Open box problem

<table>
<tr><td rowspan="4">Integration</td><td colspan="3">21st Century Theme: Optimisation problem</td></tr>
<tr><td rowspan="2">Concepts for STEAM Disciplines</td><td>Mathematics
Optimization</td><td>Science Education
-</td></tr>
<tr><td>Technology
GeoGebra</td><td>Arts
Develop the prototype</td></tr>
<tr><td colspan="3">Prerequisite Knowledge

Mathematics
Students are able to understand polynomial functions.

Information Technologies
Students are able to use GeoGebra in a basic way.

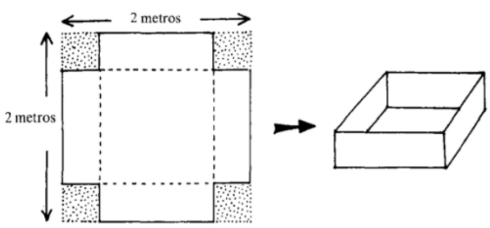
Arts
-</td></tr>
<tr><td></td><td colspan="3">Learning Outcomes

Grade Level: 16-17 years old
Duration: 180 minutes

Learning Outcomes for Mathematics
Students learn or improve their knowledge about how to work with problem solving.
Students are able to create and interpret models, tables and graphs in GeoGebra.

Learning Outcomes for Information technologies
Students are able to improve the use of the tools provided by GeoGebra.
Students are able to use spreadsheets in GeoGebra to support their conjectures.

Learning Outcomes for Arts
Students are able to create a prototype made of cardboard.</td></tr>
<tr><td rowspan="3">Real World Context</td><td colspan="3">Problem Situation
Students are asked to decide the most effective way to manufacture a box from a metal plate, trimming squares from corners and folding the plate to obtain the square-based prism with the largest possible volume.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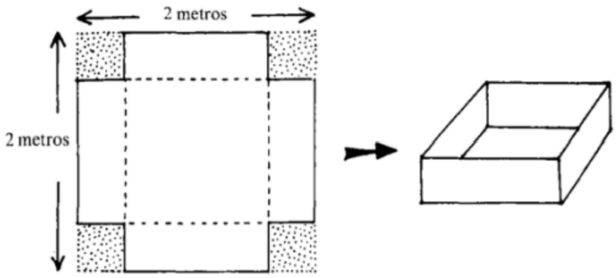
<tr><td colspan="3">Materials
Computers
Scissors
Cardboard
Glue</td></tr>
<tr><td colspan="3">Preparation for the lesson
Answers will be sought to the following questions:
How do I obtain the volume of a prism?
Every prism that I can get in this case has the same volume?</td></tr>
</table>

Resources
www.geogebra.org
https://www.geogebra.org/m/sxytmst9

STEAM Activity

Ask
The teacher starts the lesson asking students to decide the most effective way to manufacture a box from a metal plate, trimming squares from corners and folding the plate to obtain the square-based prism with the largest possible volume.



Students will receive the instructions next to a four-square-metre cardboard square and will be told that this is the material they will have to generate the final prototype.

Research
Students are divided into groups of three or four and they work with computers. They are given the task and start working. They start discussing if every prism created in these conditions will have the same volume and how do they obtain the volume of a prism.
It can be suggested the use of GeoGebra to improve the visualisation and the case consideration. Each group will have computers for this. They can also use their phones.
Groups are given cardboard, scissors and glue to create the prototype.

Imagine
Teams work independently in the prototype required and try to solve the initial problem from different perspectives. Some groups may develop scaled physical models on paper to generate an intuition about the covariation of the magnitudes to be analysed, using a guess and check strategy.
Other teams may work with the computer to calculate volumes of cases they considered relevant, as in systematic experimentation.

Plan
This activity presents an example of technology integration by modifying an optimization problem as an initial activity of the calculus course in the last year of high school. Experimentally noted that the activity generates a high level of commitment, causing students to put in play and refine their ideas about working with functions to model reality and make better decisions.

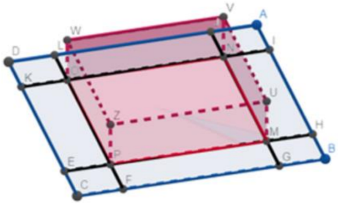
This model for technology integration into the mathematics classroom by modifying existing tasks could encourage teachers to integrate technology easily and more meaningfully.

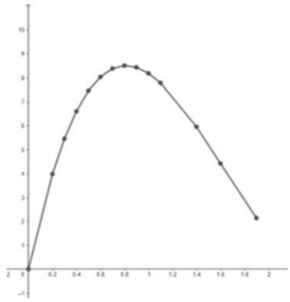
This is a classic activity of every precalculus and calculus course. It has been modified to integrate technology and, consequently, develop new ways for students to think about the involved mathematics.

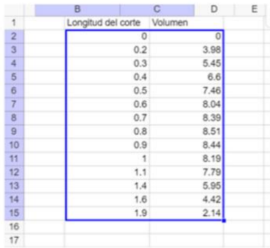
Teams collaborated, independently prototyping and addressing the initial problem from different perspectives, sharing ideas and offering help when needed.

Teams can be suggested to visualise the possible cuts on the cardboard plate by elaborating a representation in GeoGebra.
The possibility to experiment on GeoGebra can help students develop a new utilisation scheme that gives them unique views of the problem and the mathematics involved in what can be interpreted as part of the instrumentation process.

Work is driven on GeoGebra from multiple representational registers. First, developing a flat model of the original cardboard square will be suggested to observe the relationship between the trimmed squares' dimensions and the resulting box's dimensions. The results could then be tabulated in the software to begin numerically visualising the covariation between the magnitudes. And with this, start the jump to the abstract moment. It is expected that working with different instruments and the possibility offered by GeoGebra in the link of different registers of semiotic representation enhance students' work and problem-solving strategy. And so, students will be able to develop their arguments for the development, justification, and presentation of the prototype.







	B	C	D	E
1		Longitud del corte	Volumen	
2		0	0	
3		0.2	3.98	
4		0.3	5.45	
5		0.4	6.6	
6		0.5	7.46	
7		0.6	8.04	
8		0.7	8.39	
9		0.8	8.51	
10		0.9	8.44	
11		1	8.19	
12		1.1	7.79	
13		1.4	5.95	
14		1.6	4.42	
15		1.9	2.14	
16				
17				

Example file of students' construction: https://www.geogebra.org/m/sxytmst9

Create

The teams develop the prototype and a brief justification for their design decisions based on the data obtained. The process is expected to engage students enough to generate solid mathematical arguments for the presentations.

Test

Teachers can check out the GeoGebra applets.

Improve

Students can work with excel in GeoGebra, in order to obtain numbers (different volumes) to compare.

Materials

Students will receive the instructions next to a four-square-metre cardboard square and will be told that this is the material they will have to generate the final prototype. This will have the effect of having students manipulate the problem, live it as a close and actual situation and therefore get deeply involved with the activity.

Also, they will receive computers with access to GeoGebra; each team will receive computers initially as a support tool. It is expected that in need to design the solution before the prototype's development, they will use GeoGebra to make representations and calculations that allow them to build ideas on possible solutions to the problem.

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 was developed for the last high school level. The activity can be applied at the last high education level by considering the optimization subject in mathematics lessons.