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DRIVE STUDENT SUCCESS: DESIGNING A MAKERBUS TO BRING STANDARD-BASED MAKING AND TECHNOLOGY ACTIVITIES INTO K-12 SCHOOLS

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Designing a mobile makerspace, the MakerBus, originated from our goal of bringing maker education to *all* students in K-12 schools, thus empowering students to believe they could create things and make social changes. This design case was guided by the human-centered design principles and the rapid prototyping instructional design model. In this paper, we elaborated on the process of designing a MakerBus, highlighting major design decisions.

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INTRODUCTION

Maker Movement and Maker Education

The idea of designing a MakerBus was brewing for years and informed by the literature in Maker Movement and maker education. When we began the journey of designing the actual bus, we carefully considered the scholarly claims presented next and took them as assumptions informing our design.

In 2005, O'Reilly Media, a factory co-founded by Dale Dougherty, launched a new magazine called *Make* magazine (Martinez & Stager, 2013). In 2006, Dougherty invented and hosted the first Maker Faire in the San Francisco Bay Area. These two activities openly marked the beginning of the Maker Movement, which celebrates the do-it-yourself (DIY) culture and a community of makers worldwide (Peppler & Bender, 2013).

Economic, societal, and technological factors are driving the Maker Movement, which attracts more educators, students, parents, and stakeholders to bring making into education. In 2014 alone, there were 135 recorded Maker Faires, with more than 800,000 attendees. Among these Maker Faires, the first White House Maker Faire was held, and a significant number of educators, students, and parents were invited to attend. A year later, President Barack Obama declared June 12-18 the Week of Making and promoted a campaign named "Educate to Innovate." With the impacts of these efforts, museums, libraries, and schools begin to embrace maker education that facilitates students to learn, build, create, and invent in new and creative ways (Sheridan et al., 2014).

Making is a powerful way of learning. Martin (2015) summarized three essential aspects of making:

1. Playful;
2. Asset- and growth-oriented; and
3. Failure-positive.

These characteristics are critical to reform education to focus on active learning. Since Maker education emphasizes approaches, mindsets, and community, it promotes not only STEAM education but also deeper and personalized problem-based, project-based, community, and environmental learning experiences. It represents student-centered active learning with low-tech and high-tech materials, technological tools, and opportunities to learn through firsthand experiences. It makes learning relevant and sensitive to each student's curiosity, learning needs, and impulse to create. It empowers students to build agency and character through problem-solving.

Furthermore, maker education blurs the boundaries among content areas and offers new opportunities for interdisciplinary learning experiences. Students work on projects that cross a wide variety of fields, such as photography, game design, ceramics, fashion, sculpture, comics, magazines, street art, music, audio and video production, coding, and 3D manufacturing, to name a few. Transcending beyond traditional content areas, maker education allows students to design their own active learning experiences. Teachers and students could easily reconfigure content area projects to be personalized using design thinking processes that include curiosity, creativity, and communication. This kind of maker education prepares students for their future career paths. Moreover, maker education trains students from diverse backgrounds to collaborate and solve social problems together through different perspectives and various ways of thinking.

Maker education is crucial for *all* students, especially those who could not afford the opportunities to have making experiences through after-school programs, clubs, libraries, and museums. High-quality maker education has the potential to level the playing field for *all* students, especially minorities, by providing access to materials and technology for them to create and invent. Maker education should be for *all* students, including African American and Latino American students, a challenge with its roses and thorns.

Why Maker Bus?

The concept of a mobile makerspace is not new. Around 2000, MIT invented a mobile Fab Lab for people to make things using digital and analog tools. In 2014, Neil Gershenfeld, the director of the Bits and Atoms Center at MIT, showcased the mobile Fab Lab at the first Maker Faire hosted by the president at the White House. STEM Revolution designed a STEM Bus that offers making activities to students. The SparkBus by Stanford delivered maker activities across the country. The BioBus and Rosybelle bus aim to bring STEAM activities to underserved schools and communities. This approach of creating a mobile makerspace targets one major problem faced by educators who promote makerspaces, challenges of providing maker education to *all* students.

The designers of this project believe it is necessary to use this approach in practice because not all schools could afford a makerspace or STEM lab. They presume that mobile makerspaces like a MakerBus is a unique way to engage young minorities and at-risk students. They learn from some of the unique programs such as The Parachute Factory, Verizon's Minority Male Maker, DIY Girls, and The South End Technology Center. The designers also have confidence in that driving the MakerBus to high-poverty schools that are under-resourced in funding, qualified teachers, high-quality curricula, books, technology, and materials, and providing high-quality making activities offer students somewhat equal access to maker education in the hope of addressing the achievement gap and providing an equal playing field.

The MakerBus project is the result of the idea that students must use their imagination and intelligence to design something. Then they must have the opportunity to fulfill those designs using tools and materials that are brought to their doorstep. However, in reality, the lack of materials, spaces, and training for teachers prevent *all* students from experiencing maker education. Only a small group of students have the chance to experience maker education or making in classrooms, libraries, museums, after-school programs, and clubs. We are far away from the goal of having *all* students experience maker education. Thus, designing a mobile makerspace, like the MakerBus, breaks the boundaries and limitations in schools. We hope that the maker experiences brought by the MakerBus might have a lasting impact on students' learning and the community around them, while pushing forward the transformations of curriculum and pedagogy, and eventually the establishment of a makerspace or STEM lab in their schools.

The MakerBus is a sum of the experiences of every child that steps on board. As a physical representation of active learning, it will also be a clean slate for every maker that hatches a new idea there without the confinement of traditional classrooms. The goals of creating and designing the MakerBus are:

1. promote maker education to schools not traditionally have the opportunities,
2. implement maker education activities and professional development in schools,
3. help others see an example of designing a mobile MakerBus,
4. promote inclusion and neutrality
5. provide modeled experiences of the processes of failure and errors,
6. cultivate maker mindset,

7. develop resilience, grit, focus, and perseverance, reaching the 4Cs, communication, collaboration, critical thinking, and creativity,
8. prepare students for lifelong learning through engagement.

Next, we will unpack and reflect on the design of the MakerBus.

CONTEXT

iTeach Unit and Instructional Technology Coaches

The iTeach unit is a service center of the Department of Instructional Technology at Kennesaw State University, which is committed to the mission of transforming teaching and learning by using specialized instructional technologies to increase student outcomes in schools and districts. Members of iTeach believe that the most effective way to fulfill this mission is through embedded and on-demand instructional coaching. This allows the instructional coaches to work side-by-side with students, teachers, media specialists, and administrators every day, as well as co-plan, co-teach, and model the effective use of modern classroom technologies to improve learning. By working individually with teachers, the instructional coaches are able to identify their specific needs, help to plan and design effective lessons that meet the lesson objectives and to model research-based best practices for technology integration and innovation with students, helping move instructional practices into the next frontier of education.

By establishing strategic partnerships with industry leaders, iTeach can connect modern pedagogy with breakthroughs in instructional technology innovation and help districts to envision, plan, and implement today's best, research-based practices into their curriculum.

Specializing in modern classroom innovation and instructional design, the iTeach team also offers professional development to schools, districts, and individual teachers based on their immediate needs. Having proven leadership and experience in the fields of personalized learning, instructional coaching, program evaluation, educational technologies, and more, the iTeach team helps schools to evaluate their curriculum and then design a targeted plan and solutions to guide each school and teacher through solutions, tools, and trainings that help them reach their professional development goals.

The leadership team members are experts in the field and have expertise on the topics of personalized learning, systematic change, and change management. They focus on three aspects:

1. consult with district-level administration to help construct the vision for change,
2. consult with district and school level admin teams to design and plan for change management, and
3. consult with district and school-level teams to ensure the vision and plans are implemented and executed effectively and efficiently.

Initial Impetus

The instructional coaches from iTeach began their maker education experiences with small-scale makerspaces in libraries, classrooms, and even at home in basements and storage rooms. They observed children experimenting with making activities and saw their eyes light up as they realized they could make the rules there and personalize their own learning experiences. They also observed students persevere through multiple failures and marveled as students began to understand that their mistakes were just chances to learn, grow, and try again. Collectively, they used their varied experiences to envision a maker camp where they could fully immerse students in the maker mindset (Regalla, 2016).

In the summer of 2016, the iTeach unit launched a K-8 maker camp. Participating instructional coaches offered maker education to about 30 students and 15 educators in a conference room and the adjacent hallway in the college. The central goal was to inspire students to make while helping them believe that they had the power to change the world with their ideas and effort. From coaches' observations, the maker camp in which students explore, create, fail, invent, and persevere was a success. The enthusiasm of the students and educators reinforced the belief of the impacts of maker education. This experience confirmed the belief that students learn and develop a maker mindset by conducting making activities. A new goal was set among the coaches that iTeach should reach out to schools to conduct more maker education sessions, especially those schools without such opportunities. However, a traditional makerspace could hardly achieve the goal of reaching out to under-resourced schools since transporting teachers and students would be a challenge.

As the unit developed a strategy around promoting maker education in K-12 schools, it was natural to begin showcasing strategies and tools in classrooms where the coaches were already coaching the mentee teachers towards transformational learning. The coaches found that schools were hesitant to spend money on purchasing supplies and technologies for maker activities that were still seen as extra or enrichment time. It became clear that iTeach would have to lead efforts to connect maker education to Common Core State Standards (CCSS). Traditionally, the connection to maker activities happened only within the STEM areas. STEM became STEAM, which evolved into STREAM. Thus, the instructional coaches decided to align the maker activities to all content areas and all grade levels. Making should be for everyone and might benefit all learning environments. The priority is to make this view more obvious for current

and potential partners. Once the alignment to standards was complete, a strong need to provide experiential learning opportunities to educators and students was self-evident. The instructional coaches began to bring supplies and deliver maker education at the schools. However, during the pilot sessions, a few challenges surfaced.

The most difficult challenge was that the supplies and equipment were being transported in coaches' vehicles, and instructional coaches would arrive at locations without accessible and appropriate workstations. Electricity and Internet connections could not be guaranteed most of the time. Therefore, some educational technology tools could not be used for some planned activities. Meanwhile, with the number of instructional coaches the unit has and the number of schools the unit serves, it was quite challenging to prepare supplies and technology tools for each visit and coordinate the inventory. Therefore, the idea of a mobile makerspace that could reach students and teachers at their doorsteps with supplies, electricity, Internet, and a designated project lead was proposed.

Funding and Budgets

The iTeach director created an initial case for support document and socialized with vendors, partners, the university development team, and internal college leadership. Many months went by without much appetite for funding. The iTeach team worked hard to share ideas, and at one point, were offered a used commuter bus for free. However, the cost of retrofitting and maintenance made this option not viable. Later, some one-time funding became available for distribution at the college-level, and the Dean asked for proposals to be submitted. The MakerBus project was put forward and listed, among other proposals for a prioritization activity college-wide. This anonymous prioritization activity contributed to the socialization of the idea and sparked many discussions and ideas. Ultimately, the MakerBus project was supported by the college leadership team. It was actualized after much effort to understand funding and procurement processes. As a result, funding for the MakerBus came as a one-time funding opportunity from the Bagwell College of Education valued at $85,000.00. The team partnered with a faculty member from Virginia Tech (VT), Dr. Nathan King, who assisted with the modification and conceptualization as part of his work on an existing grant, so there was no additional cost associated with this activity. The revenue from other contract work funded the initial technology purchases. Now, the operational budget is supported by the paid visits and events offered to schools and institutions.

Staffing

A total of 30 instructional coaches from the iTeach unit are the primary staff on the MakerBus, who are all available to support MakerBus installations. One instructional coach serves as the main project lead of the MakerBus, who ensures a cohesive prep and responsibilities process. However, there is no fixed team; instead, in practice, the team is in flux depending on the requests from the schools and the logistics. To date, more than 30 instructional coaches have delivered co-planning, co-teaching, and instructional coaching on maker education.

THE DESIGN CASE

Design Frameworks

Human-centered design framework guided the design of the MakerBus. This framework starts with empathy, considering the people the design is for and adds tailored solutions to suit people's needs. It is composed of three phases:

1. The inspiration phase,
2. The ideation phase, and
3. The implementation phase (Giacomin, 2014).

Six characteristics are recommended by ISO 9241-210:

1. The adoption of multidisciplinary skills and perspectives,
2. Explicit understanding of users, tasks, and environments,
3. User-centered evaluation driven/refined design,
4. Consideration of the whole user experience,
5. Involvement of users throughout design and development, and
6. Interactive process (ISO, 2010).

In this design case, the human-centered design framework was coupled with the rapid prototyping instructional design model at each of the three phases. Rapid prototyping is an iterative and spiral process, during which the design is revised continuously as the cycle continues (Tripp & Bichelmeyer, 1990). During each design cycle, designers go through the processes of prototype, review, and refine. There might also be multiple processes during one design cycle with stakeholders' participation and feedback loops built into the process (Jones & Richey, 2000). These iterative cycles combine the design and development with simultaneous evaluation throughout the design process. Implementing a combined design framework helped the designers of the MakerBus to work effectively with a large number of stakeholders while always keeping students and teachers at the heart of the design.

The Inspiration Phase

After the one-time funding was allocated to the MakerBus project, the iTeach unit began to research various buses that could be designed as a MakerBus. A state contract procurement process was conducted, which generated a list of buses that could be purchased with the fund. State contractors preferred a type of school bus operated as the commuter bus in the university and informed the center that RVs were not on the list. A leadership team of instructional

coaches then compared and contrasted different buses available for purchase and decided to choose the one that had the most internal space, which was a Glaval Bus. The bus is 37 feet long. The distance between the back of the driver's seat and the rear is 22 feet. The inside is about 8 feet wide. Its vertical clearance is about 14 feet.

Meanwhile, the instructional coaches invited an expert to help with the design because this individual had expertise and experiences with power, electricity, functional design, and interior design. A faculty member at the Center for Design and Research of Virginia Tech, Dr. Nathan King, was invited to be on board. Dr. King specialized in technologies and design and had much expertise with different machines.

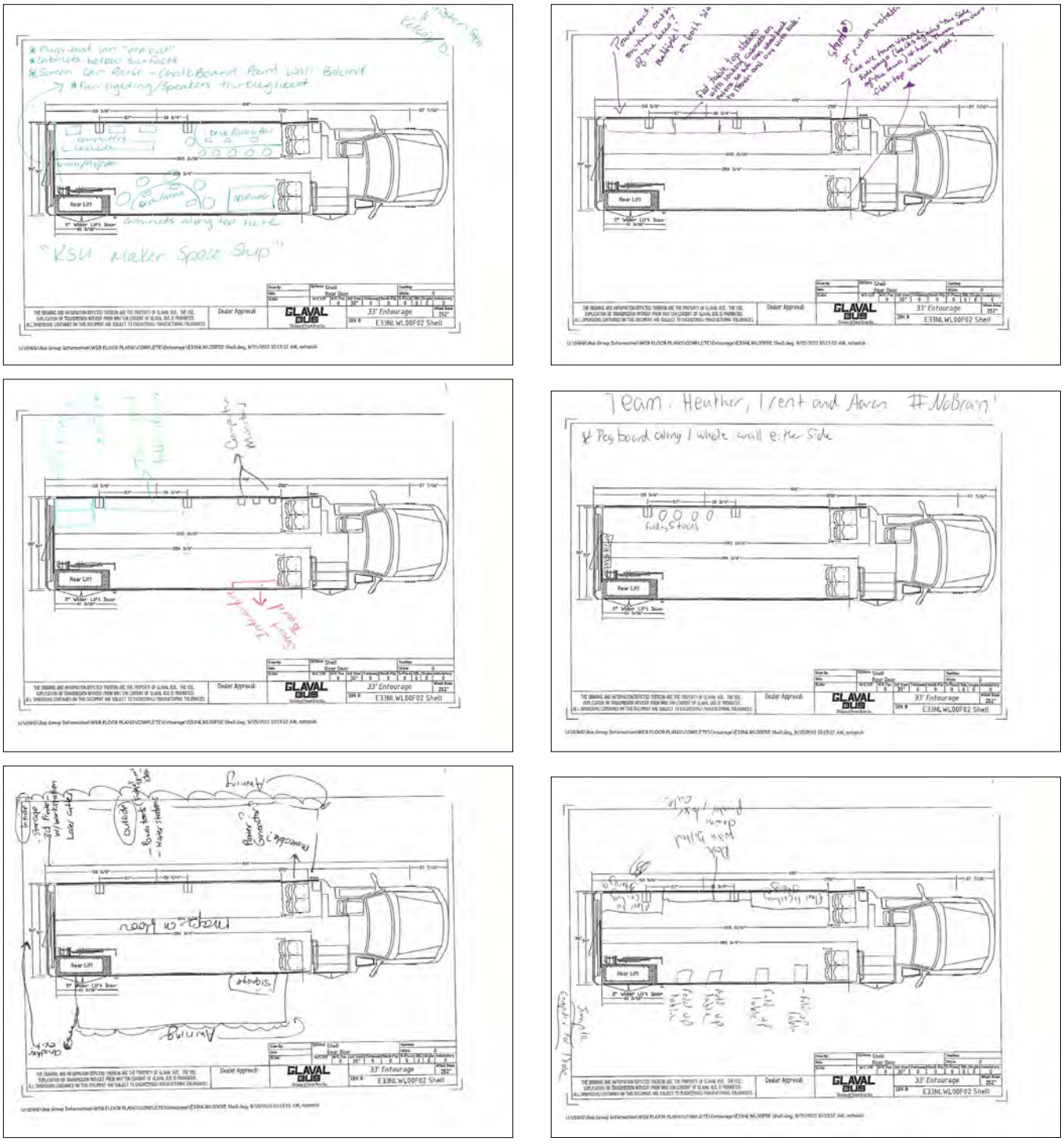

FIGURE 1. Blueprints of the functional design of the MakerBus during the Ideation Phase. Used with permission.

During this time, the instructional coaches looked into the designs of the SparkBus from Stanford University, the STEAM Bus in Canada, and Mobile Fab Lab Trucks from MIT for inspiration. They also researched the Instructables website, NUVU academy charter school, Autodesk Pier 9 in San Francisco, and Autodesk BUILD Space in Boston for ideas and the utilization of different makerspaces. The coaches also contacted various makerspaces for tours, training, and support. They visited the Autodesk Pier 9 in San Francisco and connected with Autodesk for potential collaborations.

The Ideation Phase

During the inspiration phase, the coaches generated some brief ideas for the design of the MakerBus. Later during the ideation phase, they began to brainstorm, draft, and draw concrete plans. First, the coaches met and worked on a wish list for the tools, materials, and machines they wanted to have on the MakerBus for various making activities. A few criteria were set to facilitate this process: cost, open-source or proprietary, subject and grade compatibility, knowledge barrier, preparation requirements, applicability, and affordances. This phase needed to happen first because the hardscapes on the bus needed to be determined. The hardscapes included storage, workspace (countertops), power (outlets), and so on. This wish list came from years of experience operating Maker Camps, providing maker education to K-12 students, offering instructional coaching to teachers, searching information online, and reading literature on the design and research of makerspaces. After a while, the list was created that included tools, materials, and machines for woodwork, 2D and 3D printing, physical programming, computer programming, and robotics. The list also included consumables, stationeries, and technology devices. During the creation of the wish list, the expert, Dr. King, worked along with the coaches to determine the power needs (how much power draw) of the machines and devices on the MakerBus.

Once the wish list was created, the coaches brainstormed on the functional design of the MakerBus. Through discussions, they agreed that the making activities should be student-centered, and the MakerBus events should be designed in a station-rotation format. In this way, students could lead the making activities at each station and engage in discussion and collaboration. The functional design of the MakerBus should support this station-rotation format, which was the most important consideration for the design. The coaches met several times afterward to brainstorm ideas for the functional design of the bus. A clear blueprint was given to the coaches who were divided into six groups. Each group drew and marked on the blueprint for generating ideas for the functional design (see Figure 1).

The college assigned one of the computer labs in the building to be the storage room for the MakerBus. The coaches met in this computer lab and physically designed the room focusing on organization, space, and storage to imitate the back of the bus. The coaches took pieces of design ideas from the six blueprints and tried out different design elements. During the mock design of the computer lab, the coaches went through several rapid prototyping processes to further tweak the functional design. For example, some coaches suggested adding stools in the MakerBus. However, it would be hard for students to move in the MakerBus, so this design element was eliminated. Initially, the coaches wanted foldable countertops for the stations. After trying it out in the computer lab, they decided to have stationary

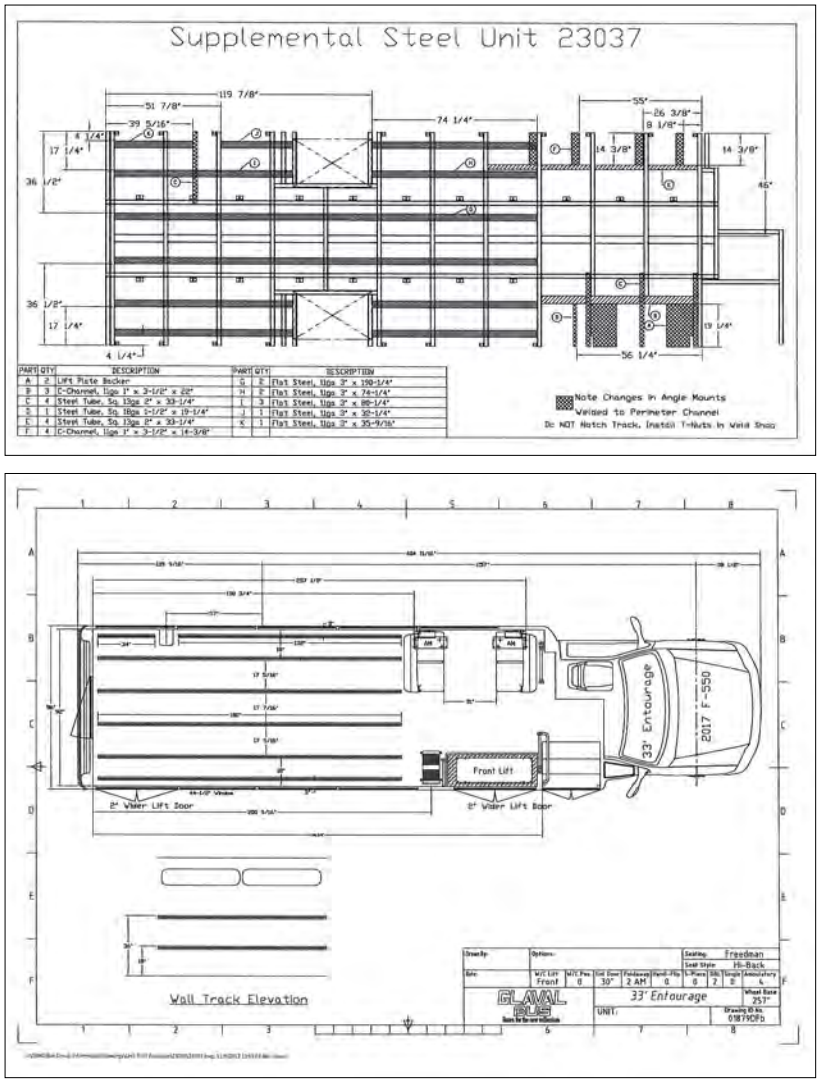

FIGURE 2. Digital blueprints for the MakerBus. Used with permission.

countertops, which would provide students more workspace and a place to display maker artifacts. The coaches also suggested some foldable furniture so space could be cleaned up after students' work in the MakerBus. Once the coaches agreed on a rough draft of the functional design, a digital blueprint was created by Dr. King (see Figure 2).

There were several items of concern in the blueprint: 1. Where to place the laser cutter? 2. The amount of space needed for wheelchairs, 3. The placements of the power outlets, 4. The window placement, 5. The L-tracks, and 6. Outdoor space and power sources. The leadership team further collaborated with Dr. King to address the design to answer each of these concerns.

For the laser cutter, the team agreed that it had to be at the rear of the bus so it would not block people's workspace on the bus. The rear of the bus also made the venting of the laser cutter easier. Usually, the MakerBus would be parked on the passenger side of the school. The laser cutter should be on the driver's side at the rear so the smoke could be vented to the other side away from teachers and students.

Accordingly, the wheelchair lift should be moved to the front of the bus. Using foldable furniture also made sure that enough space was available for the wheelchairs.

For the power outlets, one outlet needed to be placed with the stationary laser cutter and venting. Other power outlets should be placed with the workstations. Two exterior outlets were designed because some of the maker events would be outside.

For the window placement, the team decided to take out all the windows except for the small windows above the workstations and a big window beside the foldable table. The reasons for keeping these windows was 1. For the comfort of the people riding the MakerBus, and 2. For supervising students' making activities on the bus.

For the L-tracks, the team decided to have the L-tracks on the floor and the walls of the bus. Having L-tracks was for securing any loose items on the bus. It will also help in securing wheelchairs and other equipment.

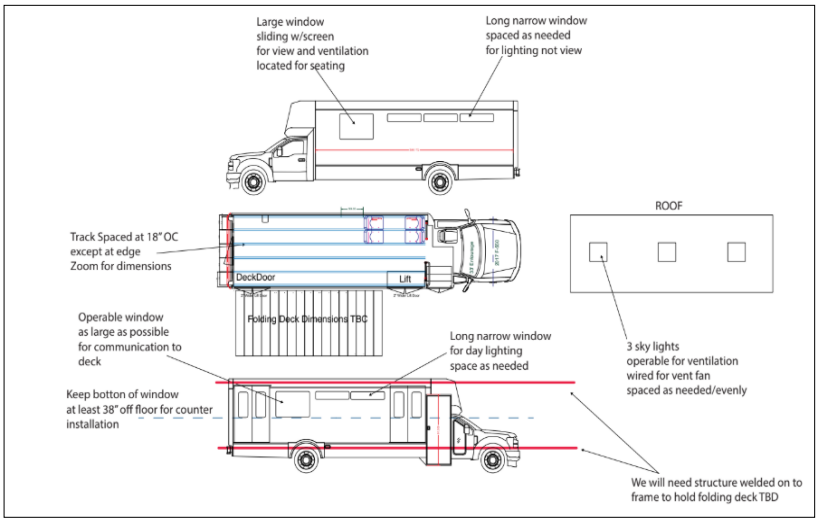

FIGURE 3. Blueprints of the MakerBus drawn by the expert. Used with permission.

FIGURE 4. Inspirations for the wrap design. Used with permission.

For the outdoor space and power sources, the team decided to have retractable awning and tents with sides to expand the space. The MakerBus would also be equipped with portable tables because most maker events would be outdoor so students could have more space for different stations.

Three power sources were discussed: generator, inverter, and shoreline to plug into school buildings. The team decided to use the shoreline and a generator depending on the context of the school. Some of the schools do not have options for the shoreline, so a generator should be available as needed. The inverter idea was eliminated for two reasons: 1. It was expensive to purchase the inverter and 2. The schools are no idle zones. They would not allow the MakerBus to run on school properties due to air quality considerations. Dr. King drew an updated plan based on these decisions (see Figure 3).

During the functional design phase, the instructional coaches also collaborated with the graphic designers in the college to design the wrap of the MakerBus. The coaches communicated with the graphic designers about the main focus of the MakerBus, which is to empower students to believe they could create things and make social changes. The team met and created a Wordle image and sent it to the graphic designers. A maker map from Montague Workshop was also used as a major inspiration (see Figure 4).

The coaches also provided the graphic designers some key elements in maker education, such as design thinking, soft skills, STREAM education, and maker mindset. With the information provided, the graphic design team created two different designs (see Figure 5).

The leadership team met again to decide on which wrap design would best represent the mission of the MakerBus. They decided on the second design because the first design mostly focused on promoting STEM education, which did not align with the mission of the MakerBus. The coaches wanted the students and teachers to know that maker education was not only for STEM; its goal was to empower students to believe they could create things and make social changes. Thus, the second wrap design was chosen for it showcased the design thinking process, soft skills, and maker mindset, which were the core of maker education. The color scheme of the second design was also bright and bold, which matched maker education. A few elements were added to this design, such as paintbrushes, the binary codes, a few quotes, markers, and so on. These elements represented art, literacy, and computational thinking, which added on to the original design. Figure 6 demonstrated the final wrap design of the bus.

FIGURE 5. Initial wrap designs of the MakerBus. Used with permission.

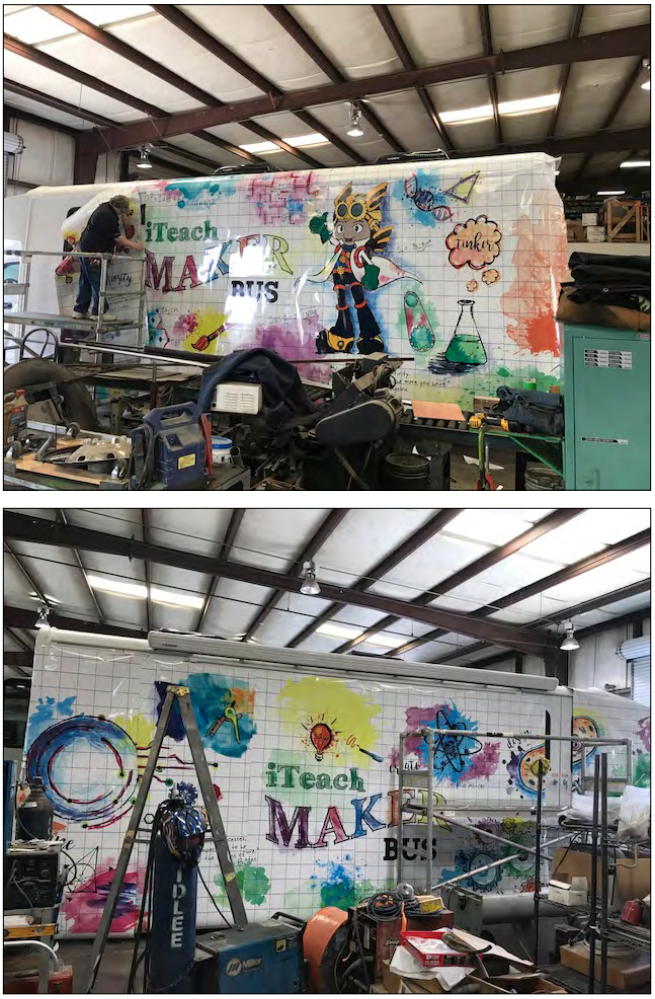

FIGURE 6. Final wrap design of the MakerBus. Used with permission.

FIGURE 7. Final design of the MakerBus. Used with permission.

The Implementation Phase

After the functional and wrap design of the MakerBus were complete, the iTeach unit began to contact the contractors, marketing team, and industry partners. Per requirements, the Glaval bus came with four front seats and L-tracks on the floor from the manufacturer. The center communicated the requirements and designs with the bus company. Then, Glaval, the bus company, contacted the contractor they had for the company and got pricing and details for the work. A negotiation process was conducted to determine the scope of the work and make the final pricing within the project's budget. After the plan and price were finalized, the contractor worked on the interior of the MakerBus according to the digital blueprint created by the faculty member at VT. Due to the budget of the project, minor changes were applied during the contractor's work, for example, removing the addition of a deck or extra door. The coaches also decided to set up the stationary workbench, storage, and stations, and to add a few portable stairs purchased from another source for the accessibility of students.

The leadership team and Dr. King met with the contractor to discuss a few important items, such as the placement and venting of the laser cutter and the materials for the stations. For the laser cutter, the leadership team found a pre-made stand for a particular brand of laser cutters, Epilog. They communicated with the contractor to change the blueprint and affix the stand to the MakerBus instead. The original venting solution was suggested by the risk management department of the university. It did not work in actual practice. Therefore, the team contacted Autodesk for a solution. Experts from Autodesk Technology Centers, Dr. King, Joe Aronis, and Adam Allard came up with a new plan that solved the problems for venting. For the material of the stations, the team chose a golden oak material instead of laminated materials. The reason was that if students damaged the wood, the team could sand it down to manage the damages. The team also consulted with the contractor about the measurements of the stations. The main considerations were: 1. K-12 students should have easy access to the stations, and they could work on them, and 2. The coaches could house the toolboxes under the stations and benches. Using human-centered design for guidance, the measurements were adjusted to fulfill these criteria.

Except for these minor changes, the contractors worked on the MakerBus according to the blueprint generated from the second phase and applied the wrap on the bus. However, the production timeline was prolonged by about five months because of the manufacturer's delay. Figure 7 showed the final designs of the exterior and interior of the MakerBus. Figure 8 illustrated some outside activities.

FIGURE 8. Outside activities. Used with permission.

The unit contacted the industry partners to seek equipment donation, funding, training, and support opportunities. However, the MakerBus did not receive any funding or donations from industry partners at this phase. It was challenging to seek funding and donations during the design phase because the industry partners could not see the running MakerBus.

The center formed a marketing committee to plan for the launch and create social media marketing strategies to promote the MakerBus. Some strategies were: 1. Sending out maker blast to surrounding school districts, 2. Sending announcements on Facebook and Twitter, 3. Emailing administrators at the district and school levels, and 4. Sending invitations for the MakerBus launch. The marketing team from the university also collaborated with the iTeach unit. A photographer and writer from the university marketing team took pictures and wrote an article about

the MakerBus to advertise the launch on the university website. The university marketing team contacted the local newspaper to publish an article about the MakerBus.

REFLECTION

Challenges of Running the MakerBus

After the launch, the coaches began to drive the MakerBus to local K-12 schools to offer maker events. A few challenges emerged, such as driver qualification, staffing struggles, and the sustainability of the materials and tools.

The iTeach unit worked with the risk management team of the university to determine what driver's license and requirements were needed for the coaches to drive the MakerBus. The risk management team informed the unit that all drivers needed to get CDL driver's licenses. In order to get these licenses, the coaches needed to study for at least 12 hours, take the university defensive driving course, get a driver's permit, spend more than 20 hours student driving with a CDL driver, have a test on their driving skills, and then get approved by the university insurance policies. The leadership team also began to develop a CDL driver training program and brainstormed ways to deliver training and offer tests. Some coaches began the process in order to get CDL driver's licenses as soon as possible so that they could begin to drive the MakerBus to schools. However, this process was time-consuming and costly.

Meanwhile, the leadership team contacted state DMV and DDS, who informed the center that they would not allow the coaches to take CDL tests using the MakerBus because it had less than 15 passengers. After further communication, DDS informed the center that the coaches only needed regular driver's licenses since the MakerBus could only have one driver and three passengers on board. In the end, the coaches could drive the MakerBus with their regular driver's licenses, and there was no need to go through the lengthy and costly training and testing process. We want to suggest others who hope to design and operate a MakerBus contact all stakeholders to determine the driver's qualifications before investing time and money.

Driving the MakerBus to deliver maker events is received well in schools, thus causing staffing the MakerBus for maker events becomes another challenge. Most instructional coaches are stationed in schools for most school days. When there is a maker event, the MakerBus project lead has to consider a variety of factors to schedule the coaches, such as date, time, weather prediction, driving distances, university's policies, reimbursement, commuting distances, training needed for a particular event, short work cycle for planning and preparation, and coaches' various skill levels and expertise. Each maker event needs at least three coaches to be present, thus making it more challenging considering the combinations of factors. One solution from the center is to designate an instructional coach to be the MakerBus project lead who knows all the details and coaches. The project lead provides training to the coaches and drivers, prepares needed materials and tools, and considers all the factors during scheduling. Having one mastermind who has the whole picture in mind to work on staffing and scheduling at the same time make the puzzle pieces work together.

For any making project, the sustainability of the materials is an unavoidable challenge. Since the maker events delivered by driving the MakerBus are received well in schools, the center continues to work with interested schools and districts. A lot of the schools decided to make a contract with the center for the maker events and instructional coaching on maker education, which makes the MakerBus have enough funds for purchasing materials and tools. For each maker event, different materials and tools are used that make preparation and purchases timely and unpredictable. These materials and tools are purchased with a small amount. The MakerBus project lead accumulates a stack of receipts from these small purchases over time, which makes it challenging for reimbursement per university reimbursement policies. The center later decided to hire a designated staff member for business-related items, travel, reimbursement, and so on, which makes the process smoother and lessen the burdens on the instructional coaches. The sustainability of materials and tools and staffing for the MakerBus are relevant topics to discuss when designing a mobile makerspace.

Reflection on Working with Teacher and Students

Compared to the practical challenges we face running the MakerBus, working with teachers and students is smooth sailing. The instructional coaches excel at meeting the needs of a school or a program. The teachers usually communicate with the coaches beforehand about their instructional goals during the maker events and co-plan with the coaches. During this process, the coaches are able to design more targeted standard-based maker activities for the schools and provide instructional coaching to these teachers. For example, during Dr. Seuss' Birthday week, the coaches worked with the teachers on designing literacy-infused making activities that cover different content standards from grades K to 5. By the early spring of 2020, the MakerBus collaborated with more than 50 administrators and served more than 1,437 teachers from various districts.

Like teachers, students love working on making activities. The physical presence of a MakerBus inspires students to explore what the MakerBus could offer. By the early spring of 2020, the MakerBus served 11,570 K-12 students and planted a seed of the maker mindset in each of their minds.

CONCLUSION

Our MakerBus serves as a visual representation of the Maker Movement in education, which promotes the

empowerment of students to create projects and make social changes. To our expectations, designing and running the MakerBus brings a substantial impact to our instructional coaches, colleagues, and students in the college, as well as stakeholders at local K-12 schools. These efforts were started from basements and bins in cars to the actualization of a MakerBus running in K-12 schools. We would encourage others to consider using mobile makerspaces as an approach to promote maker education in K-12 schools, starting something small and making ways from there.

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