at SPEC Associates will have access to the audio recording and only for the purpose of preparing the report.

This focus group is voluntary. You've all provided confirmation that you received the Consent Information Sheet when you agreed to participate in this focus group. The Information Sheet lists your rights as a focus group participant. If you don't want to stay for the focus group, that's ok. We will not report to anyone who stayed and who left.

There are only four rules to this focus group:

i. Please speak loudly and clearly and into this "talking stick" so that we can get a good recording of what you say
ii. Only one person should speak at a time so that we can clearly record what everyone says
iii. There are no right or wrong answers. Everyone's opinion matters.
iv. If you agree or disagree with something that has been said, say that and explain why.

Do you have any questions before we get started? [ANSWER QUESTIONS]

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1. **We'd like to start by asking you to think about a typical day of the virtual learning experience for your students**.

    a. In your observations, what qualities of engagement did you notice in your students, for example, what were the students doing that indicated to you that they were engaged or not engaged? Please describe.

    b. In your observations, did you see any differences in engagement by gender? For example, did you notice that the majority of students who were not engaged were girls or boys?

    c. What about with youth of color? Did you notice that the majority of students of color were equally or differently engaged compared with majority white students?

    d. What about the specific topics or modes of instruction used during different weeks of the curriculum? Did you observe students being more or less engaged or connected to particular topics or modes of instruction?

2. **Describe how the aspects of the virtual reality curriculum are, or are not, meeting the goals of 21st century learning (meaning that students master content while producing, synthesizing, and evaluating information from a wide variety of subjects and sources of understanding of and respect for diverse cultures)?**
    a. How do you know this to be the case? For example, what kinds of behaviors or skills did you observe that supports your observations.

WE ARE HALF WAY THROUGH THE DISCUSSION

3. **In your opinion, how might this curriculum (as it is currently or if it is improved) contribute to a youth's career choice in the STEM fields? For example, are there aspects of this curriculum that may have influenced interest in STEM careers for your students, such as excitement about finding solutions to challenges, a raised awareness of what it takes to conduct STEM projects, or an increase in confidence for achieving a STEM project.**
   Probe: Please describe the most important contribution this curriculum has for STEM education.

4. **If you were to redesign the curriculum, what would you keep, remove, change or add?**

5. **Is there anything else related to our conversation you'd like to share?**

Thank you. We are done with our discussion.