Curriculum Implementation Plan: After School STEM Makerspace Program

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To: Julia Ryan, Ed.D., Superintendent of Schools

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Date: May 8, 2017

Subject: After School STEM Makerspace program

With the approval and support from the Board of Education, the Western Middle School would like to organize an after school STEM Makerspace program that focuses on 3D printing.

The after school STEM Makerspace program will meet bi-monthly in the Library Media Center on Wednesdays from 3:00 PM – 4:00 PM from January 10 – May 30, 2018. The first 15-20 students interested in the program will require to sign-up by December 15, 2017 at 3:00 PM.

In order to succeed, the after school STEM Makerspace program requires the leadership and support of the school district as a whole. This effort will be overseen and directed by Krista Welz - Librarian/Media Specialist, Yalitza Vega-Bajana - Mathematics Teacher, and Stephanie Peborde Burke - Science Research Teacher of the Western Middle School, along with the help of student volunteers from the Western High School STEM Academy.

By implementing a 3D printing STEM curriculum into the program, students will be kept up-to-date of emerging trends and materials with a variety of 3D printing lesson plans and projects that will apply ingenious designs and student/instructor-led STEM inquiry and project-based learning.

We would like your approval to go forward with the after school STEM Makerspace program. **Please approve this fundraiser, in writing, by June 23, 2017**.

For more information on the after school STEM Makerspace program, please contact us at 555-246-1357 or email wms_stemmakerspace@gmail.com.

Attachments: After school STEM Makerspace program proposal

Initiative and Rationale

One of the latest technologies presently being applied in K12 STEM curriculum is 3D printing. 3D printing can help facilitate creativity, problem-solving and project-based learning in middle school classrooms. At the middle school level, it can be used to train students for more challenging work when enter high school (Rosen, 2014). The Western Middle School would like to implement an after school STEM Makerspace program that focuses on 3D printing. The after school STEM Makerspace program will meet bi-monthly in the Library Media Center on Wednesdays from 3:00 PM – 4:00 PM from January 10 – May 30, 2018. The first 15-20 students interested in the program will require to sign-up by December 15, 2017 at 3:00 PM.

The after school STEM Makerspace program will teach students about the basics of 3D printing, the mechanics of 3D printers, the exploration of several 3D printing modeling web-based programs such as Usecubes, Tinkercad, SketchUp and Fusion, save their designs via STL file formats, and print their designs using the 3D printing Cura software. The after school program will utilize the Western Middle School's two Printrbot Play 3D printers. The 3D printers themselves exemplify the combination of several engineering specialties into their own mechanics and provide the participants physical examples of how the incorporation of various procedural systems can synergize to create physical objects. Because most students learn physics and engineering through hypothetical perceptions, the 3D printers will help students learn about the physical and engineering experiences via mathematical intellection. The 3D printers will allow the instructors to help students generate tangible models that they can all view, touch and eventually assess under several physical limitations (Martin, Bowden & Merrill, 2014).

Considering the ever-expanding variety of 3D printing materials, the projects will be delivered with the suitable 3D printing materials provided by the school. With the help of both instructors and student volunteers from the Western High School STEM Academy, students in the after school STEM Makerspace program will develop innovative hypotheses based on the instructors' assigned tasks. Students will then analyze and design experiments to explore their hypotheses and match instructors' requirements, and then construct and engineer structural 3D designs to carry them out. Students will be required to evaluate and reflect on their results. Project assignments can be personalized to students' individual abilities and chosen from already-made models from various 3D printing websites, or student-designed (Hughes et al., 2017; Martin, Bowden & Merrill, 2014). Students will be encouraged to work in groups with their assigned projects, ultimately enhancing interaction and teamwork skills to the program. Groups of students can provide value to the program based on their specific strengths and camaraderie as groups work towards common goals (Murray, 2013).

By implementing a 3D printing STEM curriculum into the program, students will be kept up-to-date of emerging trends and materials with a variety of 3D printing lesson plans and projects that will apply ingenious designs and student/instructor-led STEM inquiry and project-based learning. Based on the New Jersey Student Learning Standards, National Mathematics Standards, Next Generation Science Standards, and Standards for Technological Literacy, teachers are expected to create transverse associations among STEM regions of study in a blended approach. By integrating 3D printing STEM skills, the program will apply technology and engineering designed-based pedagogical methods that purposely impart subject matter and methods of science and mathematics synchronously with methods of technology and engineering education. The 3D printing STEM lessons will encompass genuine projects that enhance theoretical awareness of STEM curricula by integrating real-world subject matter (Hughes et al., 2017).

STEM proficiencies are predominantly essential in high school, as students train for college and career readiness. As a result, 3D printers are ordinarily found in high school classrooms (Martin, Bowden & Merrill, 2014). In order to prepare students for the Western High School's STEM Academy program, the Western Middle School after school STEM Makerspace program will strive to promote innovative thinking by creating thinkers, makers and problem-solvers in engineering and technology across the curriculum. The current transition to inquiry-based learning in classrooms has persuaded Western Middle School to take full advantage of the maker movement and its endless possibilities of creating (Rosen, 2014). 3D printing is modernizing all segments of science, technology, engineering, and math (Hughes et al., 2017).

Implementing 3D Printing

in a Middle School Curriculum

After School STEM Makerspace Program on 3D Printing:	January 10-May 30, 2018 Bi-Monthly / Wednesdays 3:00-4:00 p.m.
Location:	Western Middle School Library Media Center (2nd Floor)
Course Components:	Hands-on learning, multi-media, video-clips, designing, 3D printing

Standards for Technological Literacy (STL)	**STL 1:** The characteristics and scope of technology (benchmarks include people and technology; tools, materials, and skills; creative thinking; human creativity and motivation; product demand; rate of technological diffusion; and commercialization of technology). **STL 4:** The cultural, social, economic, and political effects of technology (benchmarks helpful or harmful; unintended consequences; attitudes toward development and use; ethical issues; and influences on economy, politics, and culture).
Description:	Students will be able to analyze, design, create and evaluate objects using Tinkercad, Usecubes, or SketchUp and Fusion 360 (for more advanced modeling) as their modeling programs. Two PrintrBot Play 3D Printers will be utilized to design the finished product using Cura 2.5 as the 3D printing Software and PLA plastic filament to create the object.
Target:	Students will learn about 3D printing and experiment with designing and making 3D models while incorporating technology, engineering and geometry At the end of the course students will create a 9/11 memorial model using the Cura 2.5 software for 3D printing.

Resource required:	● Chromebases ● Cura 2.5 Software ● Two Windows computers (for using Cura 2.5 Software) ● Two PrintrBot Play 3D printers ● PLA plastic filament ● Usecubes ● Tinkercad ● SketchUp and Fusion 360 (for more advanced modeling)
Student Population:	● First 15-20 students interested (sign-up will take place December 15, 2017 at 3:00 in the Library Media Center) ● Volunteers from the Western High School STEM Academy will be willing to share their expertise on bi-monthly after-school meetings.
Student Learning Outcomes:	By the end of the course, students will be able to: ● Understand the importance of carefully engineering a design ● Discuss 3D printing techniques ● Transfer files from the computer to the Printrbot Play 3D printer ● Create 3D designs using web-based programs such as Tinkercad ● Print their own 3D objects ● Troubleshoot 3D printing errors ● Develop effective student strategies that promotes the ability for students to become innovators, creators, designers, and the ability to think critically.

Instructional Procedures:	• Collaboration with other students • Create • Innovate • Watch video clip • Student group presentations
Course Content:	**January 10:** Introduction to course review and understanding the significance of STEM **January 24:** Understanding how to create 3D designs using web-based programs such as Tinkercad and Usecubes **February 7:** Exploring the Tinkercad/Usecubes web-based programs by designing two small objects. **February 21:** Continue designing their objects on the web-based programs **March 7:** Field Trip to the PicoTurbine Facility **March 21:** Watch YouTube video: https://youtu.be/gynk2fLx8iI and discuss 3D printing techniques on the use the Printrbot Play 3D Printer **April 4:** Student will print out objects designed. **April 18:** Groups of 2-3 students will explore, collaborate and create a 9/11 memorial model. **May 2:** Continue adding finishing touches to the memorial model design and print models **May 16:** Present final 3D design in class **May 30:** Present final 3D design in class

Evaluation Plan

Assessment of the Introduction to 3D Printing curriculum will be achieved through evaluation of student learning. A Maker curriculum in a Makerspace can follow a very different model than that of other classes. Students will also likely have a very different experience working in a Makerspace than in a traditional classroom. Makerspaces are where students create, collaborate, innovate, tinker, succeed, and even fail. Kurti, Kurti, and Fleming (2014a) even encourage what most of society considers “failure” in Makerspaces. It is important to remember that this is an after school program. There are no grades, but it is important to assess student success with the topic and to help them improve as the course progresses.

An evaluation rubric can be used to assess student work and that it meets the criteria identified. The work by Yokana (2015) provides a useful basis for evaluating Maker-related products. She says that assessment can be a challenge to new and veteran teachers. The idea here is to show that “deep, rich learning is occurring though making.”

Yokana’s three-part rubric assesses process, understanding, and product. She suggests that the process of making be part of the final grade. This curriculum, again, is not grade-bearing, but the general goals of the course would essentially the same as a course that ran during the school day. The main components of Yokana’s rubric are Technique/Concepts, Habits of Mind, Reflection and Understanding, Craftsmanship, Responsibility, Effort.

Yokana’s rubric uses four domains that include Unsatisfactory, Competent, Proficient, and Distinguished. Most students in the 3D Printing course could aim for proficient, with some, but not all, students aiming for and meeting the Distinguished category. Yokana suggests that students should:

a) Show an understanding or mastery of skills, concepts, and materials

b) Are able to explore and try multiple solutions, be innovative, and ask thought-provoking questions

c) Show self-awareness, reflects deeply, and makes purposeful decisions

d) Is neat and careful throughout their work

e) Is respectful, participates in clean-up, and owns their work

f) Completes work with high or exceeded expectations and is committed

Throughout the after school program, students will create a digital portfolio of their work since they will be creating two smaller objects to practice and learn 3D modeling techniques, as well as their 9/11 Memorial model. This may be useful to show their progress and serve as evidence of their abilities and successes in this program. The portfolio may contain photos of 3D printed creations and/or print-outs of 3D rendered images.

In addition to presenting their final 3D 9/11 Memorial model design in class, it may be valuable for students to present their work or showcase it at an upcoming event. Students might present their 9/11 Memorials at a 9/11 event or even at a local Maker Faire, as the end-product created by students in this program fits well in both. Students would be giving back to the community and showcasing their innovative efforts through showcasing this memorial designs.

Should additional courses or perhaps even an Advanced 3D Printing course be run in the future, it is important that students achieve a level of proficiency in 3D Printing in the introduction course before moving on to higher level work that might involve advanced modeling like artistic modeling that treats the 3D model like “digital clay” (Kurti, Kurti, & Fleming, 2014b).

Because this is not a program in which a grade is assigned, students and their peers should be involved in evaluating their work. Students can use the rubric to assess their work at the end of each project, as well as evaluate their peers. The teacher can also provide feedback through completing a rubric. These rubrics can and should ultimately end up in the student's portfolio.

Reflection

In today's educational system, students are developing their learning skills in a framework that encompasses both a connectivity and interactive philosophy. In the early 1980s, Seymour Papert argued that the social dissemination of information and communication technologies offered people with the methods to cultivate and apply innovative didactic concepts. Since the diffusion of technology in schools, learning organizations are integrating these concepts into their own methods. 3D printing in Makerspace environments can be based on the learning theory of Papert's constructionism (Kostakis, Niaros & Giotitsas, 2015). Ackermann (2001) stresses the individualized creations of knowledge products in addition to the social nature of the learning method. Both Paiget's Constructivism and Papert's Constructionism principles stress the accomplishment of knowledge as an unremitting endeavor that individuals construct for themselves and their implication of learning as designing knowledge products, regardless to the conditions of the learning. Constructionism also occurs in environments where the learner is determinedly involved in designing a product. In comparison to the many scholars that have discussed the philosophy of education, such as John Dewey and Paulo Freire, constructionism supports the fact that students' academic progression must be established in their experience. Knowledge must be absorbed as personal, constructed experiences. 3D printing in Makerspaces allows students to congregate and design objects, while providing them the opportunities to participate in applied explorations that encourage the constructive method (Ackermann, 2001; Hira, Joslyn & Hynes, 2014).

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