Niemeyer and the Conic Sections

Integration

21st Century Themes: Additive Manufacturing, Communication, Cultural awareness

Concepts for STEAM Disciplines	**Mathematics** Conic sections Proportions Modelling	-------------------
	Technology Modelling software GeoGebra 3D printing	**Arts** Architecture History Philosophy

Prerequisite Knowledge

Mathematics
Basic Knowledge of Functions: Graphs, transformations,

Information Technologies
Basic use of GeoGebra

Arts
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Learning Outcomes

Grade Level: 17-18 years old
Duration: 450 minutes

Learning Outcomes for Mathematics
Students recognise the Equations of Conic Sections
Students can establish relations between equations and graphic representation of Conic Sections
Students can use transformations to generate the desired shapes
Students can transit the Mathematical Modelling process

Learning Outcomes for Information Technologies
Students can use Software to represent 3D Geometrical Shapes of the buildings
Students can use the software to generate printable models of the buildings
Students can use the 3D printer to obtain the model

Learning Outcomes for Arts
Students can use critical thinking skills when describing, analysing, interpreting and evaluating the architectural structures.
Students can explain how the artwork evokes feelings, emotions and aesthetic responses.
Students can interpret the work of the architect based on his philosophy, cultural background and context.

Real World Cont

Problem Situation
How to obtain 3D printed models of the work of Oscar Niemeyer focusing on the Mathematical aspects of it?

Materials
- Computers
- GeoGebra
- TinkerCAD
- 3D printer

Preparation for the lesson
The following questions will be sought answers for preparing the lesson plan. The answers to these questions will be presented in a separate document:

- Who is Oscar Niemeyer?
- What are the Mathematical characteristics of his work?

e x t	• Which building presents a better connection to the Mathematical topics? • What particular context did he live in? • What connections exist between his work and his ideology? • What information should be presented to the students?
	Resources Modelling and 3D-Printing Architectural Models—a Way to Develop STEAM Projects for Mathematics Classrooms. https://doi.org/10.1007/978-3-658-38867-6_11 https://en.wikipedia.org/wiki/Oscar_Niemeyer https://en.wikipedia.org/wiki/Bras%C3%ADlia https://www.geogebra.org/m/rjen4vj2 https://www.geogebra.org/m/ed2qsbxs https://www.geogebra.org/m/pkfzccjw Niemeyer pictures .pdf
STEAM Activity	**Ask** Teacher's topic introduction to be able to carry out this work is highly important. This stage consists of a series of *short tasks,* including pictures of buildings or structures with interesting mathematical elements, as shown in Figure 5, and the questions *"What do you notice? What do you think about these pictures?"*. A good selection of pictures can help students to start a discussion about the elements of interest that can be mathematical, cultural, historical, or architectural, among other things, and generates a climate of inquiry in the classroom (Rumack & Huinker, 2019). This can be repeated by showing a selection of 3D-printed structures to increase motivation and start the connection between the physical and digital worlds, as this is suitable for starting the class discussion about the modelling process on the computer. See https://pubs.nctm.org/view/journals/mtms/24/7/article-p394.xml for further reference about the implementation of the activity. It is important to give freedom to students in the answers and to propitiate the discussion around the pictures presented.
	Research The next task is for students to research Oscan Niemeyer and create a presentation for the rest of the class. This should include information about his life, ideas, work and relationships between his buildings and geometry. Students must have at least three examples of Niemeyers' buildings in connection with mathematics. The presentation format should be open for students to develop their creativity.
	Imagine While group presentations are shared, a class discussion setting should be created. Having completed all groups' presentations, the teacher can draw students' attention to the geometrical relationships and fine-tune an atmosphere for discussion. At this stage, it is important that the teacher points out the relationship between the buildings of Niemeyer and the conic sections. After presentations and discussions, groups are invited to draw ideas for buildings inspired by these mathematical concepts.
	Plan Students are asked to choose one building and analyse it in depth to understand the mathematical relationships. Designing a 3D model of the building in GeoGebra utilising these mathematics is presented to them. Then, they are asked to start working on the plan to design the 3D model.
	Create To create the model in GeoGebra, a good start is to load an image of the building and model the contour using the conic sections that better fit it. After that, students could move to the 3D view and, using the command surface, rotate the conic section to create a surface. A complete explanation of a possible way to address the construction of the 3D model is presented here: https://www.geogebra.org/m/ed2qsbxs It is important to present the tools to students and let them explore their possibilities by themselves. Is in the process of instrumentalisation of GeoGebra when students are expected to get the more important knowledge.

	After they obtain the 3D model in GeoGebra, is possible to print it following some simple steps presented here: https://www.geogebra.org/m/pkfzccjw
	Test Once the 3D object is printed. Is vital to observe its characteristics to decide if it complies with the desired mathematical and aesthetic goals. The objects should be presented to the rest of the class, and they should provide feedback for improving the design.
	Improve After the testing stage, students finalise their reports, including the strengths and weaknesses of the models they have created, the final object created, the presentation they made, and the connections with the mathematics topic. The groups complete the changes they want to make related to their work during this process.
Materials	• https://www.geogebra.org/m/rjen4vj2 • https://www.geogebra.org/m/ed2qsbxs • https://www.geogebra.org/m/pkfzccjw • For moving from 2d to 3d: https://www.geogebra.org/m/rjen4vj2#material/yzftbb8f
Test	This part will be completed by the teacher after the lesson plan is implemented in the classroom.
Improve	This part will be completed by the teacher after the lesson plan is implemented in the classroom. This activity has been developed for secondary-level education. The activity can be implemented at the secondary level of education about the topic of the conic section in the Mathematics subject and in relation to the topic of architecture in the Visual Arts subject.