Applied Mathematics In STEM

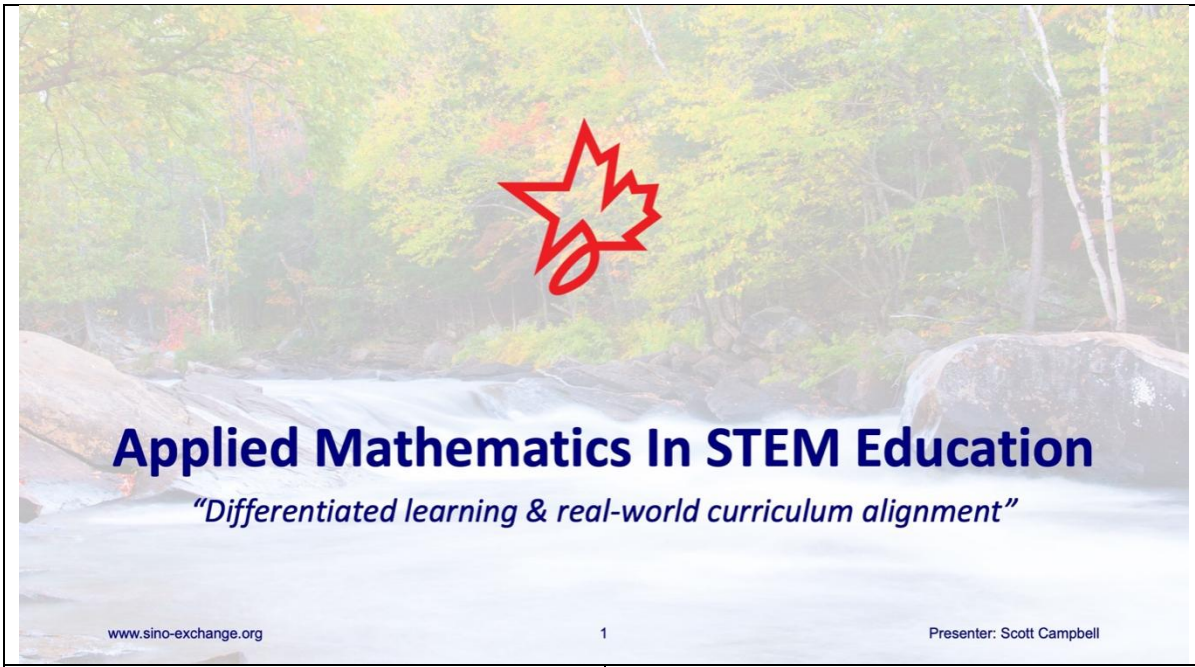
Differentiated learning & real-world curriculum alignment

“Facilitating Experiential & STEM Learning Opportunities”
Organized and Hosted by Hua Quan Village and Sino-Exchange
Presented at HuaQuan Village
By: Scott A. Campbell
September 22nd-24th

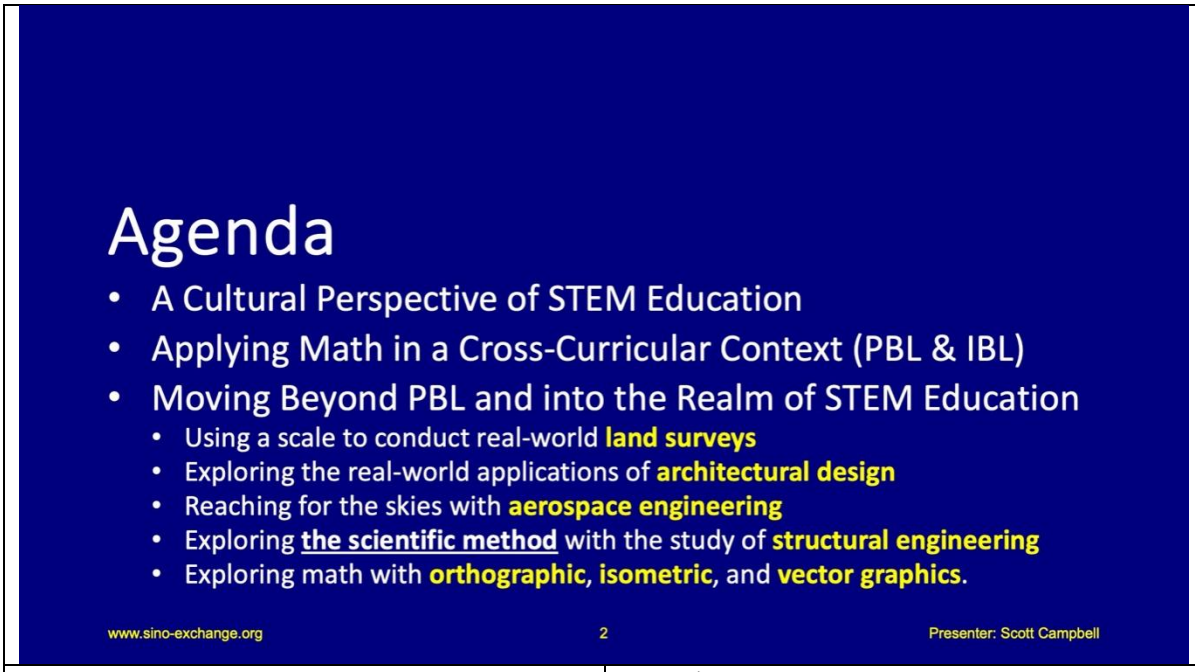
中的应用数学

差异化学习和现实世界的课程调整

主办促进体验式和 STEM 学习机会
由华泉艺文休闲度假村、中外合作交流
在华泉村举办
作者：胡屹龙
9 月 22 日-24 日



Good day and welcome to this presentation of "Applied Mathematics In STEM Education", where we will explore differentiated learning & real-world curriculum alignment techniques in addition to exploring a vast array of Mathematical concepts.	大家好，欢迎收看"STEM 教育中的应用数学"的演讲，除了探索大量数学概念外，我们还将探索差异化学习和现实世界的课程调整技术。



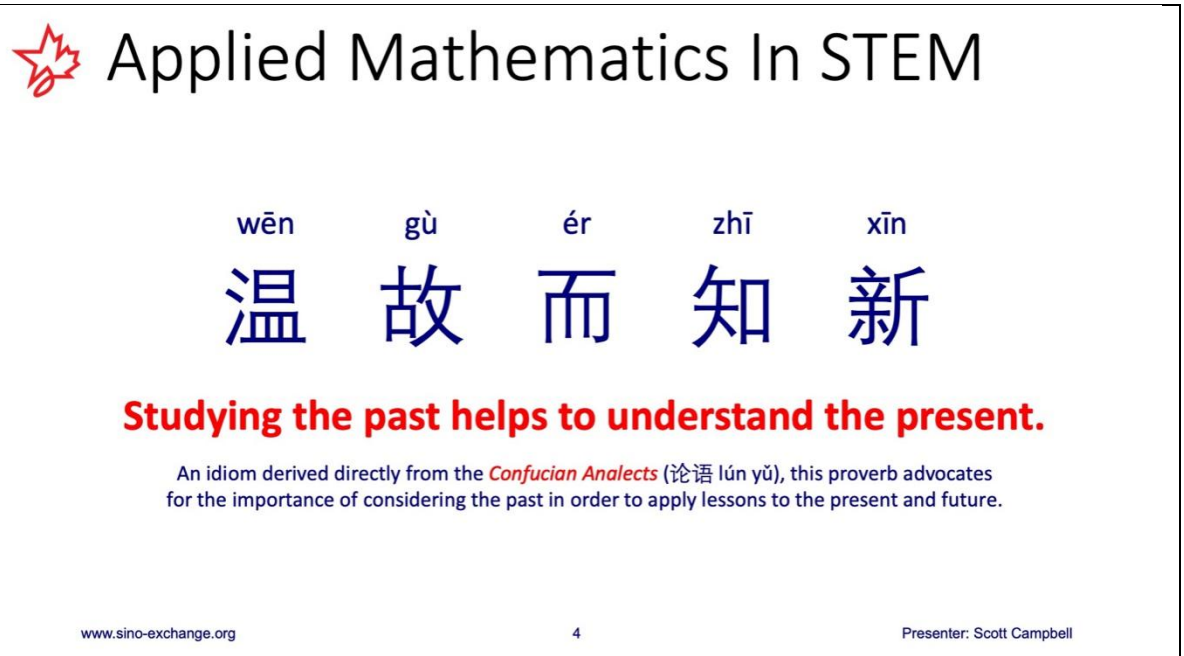
Our agenda for today is as follows:

- I would like to start with a cultural perspective of STEM education,
- Followed by a discussion on “Project & Inquiry-Based Learning” before getting into larger STEM project ideas.
- Then we will explore a range of project ideas which will include:
  - Land Surveys
  - Architectural Design
  - Aerospace Engineering
  - Structural Engineering
  - And Vector Graphics.

我们今天的议程如下：

- 我想从 STEM 教育的文化视角开始，
- 在进入更大的 STEM 项目理念之前，先讨论“基于项目和探究的学习”。
- 然后，我们将探讨一系列项目理念，其中包括：
  - 土地调查
  - 建筑设计
  - 航空航天工程
  - 结构工程
  - 以及矢量图形。

As this is the last presentation in this series, I would like to conduct a slightly different review of STEM education! One that focuses on unique a cultural perspective of STEM education here in China.	由于这是本系列的最后一篇演讲，我想对 STEM 教育进行一次稍微不同的回顾！一个关注中国 STEM 教育独特的文化视角。

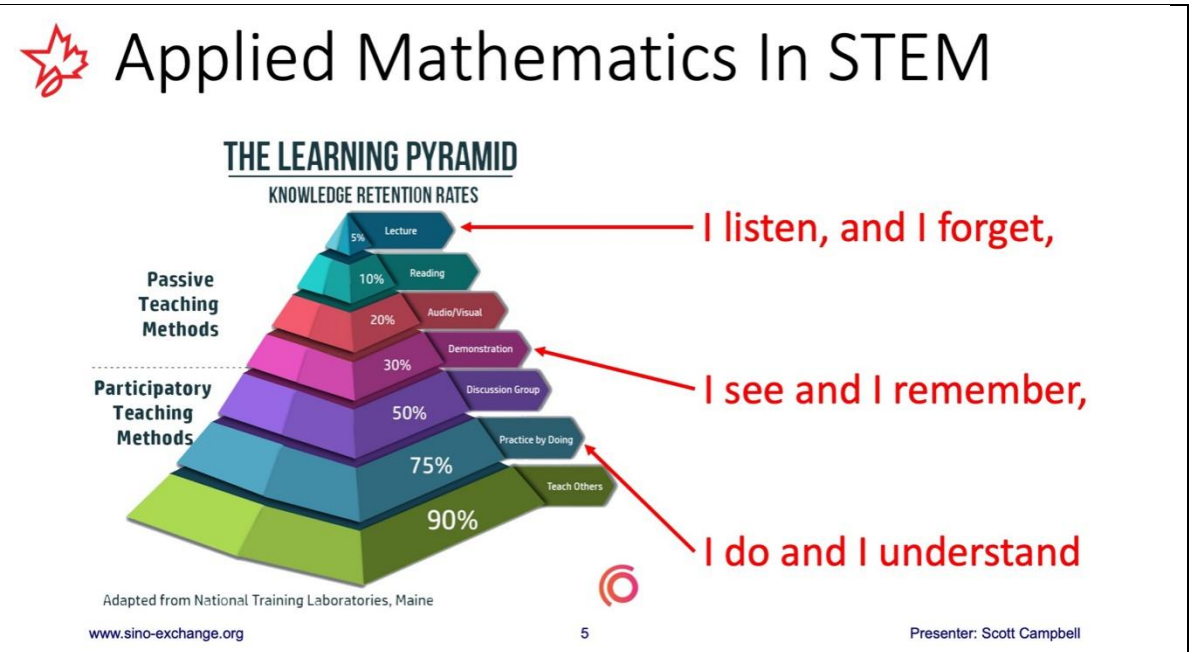


You may have noticed a common theme in all my in-service program. I am consistently looking to our past, as I work towards understanding our present. And I do this so I plan curricula that will help prepare our students for the future.

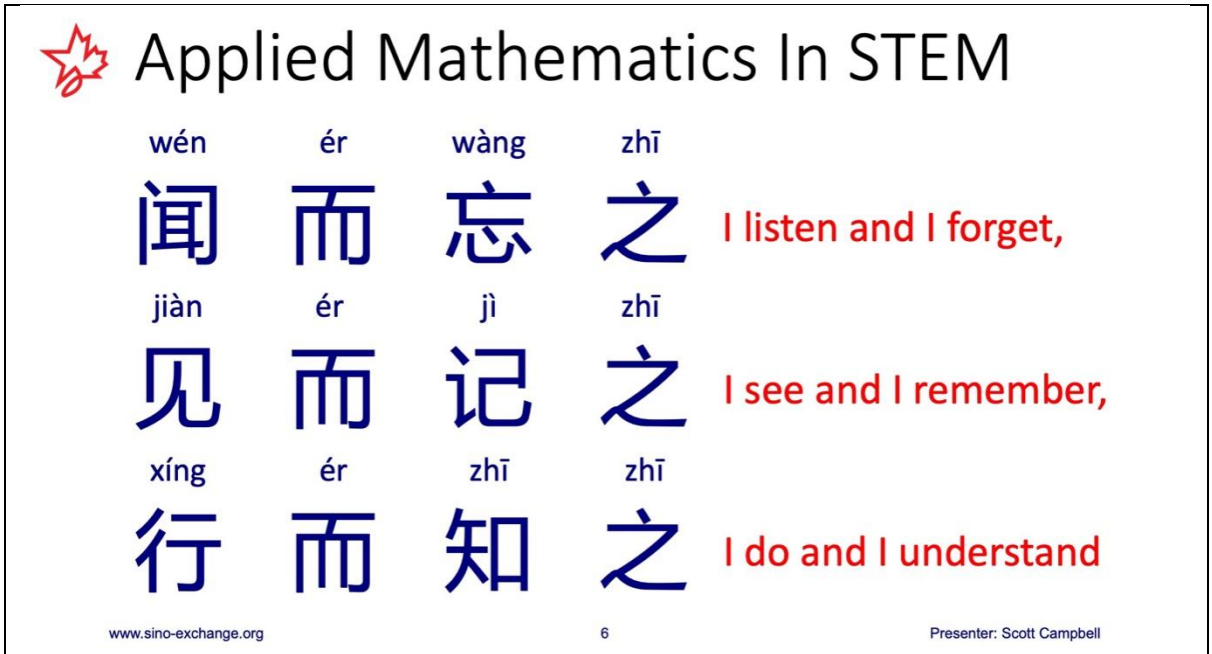
There is a famous saying which states that "studying the past helps us to understand the present"; however, what most people don't realize is that this a translated quote from Confucius that's over 2,000 years old. Yet it is still as relevant today, as when he first wrote this idea in the "Lun Yu", otherwise known as the Confucian Analects.

你可能已经注意到我所有在职课程中的一个共同主题。我一直在回顾我们的过去，努力理解我们的现在。我这样做是为了规划课程，帮助我们的学生为未来做好准备。

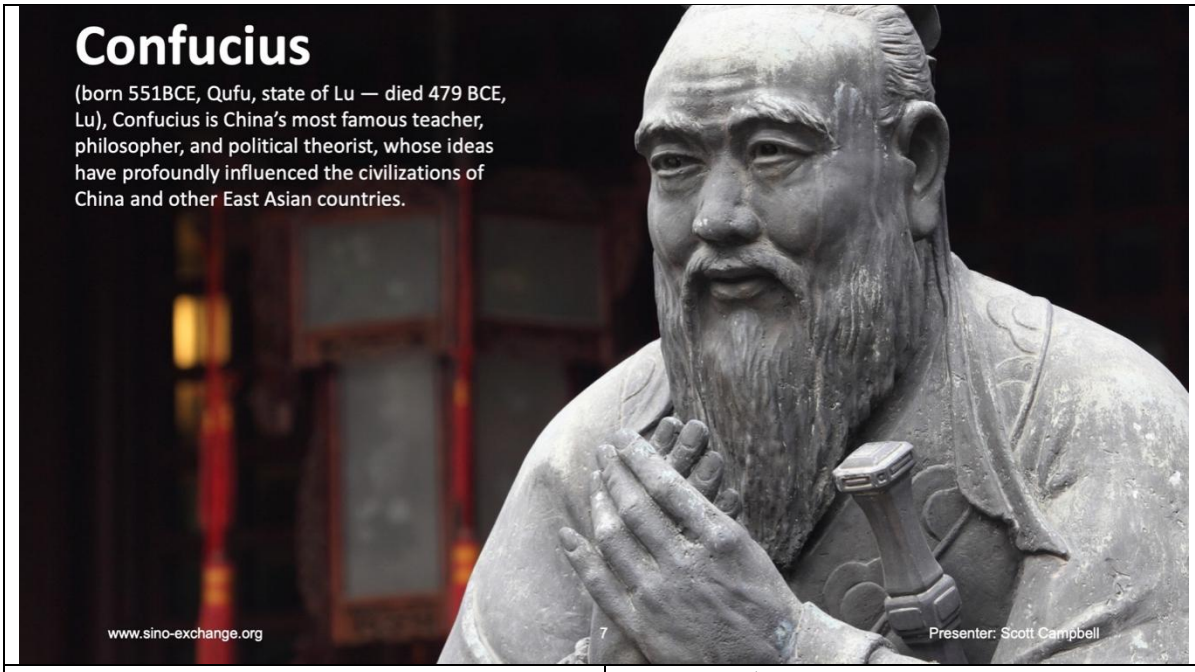
有句名言说"研究过去有助于我们理解现在"；然而，大多数人没有意识到的是，这是一句有 2000 多年历史的孔子语录。然而，这在今天仍然很重要，就像他第一次在《论说》中写这个想法时一样，也被称为儒家的《论语》。



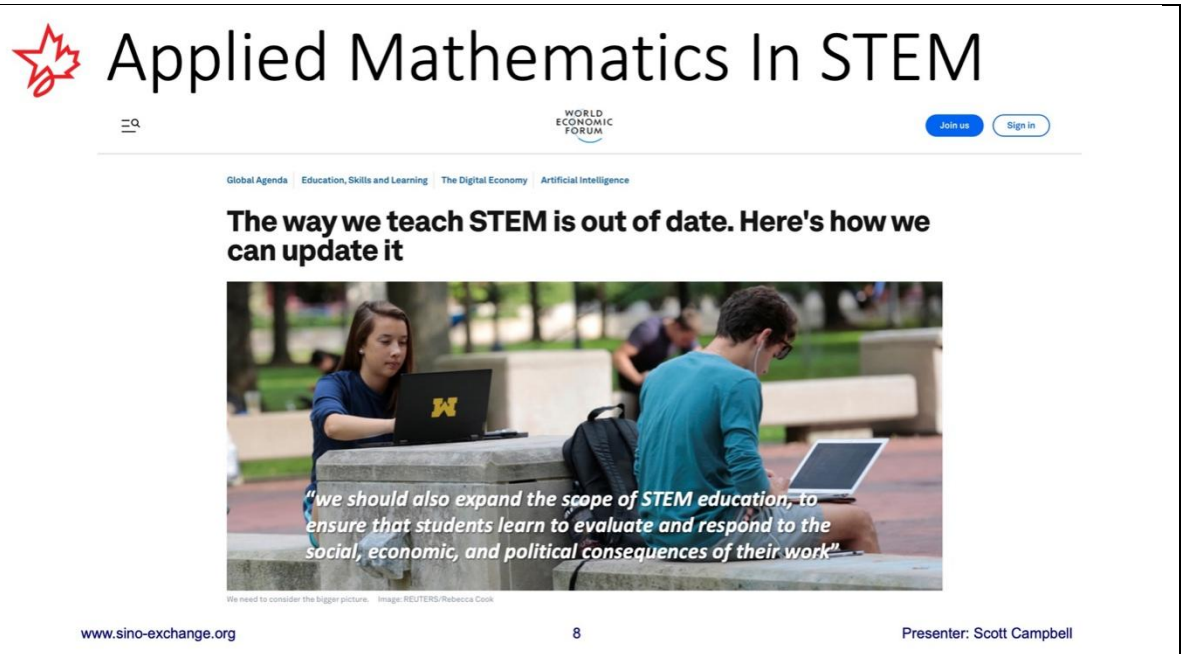
And in the modern era, we advanced our concepts of teaching and have conducted countless research studies. Ideas such as Blooms Taxonomy and the Learning Pyramid that I am showing here are the corner-stones of most academic reforms, whether you agree with them or not is a completely different story! However, regardless of your take on these pedagogical approaches to teaching and learning, I would like you to look at this visual from the National Training Laboratories in Maine. It states that lecture-based instruction has the lowest retention rates, “I listen, and I forget”. However, demonstrations are far more effective, “I see and I remember”, and finally, practice by doing and teaching others is the most effective teaching strategy when trying to learn new knowledge, “I do and I understand”.	在现代，我们提出了我们的教学理念，并进行了无数的研究。我在这里展示的布鲁姆斯分类法和学习金字塔等思想是大多数学术改革的基石，你是否同意他们的观点完全不同！然而，不管你对这些教学方法的看法如何，我希望你看看缅因州国家培训实验室的这张照片。 报告指出，以讲座为基础的教学保留率最低，“我听了，我忘了”。然而，演示要有效得多，“我看到了，我记住了”，最后，在尝试学习新知识时，通过实践和教导他人是最有效的教学策略，“我做到了，我理解了”。



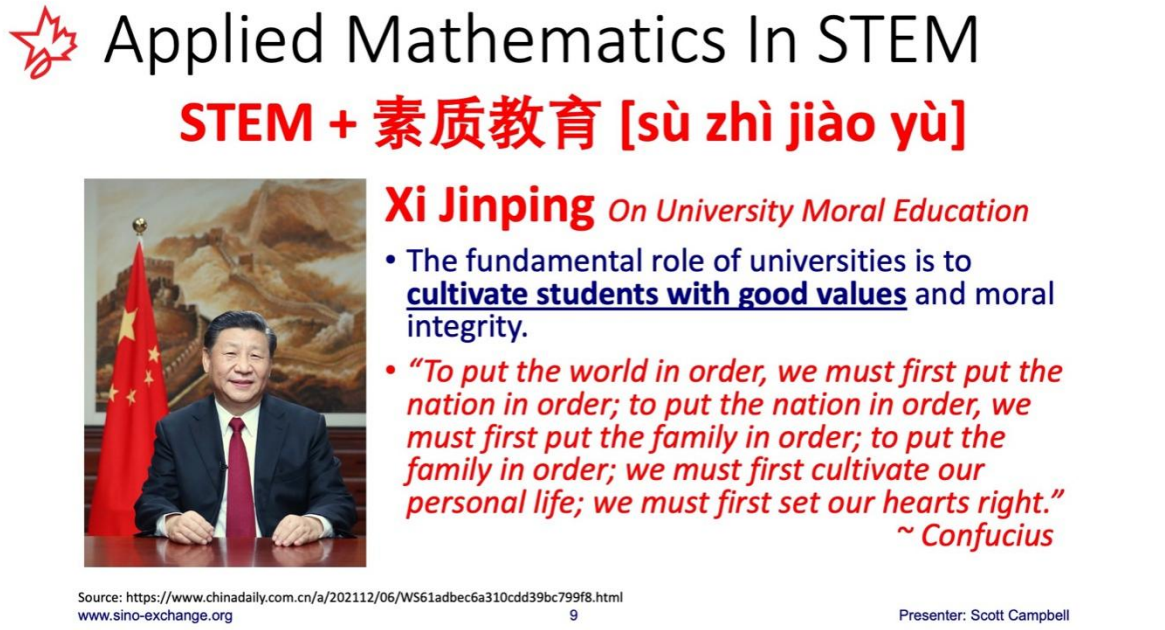
However, this too was a philosophy of education that had been put forward by Confucius more than two thousand years ago.	然而，这也是孔子在两千多年前提出的教育哲学。



Now if you are unfamiliar with Chinese history, Confucius was born in 551BCE and was one of China's most famous philosophers.	如果你不熟悉中国历史，孔子出生于公元前 551 年，是中国最著名的哲学家之一。



Fast forward more than 2 thousand years, The World Economic Forum has indicated that the way we teach STEM is out of date. Stating that, “It lacks a connection with the social, economic, and political impacts of the student’s work”. Afterall, knowledge without morals, ethics, or compassion can be one of the most destructive forces found in nature. Therefore, when China announced the introduction of STEM education into its curriculum, they didn’t just adopt the existing model of STEM education.	两千多年前，世界经济论坛表示，我们教授 STEM 的方式已经过时。指出，“它与学生工作的社会、经济和政治影响缺乏联系”。毕竟，没有道德、伦理或同情心的知识可能是自然界中最具破坏性的力量之一。因此，当中国宣布将 STEM 教育引入其课程时，他们不仅仅采用了现有的 STEM 教育模式。



Instead, the central government outlined its own interpretation of STEM education which they referred to as STEM plus **sù zhì jiào yù**, or moral education. Therefore, the entire idea of the Chinese educational framework surrounding STEM education actually, revolves around ethics and morality.

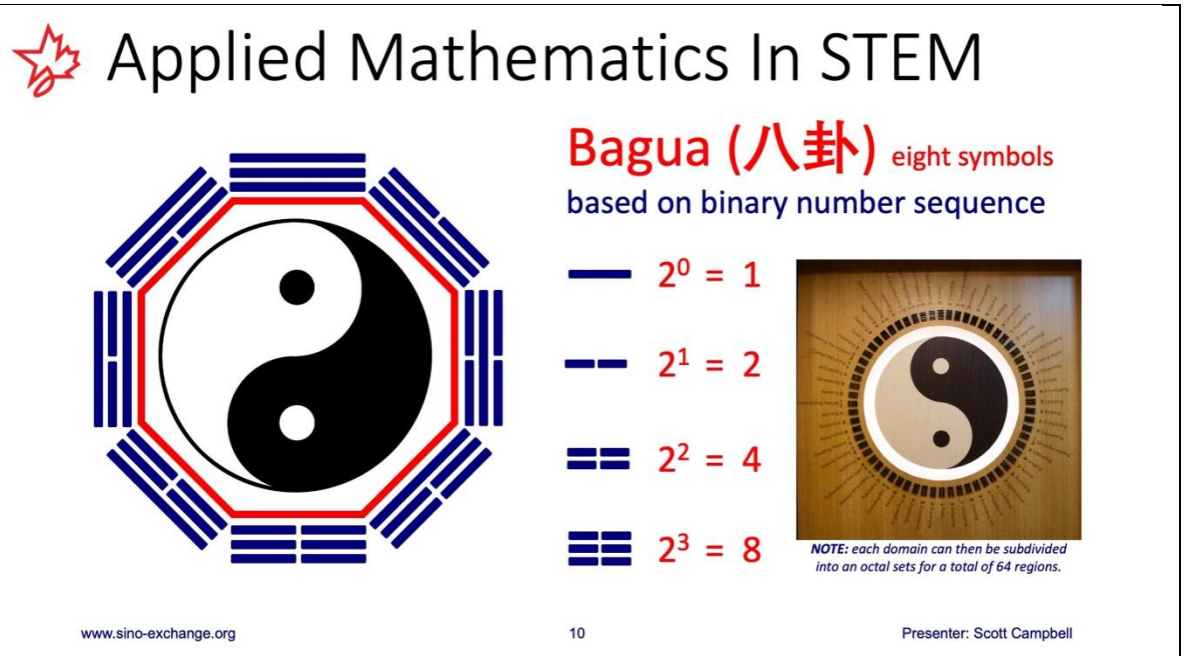
Moreover, Xi Jingping has also indicated that the role of universities is to **cultivate students with good values** and moral integrity. And when I look at this quote, it reminds me again of the teachings of Confucius, "To put the world in order, we must first put the nation in order; to put the nation in order, we must first put the family in order; to put the family in order; we must first cultivate our personal life; we must first set our hearts right."

Therefore, China does not seek to implement an outdated version of STEM that solely focuses on knowledge. Instead, they wish to implement a framework that is based morality and ethical education. A model of education that respects and capitalizes on a diverse and culturally rich history.

相反，中央政府概述了自己对 STEM 教育的解释，他们称之为 STEM 加 súzhìjiào yú，或道德教育。因此，围绕 STEM 教育的中国教育框架的整个理念实际上是围绕伦理和道德展开的。

此外，习还指出，大学的作用是培养具有良好价值观和道德品质的学生。当我看到这句话时，它再次让我想起孔子的教诲，"欲治天下，先治国家；要治理好国家，首先要治理好家庭；使家庭井然有序；我们必须首先培养我们的个人生活；我们必须先把心摆正。"

因此，中国并不寻求实施一个过时的、只关注知识的 STEM 版本。相反，他们希望实施一个以道德和伦理教育为基础的框架。一种尊重和利用多元文化丰富历史的教育模式。



Remaining on the theme of culture, I want to explore numerical and mathematical sequences before we move on, and while most of know of binary systems within a computer, perhaps one of the oldest binary number sequences can be found in Bagau.

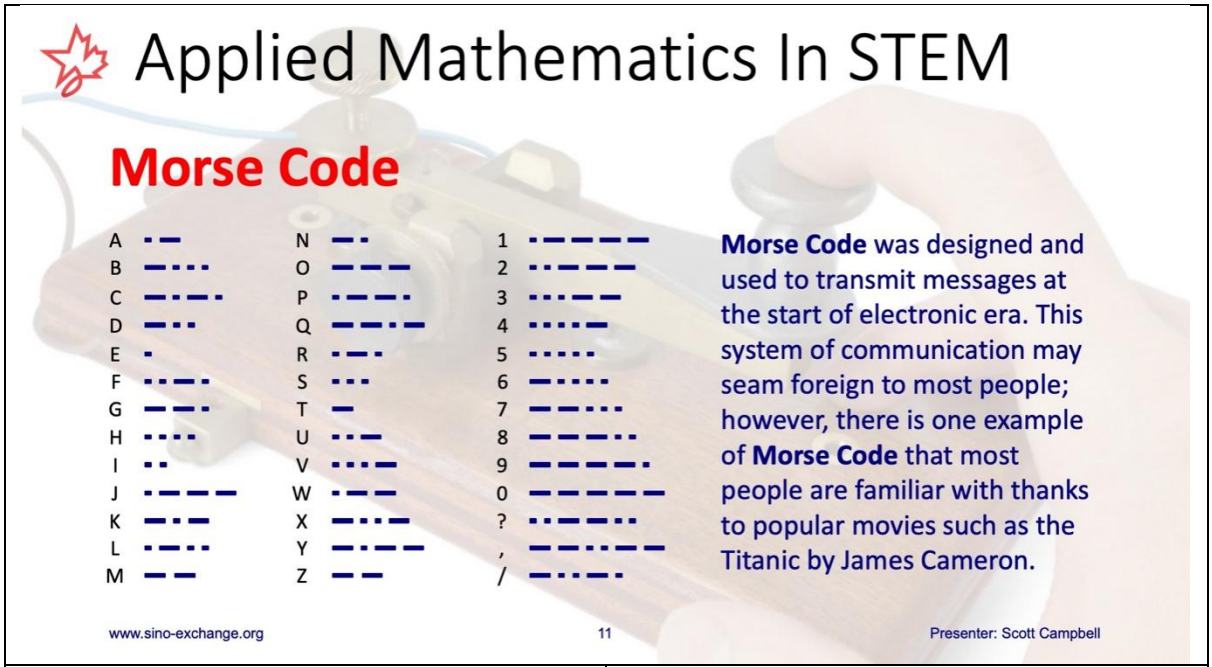
With a single row we can have no division, which would equivalent 2 to the power of 0 which equals 1. A single division would be 2 to the power of 1 which would equal 2. With 2 rows we could get a total of 4 possible combinations, and with 3 rows we can get t total of 8 combination. Moreover, each of the octets can be subdivided into 8 additional subdivisions for a total of 64 values.

However, unlike the values on a clock where the numbers increase numerical, in Bagua the number sequence is displayed based on opposites -- Finding balance and symmetry through the concepts of Yin and Yang. However, here we see possibly the oldest reference to binary and octal number systems which are the numbering systems that are used by computer technologies.

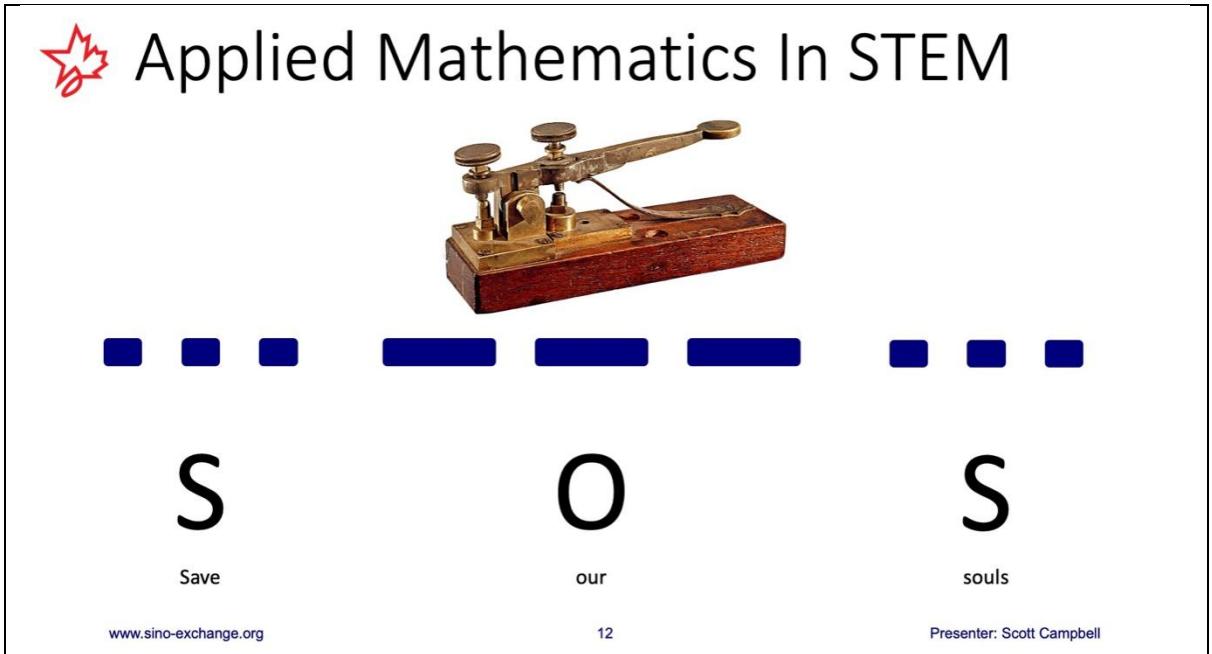
在继续讨论文化主题之前，我想在我们继续先探索一下数字和数学序列。虽然大多数人都知道计算机中的二进制系统，但也许最古老的二进制数字序列之一可以在巴哥找到。

对于单行，我们可以不进行除法运算，这相当于 2 等于 0 的幂，0 等于 1。一个单独的除法将是 2 对 1 的幂，1 等于 2。对于 2 行，我们可以得到总共 4 个可能的组合，对于 3 行，我们总共可以得到 8 个组合。此外，每个八位位组可以被细分为 8 个额外的细分，总共 64 个值。

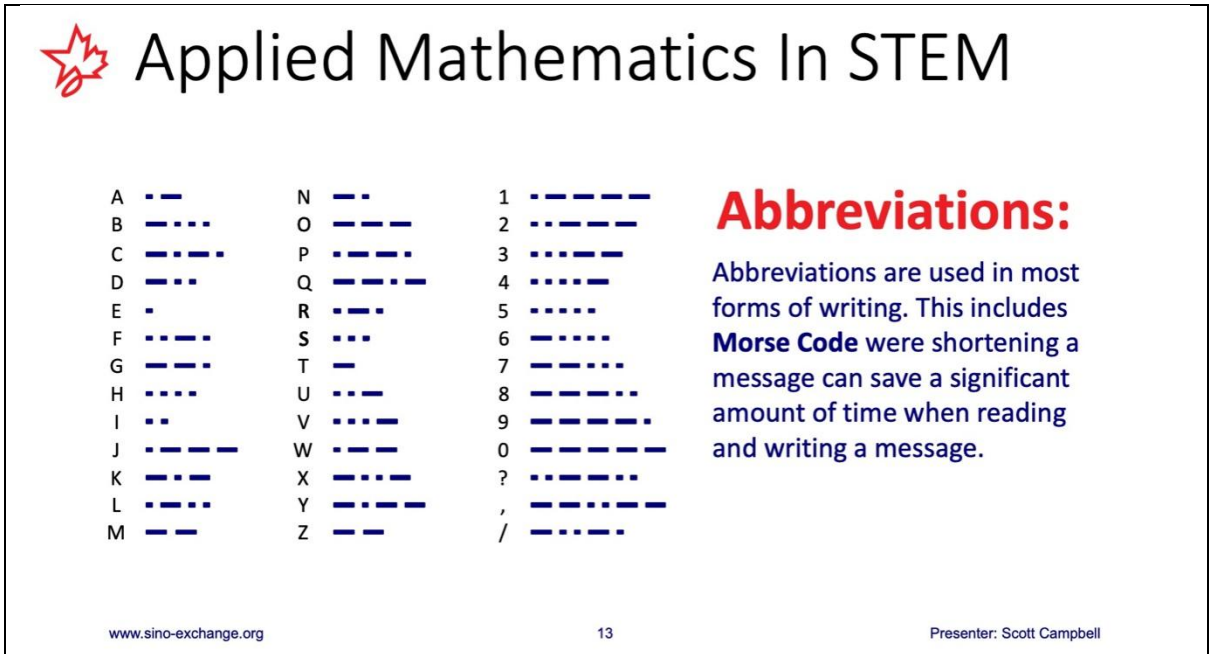
然而，与时钟上数字增加的数值不同，八卦中的数字序列是基于对立的——通过阴阳的概念寻找平衡和对称。然而，在这里，我们看到的可能是最古老的二进制和八进制数字系统，这是计算机技术使用的编号系统。



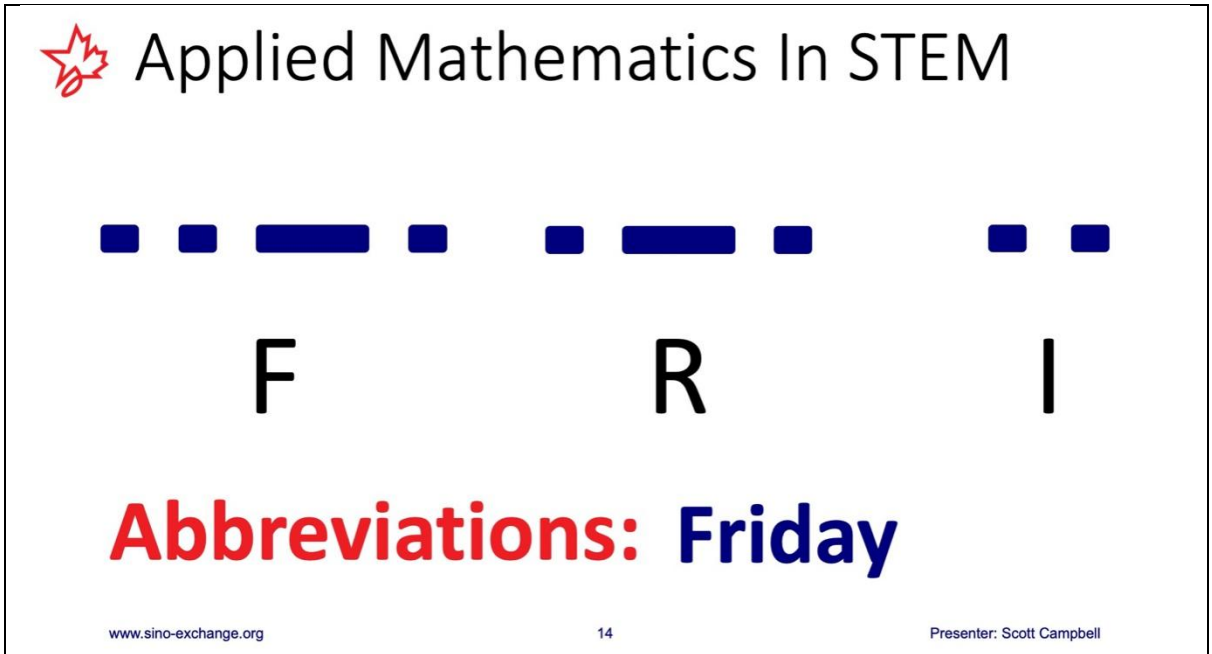
There are also other numerical sequences that we have used throughout history as well, such as “Morse Code”.	我们在历史上也使用过其他数字序列，比如“莫尔斯电码”。



Using timed numerical sequence, we were able to transmit data in the early days of electronic communication. This perhaps the most well-known example, S.O.S. which was a distress signal used to represent “Save Our Souls”.	使用定时数字序列，我们能够在电子通信的早期传输数据。这也许是最著名的例子，S.O.S.，它是一种用来代表“拯救我们的灵魂”的遇险信号。



However, operators and coders for generations have hated typing things out in full. Therefore, abbreviations were adopted.	然而，几代操作员和程序员都讨厌完整地打字。因此，采用了缩写。



What do you think this abbreviation might stand for? If you guess Friday, then you were correct.	你认为这个缩写可能代表什么？ 如果你星期五来做客，那么你是对的。

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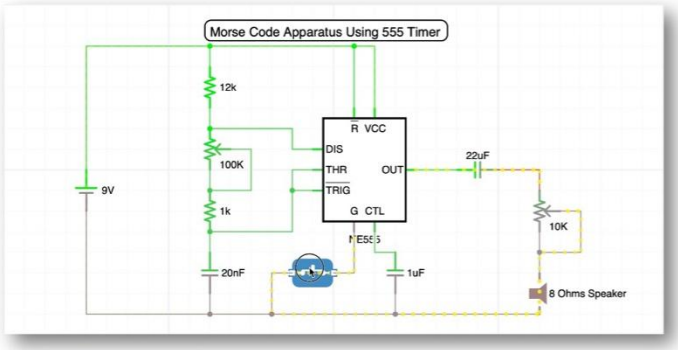

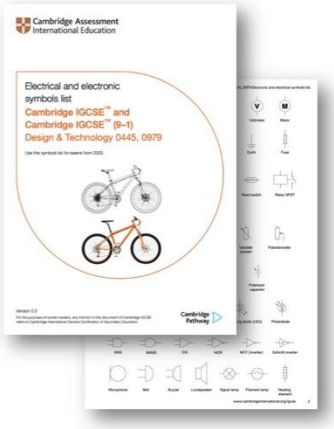

***NOTE:** This modern-day project uses electrical components that can be found in the in the iGCSE physics and Design Technology curriculums.*

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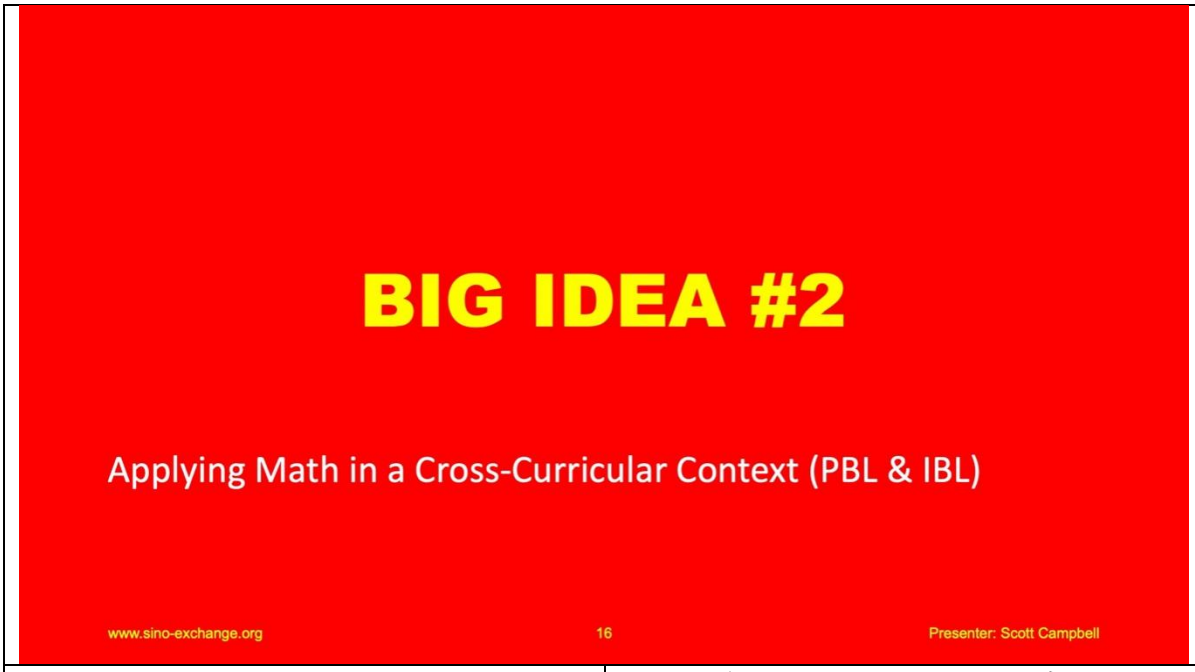
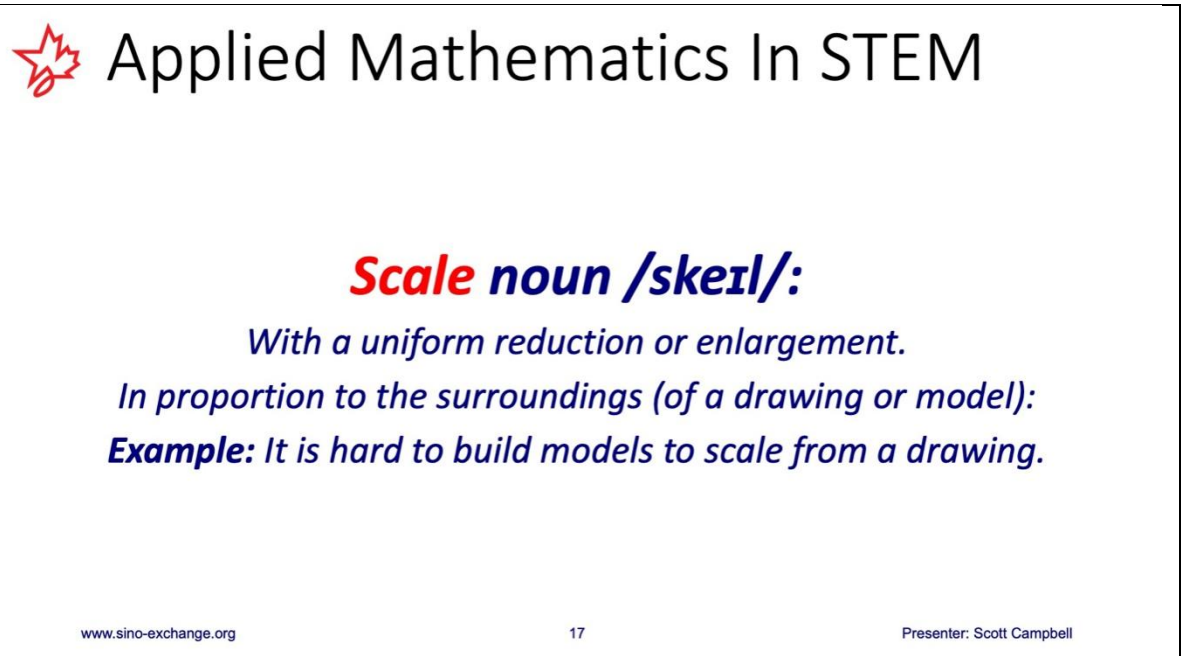
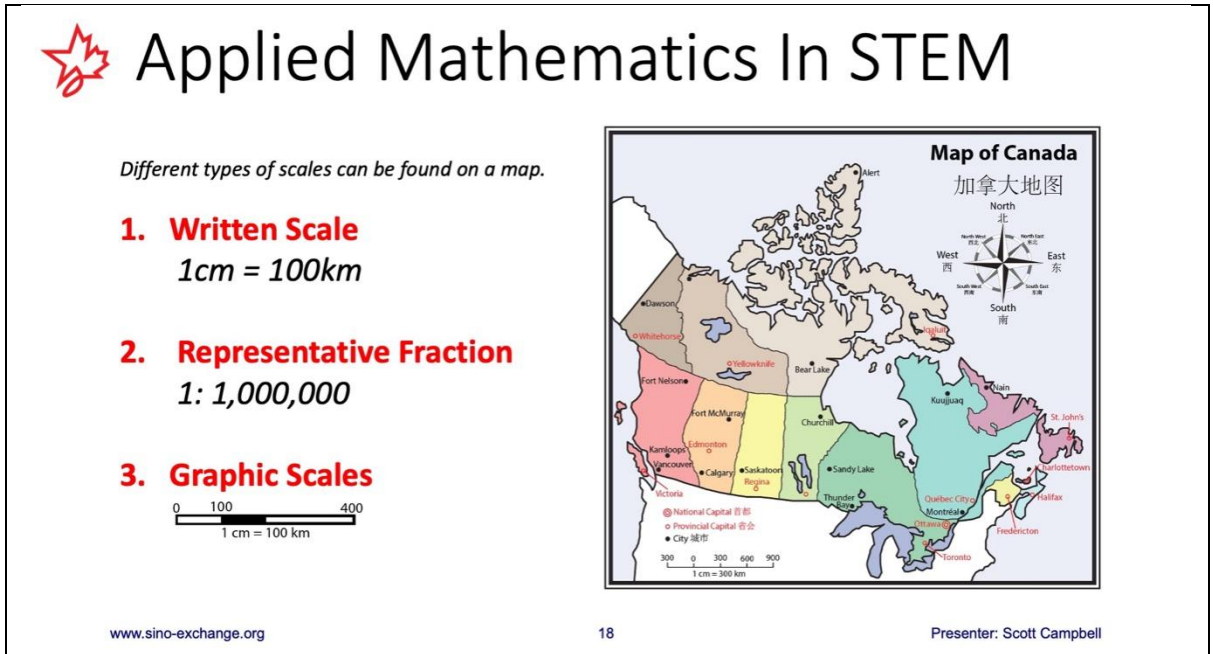
Now the reason why I wanted to share this with you is that we can use these ideas to build modern day projects. For instance, this Morse Code apparatus that I have designed uses electrical components that can be found in the iGCSE physics and Design Technology curriculums. Now the engineering in this project is quite sophisticate. Therefore, looking to our past can often be a great way to develop projects that are appropriate to our student's current level of understanding. Let's see how it works.	现在，我之所以想和大家分享这一点，是因为我们可以利用这些想法来构建现代项目。例如，我设计的这个莫尔斯电码设备使用的电气元件可以在 iGCSE 物理和设计技术课程中找到。现在这个项目的工程相当复杂。因此，回顾我们的过去往往是开发适合学生当前理解水平的项目的好方法。 让我们看看它是如何工作的。



While there is nothing wrong with subject specific lessons or projects, we need to be able to move past these artificially created subject divides if we want to explore STEM education in its truest form. As such, we can start with educational frameworks such as: “Project Based Learning” and “Inquiry Based Learning”, as these are excellent steppingstone which will help us move closer to final goal of implementing STEM.	虽然特定学科的课程或项目没有错，但如果我们想探索最真实的 STEM 教育，我们需要能够克服这些人为造成的学科分歧。因此，我们可以从“基于项目的学习”和“基于探究的学习”等教育框架开始，因为这些都是极好的垫脚石，将帮助我们更接近实施 STEM 的最终目标。



In this example, I would like to start with the idea of scale, as this is a concept that is relevant to many different subject areas. For instance, we study things that are far too small for us to see in biology and chemistry. Whereas, in the fields of architecture and engineering we need to design and build prototypes in the lab, And we do this before we can build much larger structures in the real-world. You even need scale in regular day-to-day life as well! And if you don't believe me? Just ask yourself, have you ever looked at map while traveling. Therefore, if you had to choose just one idea to teach, I would recommend teaching students about scale.	在这个例子中，我想从规模的概念开始，因为这是一个与许多不同学科领域相关的概念。例如，我们研究的东西太小了，我们在生物和化学中看不见。然而，在建筑和工程领域，我们需要在实验室中设计和建造原型，在我们能够在现实世界中建造更大的结构之前，我们就要做到这一点。 你甚至在日常生活中也需要量表！ 如果你不相信我？ 问问你们自己，你们在旅行时看过地图吗。 因此，如果你必须只选择一个想法来教授，我建议你教学生关于量表的知识。



Now before we get into STEM, I want to look at some simple Project-Based-Learning examples. However, the first thing we need to understand is that a numerical scale can be presented in several different ways, these methods include: • Written Scale • Representative Fraction • Graphic Scale	现在，在我们进入 STEM 之前，我想看看一些简单的基于项目的学习示例。然而，我们需要理解的第一件事是，数字刻度可以用几种不同的方式表示，这些方法包括: • 书面刻度 • 代表分数 • 图形刻度

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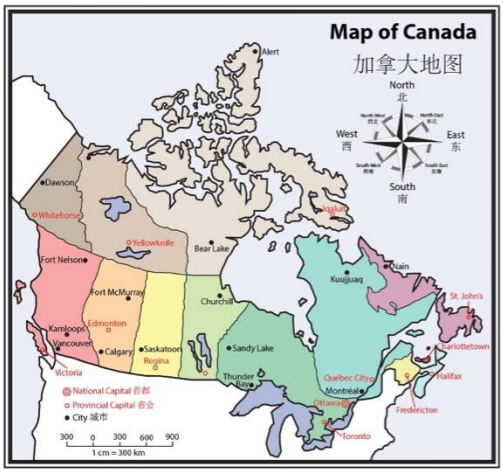

Use a ruler to measure the distance between the indicated cities on the chart. Record the distance at the reduced scale of the map. Then using math calculate how far apart the actually cities are. Measure to the nearest Millimeter. Make sure you measure from the center of one city marker to the center of the other city marker.

使用直尺测量下图城市之间的距离，并把所测量的结果记录入下表，然后根据比例计算公式计算出实际距离。测量结果保留到毫米。测量时注意从一个城市城标的正中心到另一个城市城标的正中心。

	Measurement on Map	Distance
Churchill ⇒ Sandy Lake	1.5 cm	1.5 cm * 400 km/cm = 600 km
Vancouver ⇒ Fort Nelson		
Ottawa ⇒ Calgary		
Whitehorse ⇒ Yellowknife		
Thunder Bay ⇒ Iqaluit		

Requiring students to show their process work allows teachers to conduct quick "**Assessment for Learning**".

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A simple project like this might have students calculate the distance between 2 points using "scale conversions". And I would also strongly recommend require your students to show their process work, as well as this will help you identify where students are making mistakes.

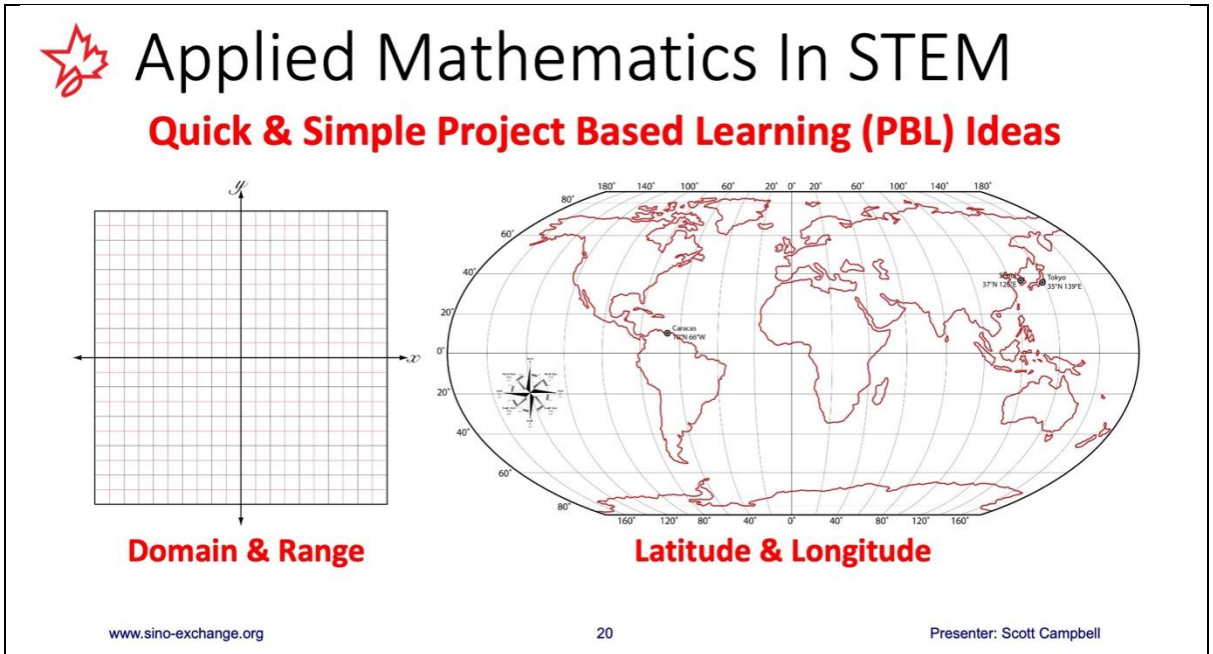
For instance, I have found that many middle students can do these kinds of calculations. However, they lack the ability to properly measure an object for themselves, and if your input data is wrong, then your final answers will be wrong as well. Even if you have done the math correctly!

Therefore, by having students show their work you can quickly perform informal "Assessments for Learning". Another thing we should also encourage students do at an early age is to cross out units, as this will help prepare them for subjects like physics and chemistry.

像这样一个简单的项目可能会让学生使用"比例转换"来计算 2 个点之间的距离。我还强烈建议你的学生展示他们工作的过程，此外，这将帮助你识别学生在哪里犯错误。

例如，我发现很多中学生都能做这些计算。然而，他们缺乏自己正确测量物体的能力，如果你的输入数据是错误的，那么你的最终答案也会是错误的。即使你数学做对了！

因此，通过让学生展示他们的作品，你可以快速进行非正式的"学习评估"。我们还应该鼓励学生在小时候做的另一件事是划掉单位，因为这将有助于他们为物理和化学等科目做好准备。



Moreover, there are often many similarities between the different subjects that we teach in school.

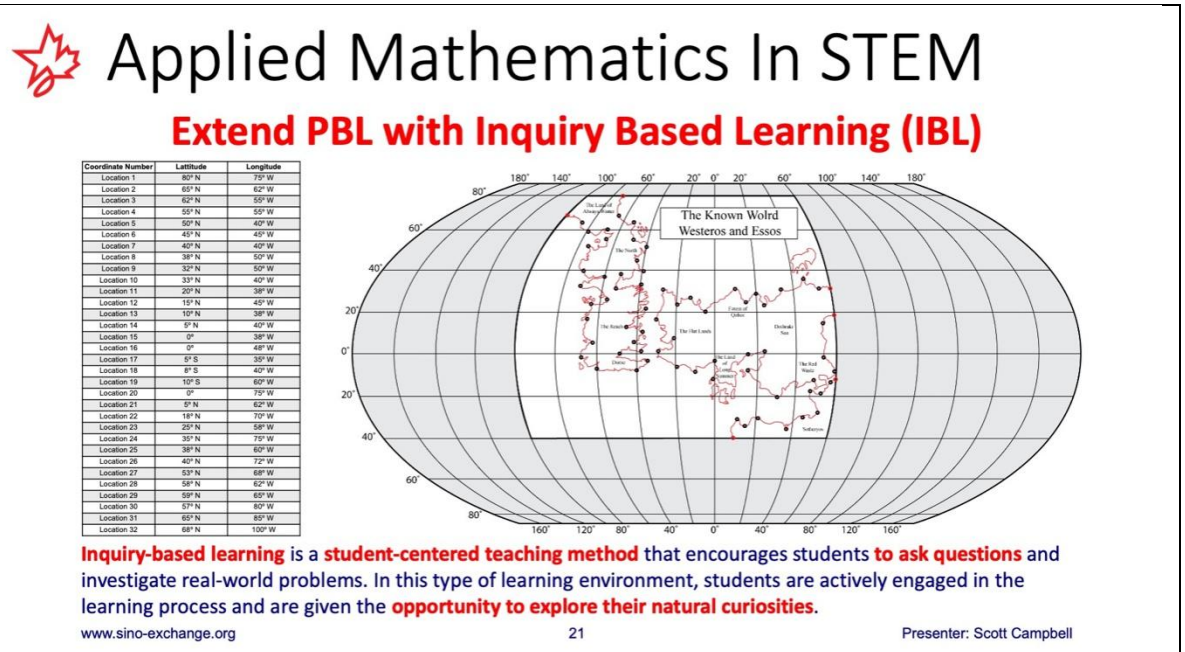
In this example would like to illustrate how "***domain and range***" demonstrates the same concepts as ***"latitude and longitude"***. We have our origin (0,0) in the center of the graph, and we can move up or down and left to right in both cases. Now in math we define the values as positive or negative. However, in geography we define values by "North and South" along the Y-axis, and "East and West" along the X-axis.

Therefore, in both classes we could have students plot locations on a coordinate plane, and in the case of a geography, we can also have the students check their own work by looking up each location in the atlas. Therefore, any project that involves plotting points on a coordinates plane will develop highly transferable skills sets.

此外，我们在学校里教的不同科目之间往往有很多相似之处。

在这个例子中，我们想说明"域和范围"如何展示与"纬度和经度"相同的概念。我们的原点（0,0）在图的中心，在这两种情况下，我们都可以上下左右移动。现在在数学中，我们将数值定义为正或负。然而，在地理学中，我们通过沿 Y 轴的"北和南"以及沿 X 轴的"东和西"来定义值。

因此，在这两门课上，我们都可以让学生在坐标平面上绘制位置，在地理的情况下，我们也可以让学生通过在地图册中查找每个位置来检查自己的作业。因此，任何涉及在坐标平面上绘制点的项目都将培养高度可转移的技能。



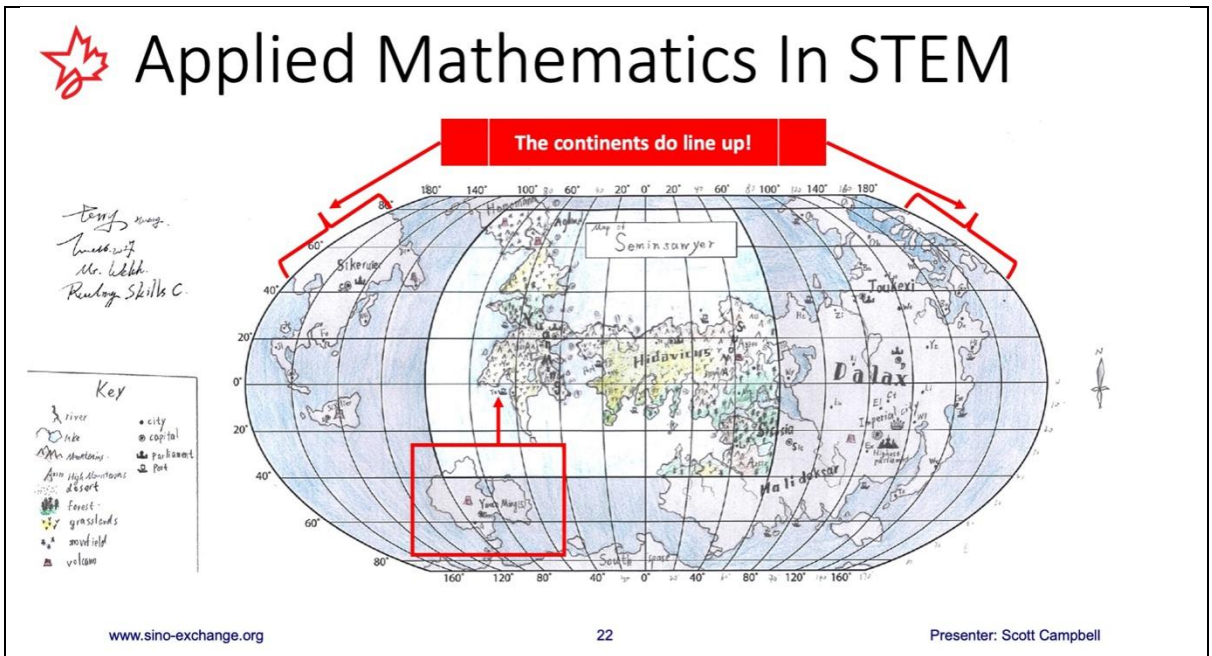
Coordinate Number	Latitude	Longitude
Location 1	80° N	75° W
Location 2	65° N	62° W
Location 3	62° N	55° W
Location 4	55° N	55° W
Location 5	50° N	40° W
Location 6	45° N	45° W
Location 7	40° N	40° W
Location 8	38° N	50° W
Location 9	32° N	50° W
Location 10	33° N	40° W
Location 11	20° N	38° W
Location 12	15° N	45° W
Location 13	10° N	38° W
Location 14	5° N	40° W
Location 15	0°	38° W
Location 16	0°	48° W
Location 17	5° S	35° W
Location 18	8° S	40° W
Location 19	10° S	60° W
Location 20	0°	75° W
Location 21	5° N	62° W
Location 22	18° N	70° W
Location 23	25° N	58° W
Location 24	35° N	75° W
Location 25	38° N	60° W
Location 26	40° N	72° W
Location 27	53° N	68° W
Location 28	58° N	62° W
Location 29	59° N	65° W
Location 30	57° N	80° W
Location 31	65° N	85° W
Location 32	68° N	100° W

However, the students did not need to demonstrate a high-level critical thinking in the previous example. Therefore, “Inquiry Based Learning”, will challenge your students even more by encouraging them to: Ask questions, postulate or theorize ideas, and to explore their natural curiosities. Furthermore, projects will become more complex and interdisciplinary.

In this example, I have mapped the geography of George R.R. Martin’s fantasy world from his critically acclaimed novel series, and I choose this example as it can be properly mapped according to geographic temperate zones. However, when doing this, you will discover that about 60% of the world has been left undiscovered, and this makes scene as most of the story has been inspired by European history at a time when the New World, the Orient and much of Africa was still undiscovered. Therefore, in this project, students had to plot an unknown fantasy world, before having to extrapolate what the rest of this undiscovered world might look like based on their understanding of plate tectonics.

然而，学生们不需要在前面的例子中表现出高水平的批判性思维。因此，“基于探究的学习”将通过鼓励学生提出问题、假设或理论化想法，并探索他们天生的好奇心，对他们提出更大的挑战。此外，项目将变得更加复杂和跨学科。

在这个例子中，我绘制了乔治·R·R·马丁广受好评的小说系列中幻想世界的地理图，我选择这个例子是因为它可以根据地理温带进行适当的绘制。然而，当你这样做的时候，你会发现世界上大约60%的地方还没有被发现，这使得故事的大部分内容都受到了欧洲历史的启发，当时新世界、东方和非洲大部分地区仍然没有被发现。因此，在这个项目中，学生们必须绘制一个未知的幻想世界，然后根据他们对板块构造的理解来推断这个未被发现的世界的其他部分可能是什么样子。



Here we can see how the student completed the activity. They extrapolated the coastline, while also making informed predictions as to what the remaining land masses may look like.

And as you can see the continents do align!

And this large Southern Island aligns nicely with this continent, as if the island has slowly drifted away from the main land mass over millions of years. Much like Australia has done in the real-world!

As you can see in this example, we have moved beyond a simple project. We have created cross-curricular connections, sparked the students interests by igniting their interests, and have created a safe learning environment as there are no definitive right or wrong answer. The validity of the student's solution is directly related to the depth of their inquiry.

However, this still isn't STEM education.

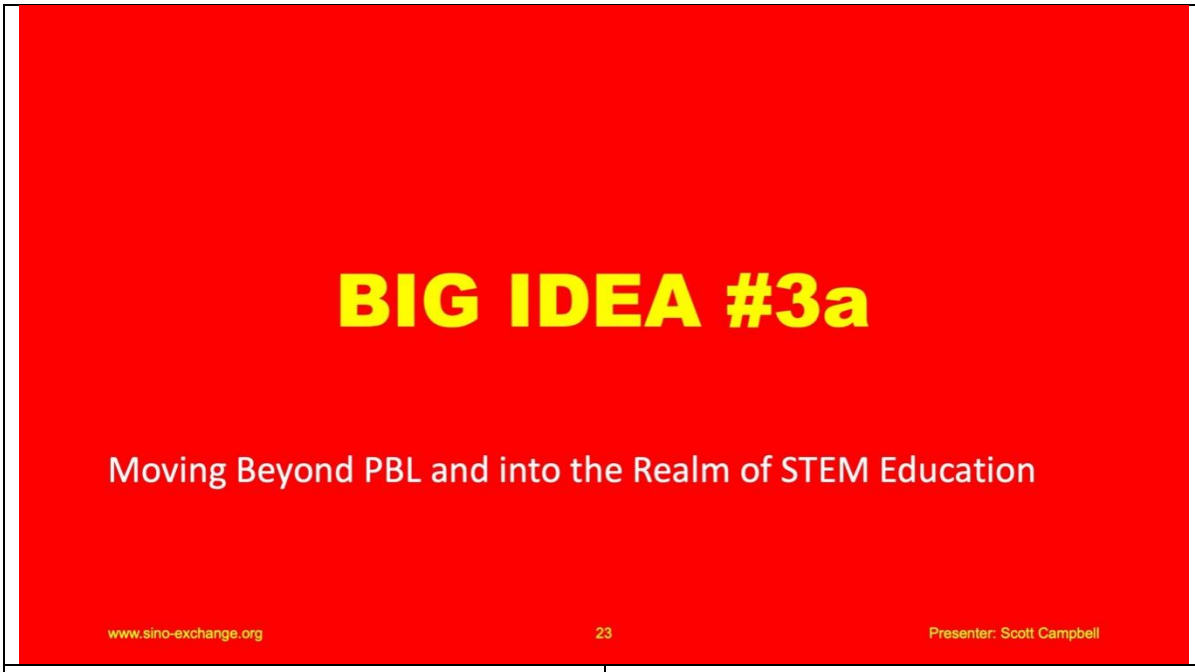
在这里我们可以看到学生是如何完成活动的。他们推断了海岸线，同时也对剩余的陆地可能是什么样子做出了明智的预测。

正如你所看到的，大陆确实对齐了！

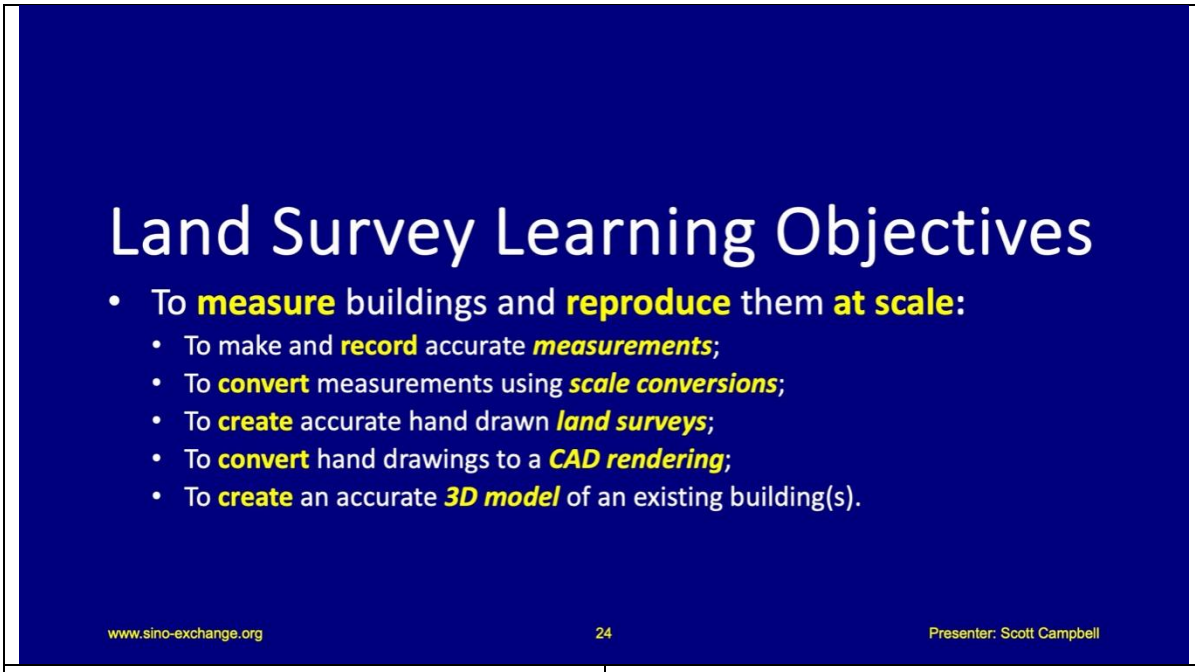
这个巨大的南部岛屿与这块大陆很好地排成一条直线，就好像这个岛在数百万年的时间里慢慢地漂离了大陆板块。就像澳大利亚在现实世界中所做的那样！

正如您在这个例子中看到的，我们已经超越了一个简单的项目。我们建立了跨学科的联系，通过激发学生的兴趣来激发他们的兴趣，并创造了一个安全的学习环境，因为没有明确的对错答案。学生解决方案的有效性直接关系到他们探究的深度。

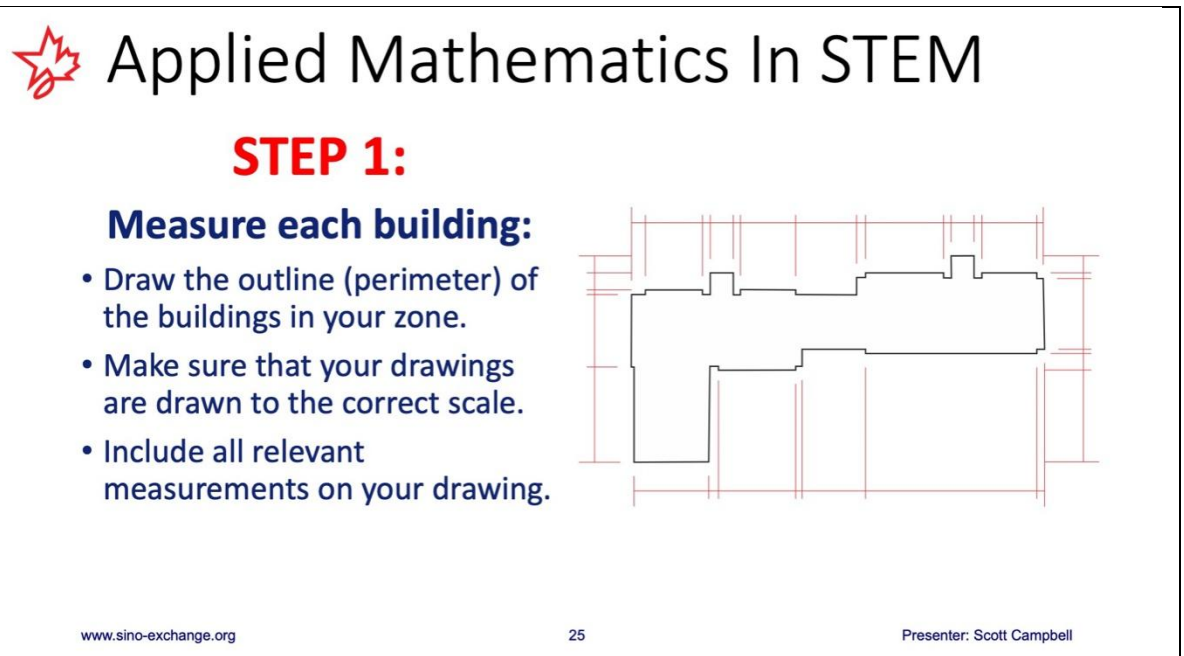
然而，这仍然不是 STEM 教育。



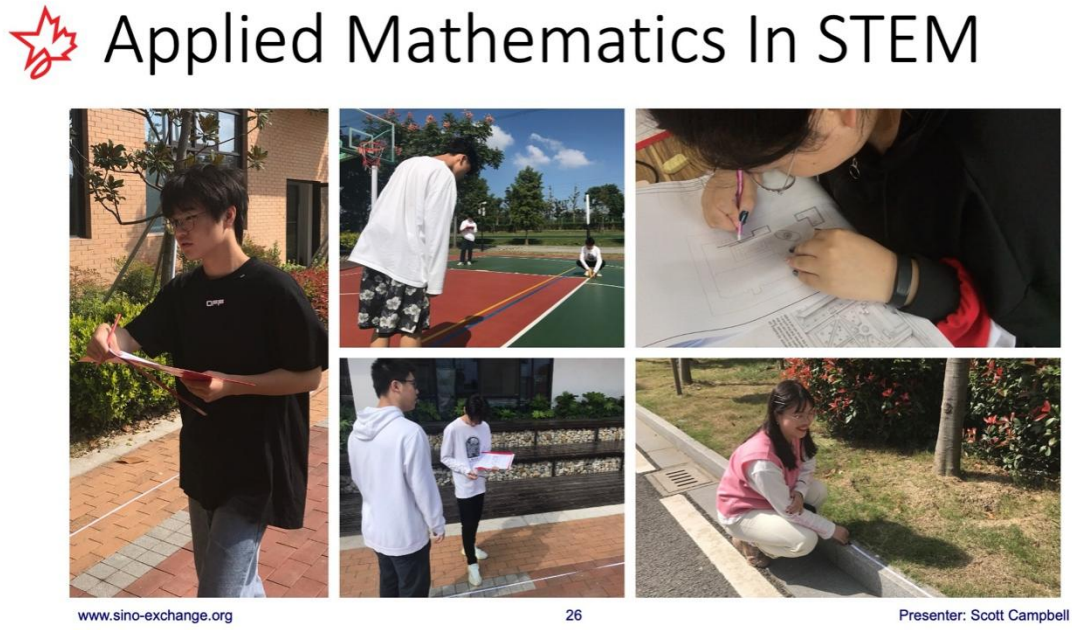
For STEM, a project needs to fully cross curricular. It needs to explore Science, Technology, Engineering, and Mathematics in an authentic real-world context, and the project needs to solve a problem in the real-world.	对于 STEM，一个项目需要完全跨课程。 它需要在真实的现实世界中探索科学、技术、工程和数学，项目需要解决现实世界中的问题。



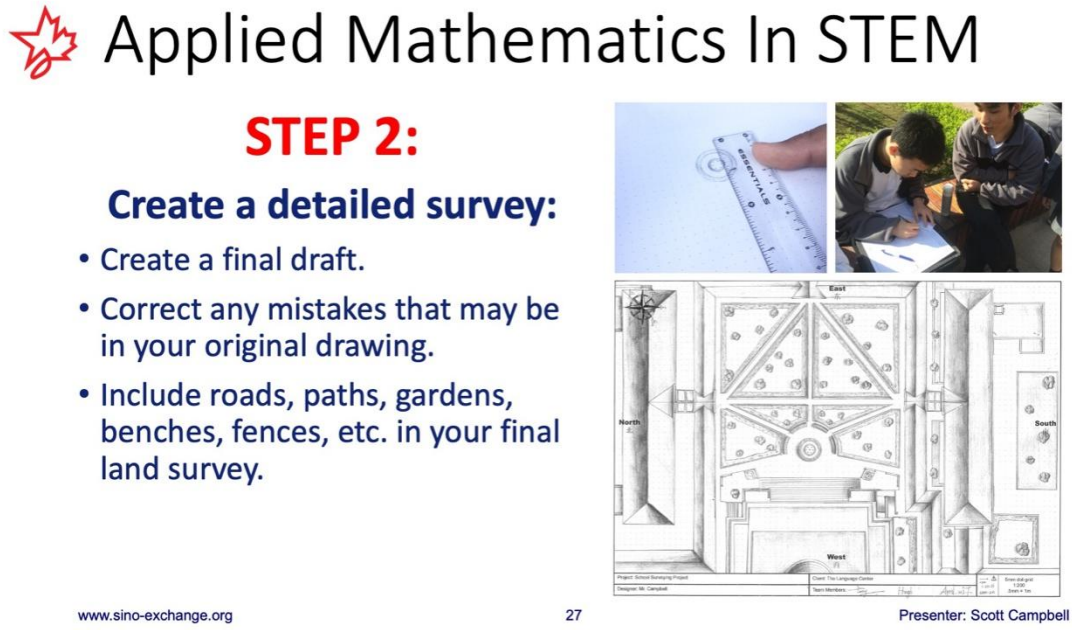
Therefore, to start our exploration of Math in STEM I would like to start with this land survey project. In this kind project students will learn by doing! They will reverse engineering structures that have been designed by professional engineers and architects. While also learning how to record accurate measurements, perform numerous scale conversions, and create an authentic land survey by hand before digitizing and even 3D printing their work. Moreover, this project can be done with minimal associated costs, and it will develop skills that will prepare your students for a career in the field of STEM.	因此，为了开始我们对 STEM 数学的探索，我想从这个土地调查项目开始。 在这种项目中，学生将在实践中学习！他们将逆转由专业工程师和建筑师设计的工程结构。同时还学习如何记录准确的测量结果，进行多次比例转换，并在数字化甚至 3D 打印之前手工创建真实的土地调查。此外，该项目可以以最低的相关成本完成，它将培养学生的技能，为 STEM 领域的职业生涯做好准备。



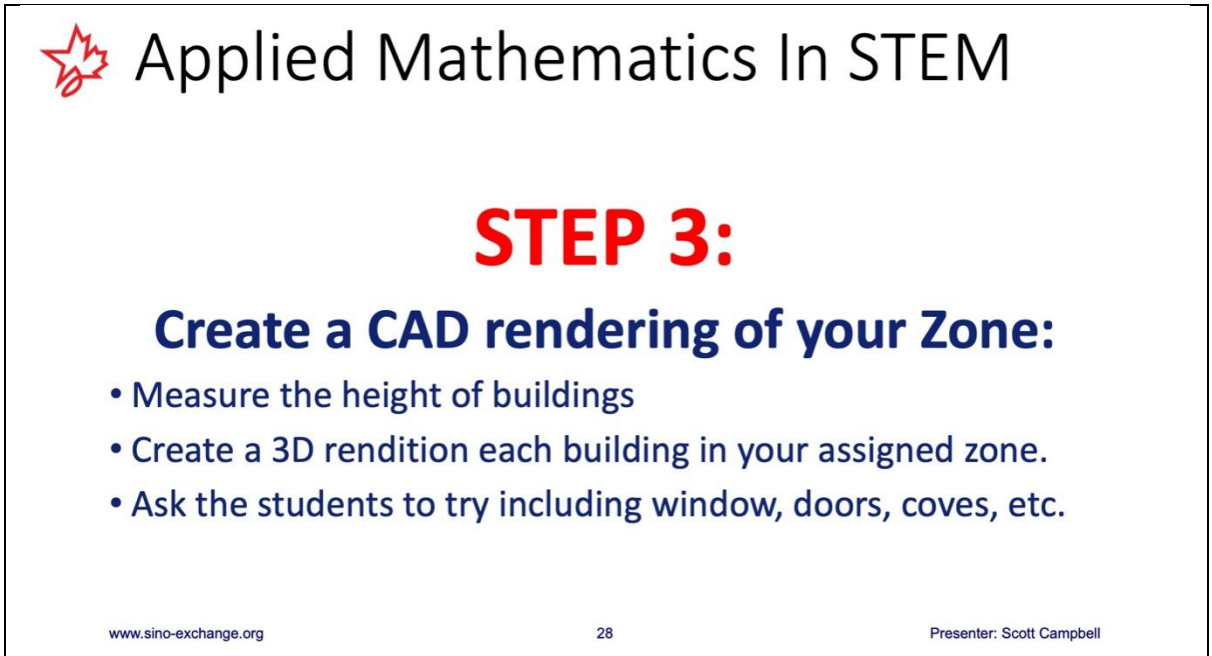
The first step in the process is to get out of the classroom and measure buildings in the real-world, and you don't even need to go that far. Your school campus is equally as beneficial towards establishing the desired learning outcomes as any other location. At this stage, have your students try their best to complete their rough draft with as much accuracy as they can. However, we can always correct inaccuracies in drawing later if we've recorded accurate measurements.	这个过程的第一步是走出教室，在现实世界中测量建筑，你甚至不需要走那么远。你的校园在建立期望的学习成果方面与任何其他地方一样有益。在这个阶段，让你的学生尽可能准确地完成他们的草稿。然而，如果我们记录了准确的测量结果，我们以后总是可以纠正图纸中的不准确之处。



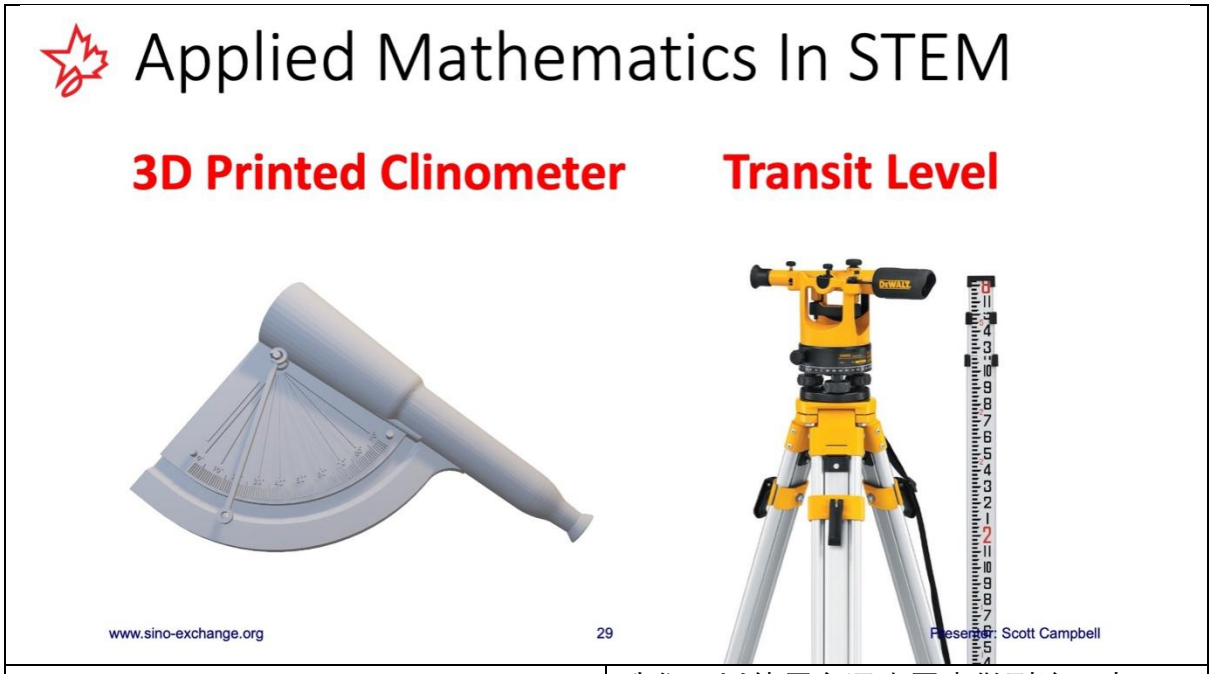
Here you can see students measuring their school's campus in teams, and you don't need expensive equipment to do this. All the students need is a blank design template, clipboard, pencil, ruler, and a low-cost measuring tape.	在这里，你可以看到学生们组队测量学校的校园，你不需要昂贵的设备。学生只需要一个空白的设计模板、剪贴板、铅笔、尺子和一个低成本的卷尺。



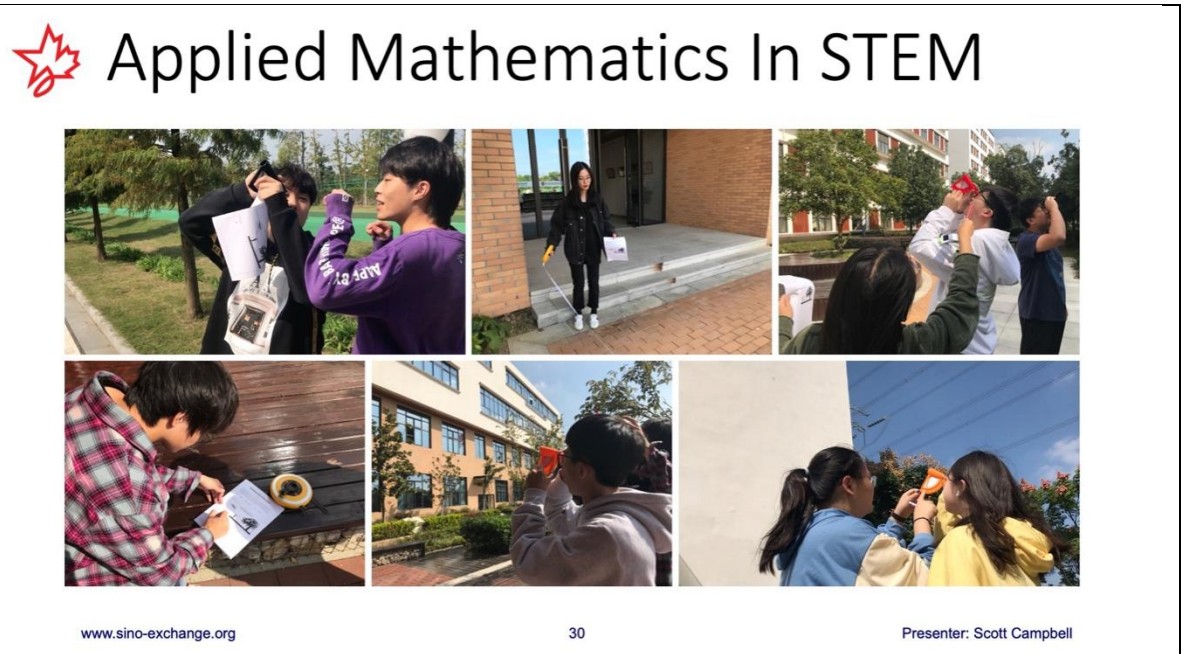
Keep in mind that the students' rough drafts will never be perfect. They will have mistakes, and the papers will often be creased or torn; Therefore, it is important for students to revise their original design schematics, and this is a great time for students to discuss and resolve issues through mutual collaboration, while also giving them a chance to double check their work.	请记住，学生们的草稿永远不会完美。他们会有错误，纸张经常会被弄皱或撕裂；因此，对学生来说，修改他们的原始设计原理图是很重要的，这是学生通过相互合作讨论和解决问题的好时机，同时也给了他们一个重新检查工作的机会。



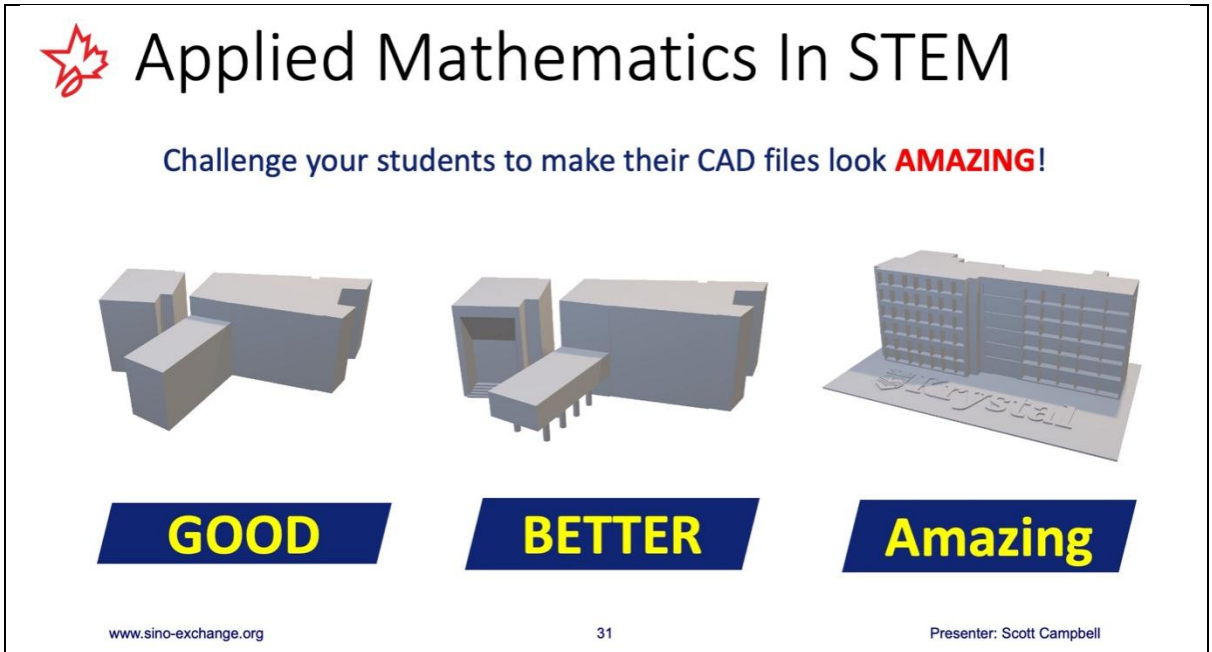
Once the students have an accurate 2-dimensional design, we can then start on the process of digitizing those designs using the computer. However, we will need determine the height of each building. That way we can plot the elevation of each building along the z-axis.	一旦学生们有了准确的二维设计，我们就可以开始使用计算机将这些设计数字化。然而，我们需要确定每栋建筑的高度。这样我们就可以沿着 z 轴绘制出每栋建筑的标高。



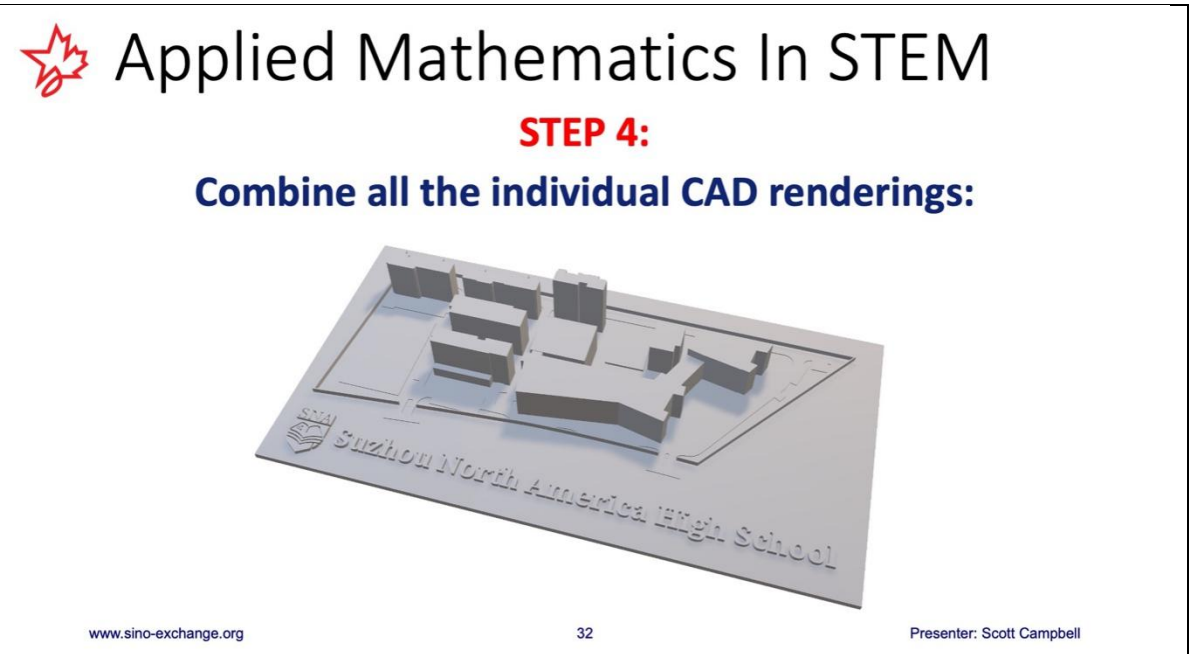
We could use transit level to do this. However, these devices are expensive, and difficult to use. Instead, a low-cost clinometer and some simple trig functions can do the same thing, while also reinforcing concepts that are already being taught in most math curriculums.	我们可以使用交通水平来做到这一点。然而，这些设备价格昂贵，而且难以使用。相反，低成本的测斜仪和一些简单的三角函数可以做同样的事情，同时也强化了大多数数学课程中已经教授的概念。



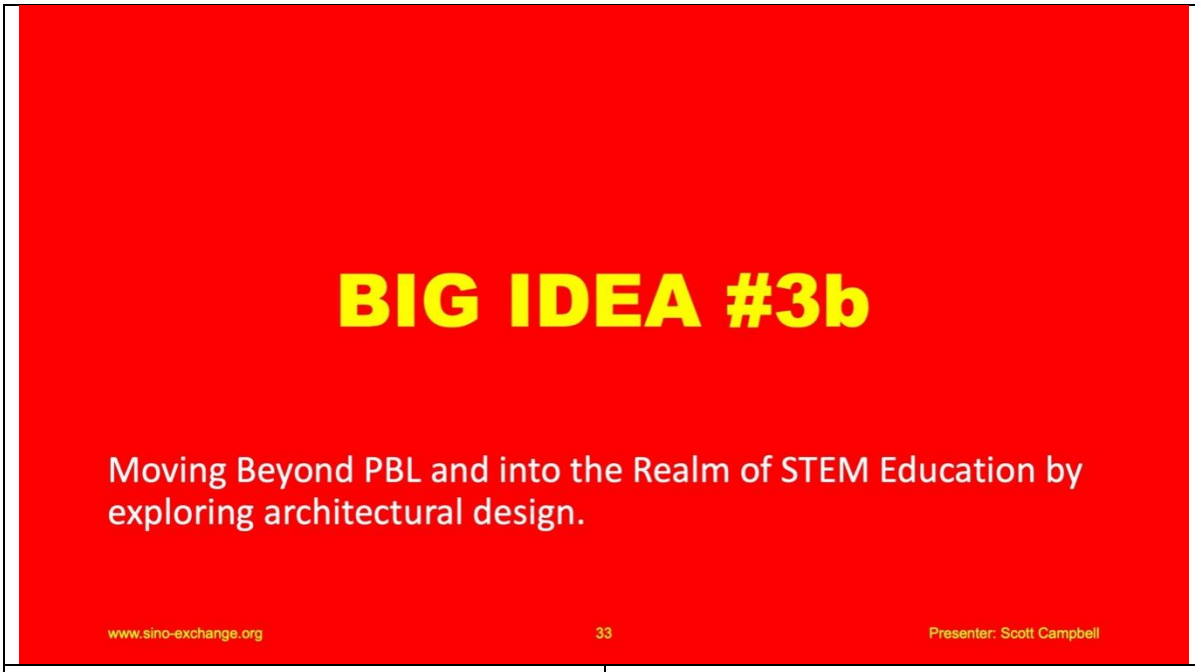
In these examples, you can see the students working together in pairs, measuring the height of the buildings using clinometers and the formula for TAN to solve for the unknown value.	在这些例子中，你可以看到学生们两两合作，使用测斜仪测量建筑物的高度，并使用 TAN 公式来求解未知值。



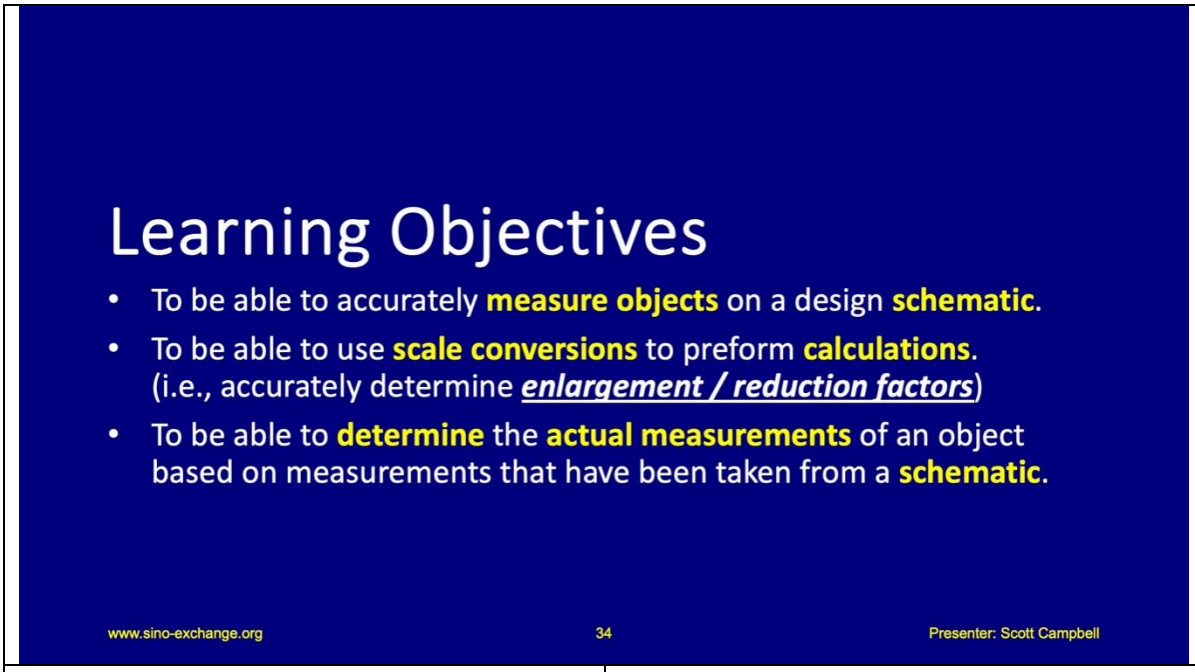
Then with the height each building known, the students can begin the process of digitizing their designs. Keep in mind that you will have a range of computer skills in your class but try pushing your students to make their designs as detailed as they can.	然后，在每个建筑物的高度已知的情况下，学生们可以开始数字化他们的设计。请记住，你在课堂上会掌握一系列的计算机技能，但试着督促学生尽可能详细地设计。



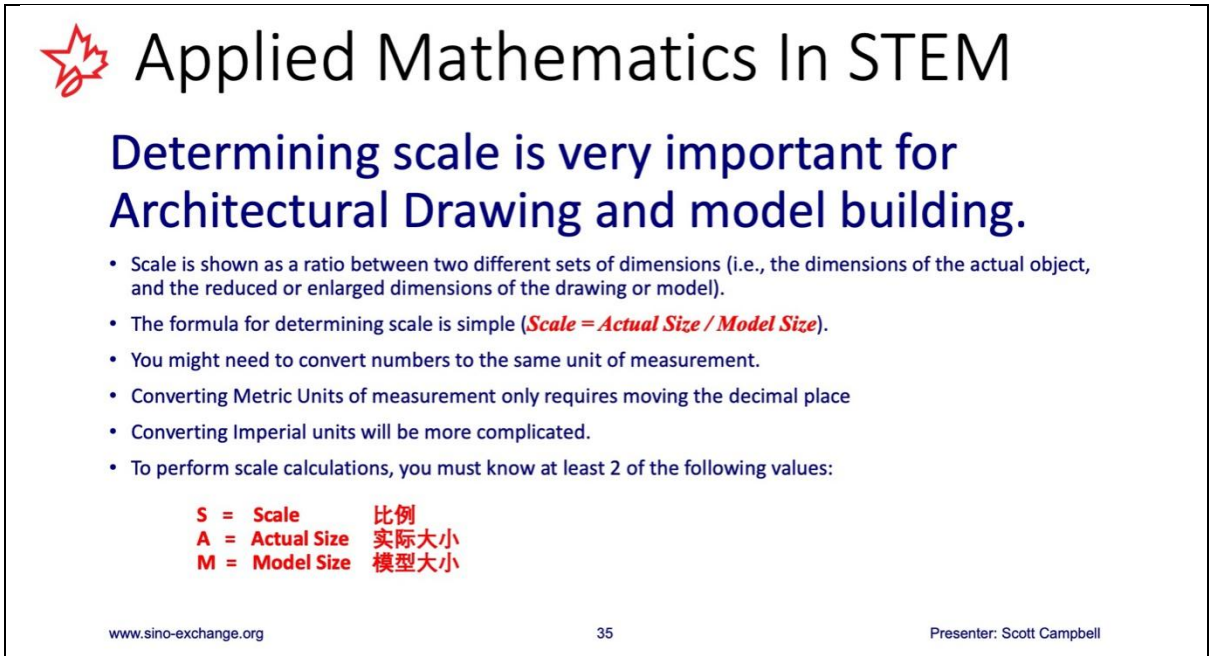
And finally, all the students' models can be combined to create a whole school rendering which can be 3D printed. However, printing projects can add significant costs to your program, while offering very little in terms of developing meaningful learning opportunities for your students.	最后，可以将所有学生的模型组合起来，创建一个可以 3D 打印的整个学校的渲染图。然而，印刷项目可能会给你的课程增加大量成本，而在为学生开发有意义的学习机会方面却收效甚微。



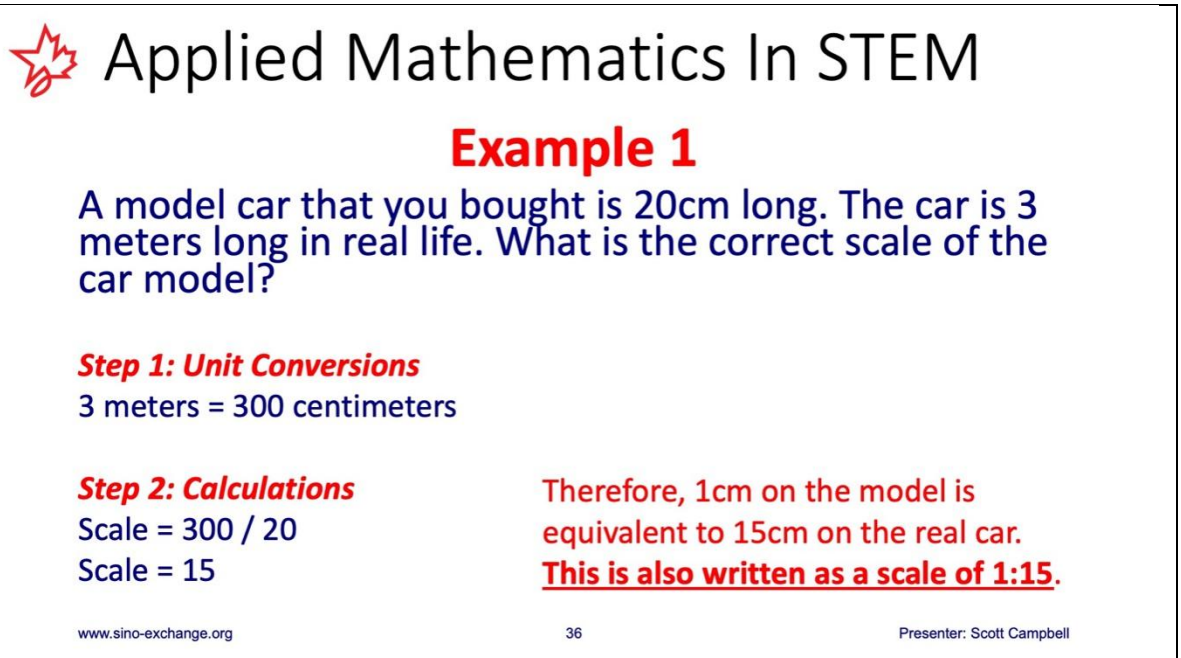
Now that we understand how we can move beyond Project Based Learning, and Inquiry Based Learning, which are both important milestones in the pathway towards STEM education, we are now ready to explore how we can create differentiated projects. Both for within a given class or cohort, and vertically for different grade levels.	既然我们了解了如何超越基于项目的学习和基于探究的学习，这两种学习都是 STEM 教育道路上的重要里程碑，我们现在准备探索如何创建差异化项目。既适用于特定班级或群体，垂直适用于不同年级。



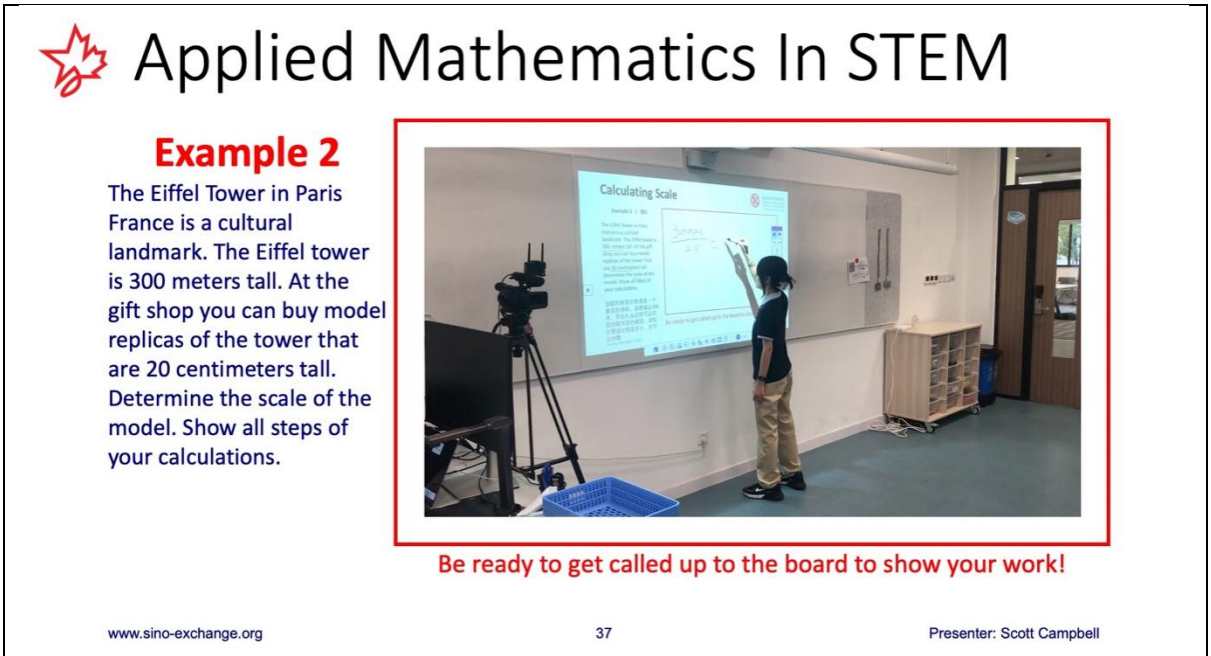
Therefore, to start our exploration of Math in STEM I would like to start with this land survey project. In this kind project students will learn by doing! They will reverse engineering structures that have been designed by professional engineers and architects. While also learning how to record accurate measurements, perform numerous scale conversions, and create an authentic land survey by hand before digitizing and even 3D printing their work. Moreover, this project can be done with minimal associated costs, and it will develop skills that will prepare your students for a career in the field of STEM.	因此，为了开始我们对 STEM 数学的探索，我想从这个土地调查项目开始。 在这种项目中，学生将在实践中学习！他们将逆转由专业工程师和建筑师设计的工程结构。同时还学习如何记录准确的测量结果，进行多次比例转换，并在数字化甚至 3D 打印之前手工创建真实的土地调查。此外，该项目可以以最低的相关成本完成，它将培养学生的技能，为 STEM 领域的职业生涯做好准备。



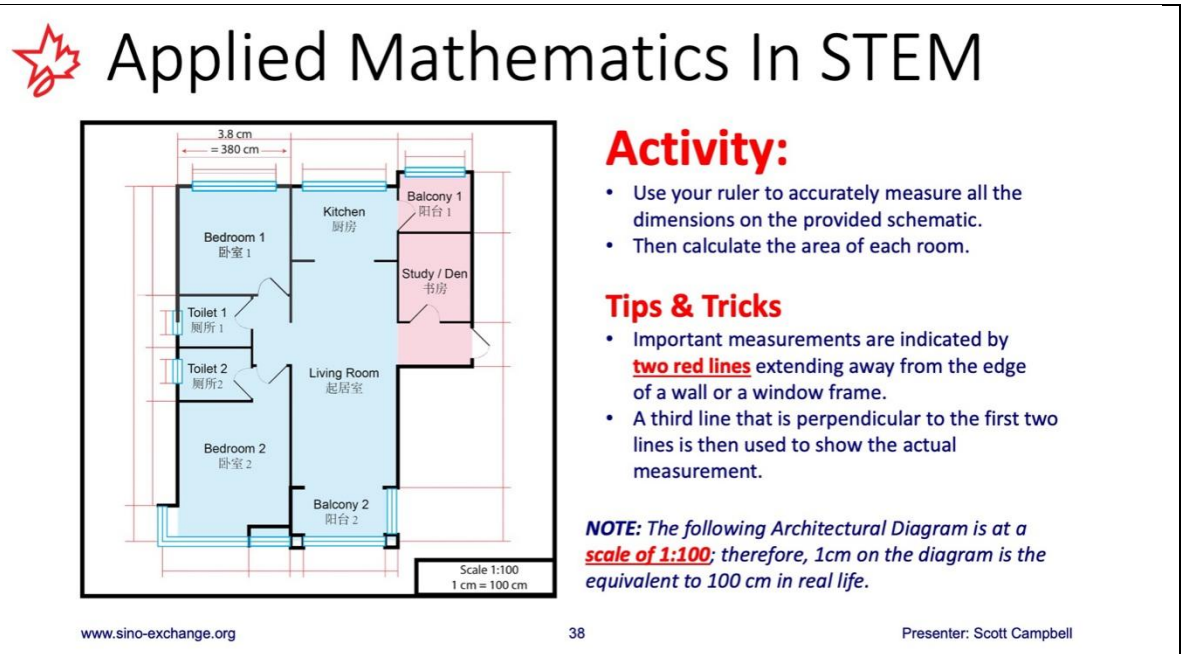
Now students typically learn scale, proportions, and fractions by grade 6. However, they seldom get to use these skills in an authentic, real-world context. That said, by grade 7, students should have the necessary prerequisites to start learning architectural design.	现在，学生通常在六年级之前学习量表、比例和分数。然而，他们很少能在真实的、真实的环境中使用这些技能。也就是说，到 7 年级时，学生应该具备开始学习建筑设计的必要先决条件。



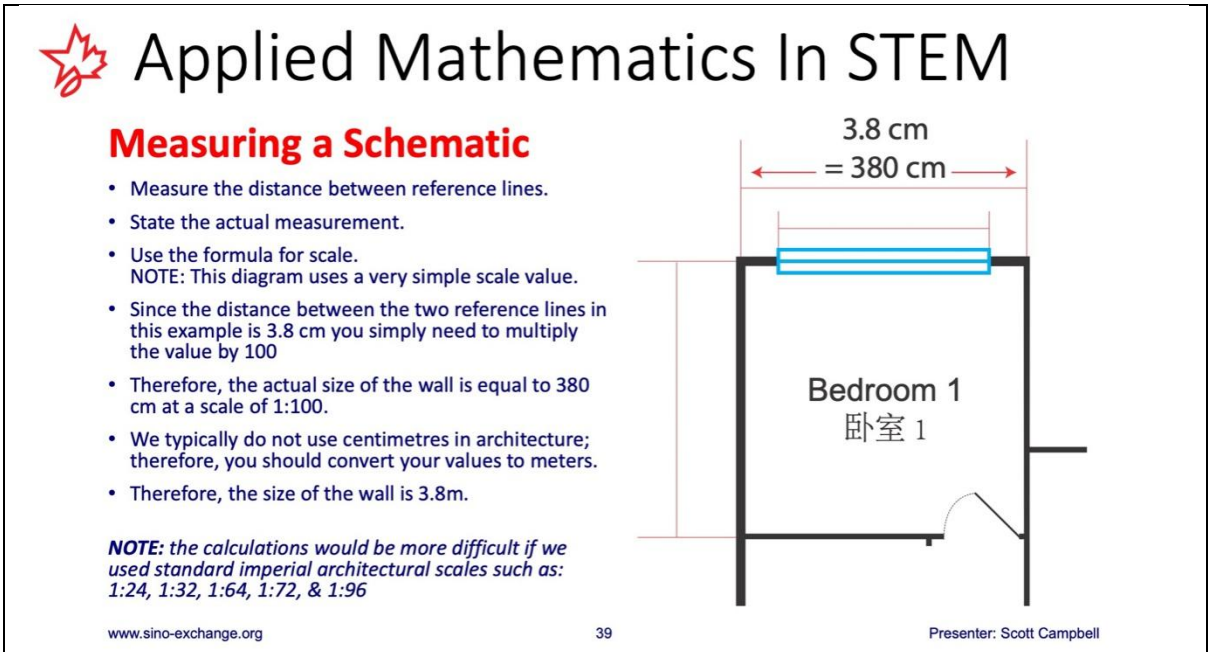
However, you should never assume prior knowledge. Therefore, always start by reviewing a concept, gauge the student's familiarity with it, and reteach a concept when its necessary to do so.	然而，你永远不应该假设事先知道。因此，总是从复习一个概念开始，衡量学生对它的熟悉程度，并在必要时复述一个概念。



Then have your students solve practice problems for themselves. You can also use the interactive whiteboard function to have students solve problem at the front of the class. With this method you will often find that the whole class will work together and try coaching their peers through a problem if they get stuck, and this is the type of supportive learning environment that we want to develop in our classrooms.	然后让你的学生自己解决练习题。您还可以使用交互式白板功能让学生在课堂前解决问题。 有了这种方法，你经常会发现，如果同伴遇到问题，全班同学会一起努力，并尝试指导他们解决问题，这就是我们希望在课堂上培养的支持性学习环境。

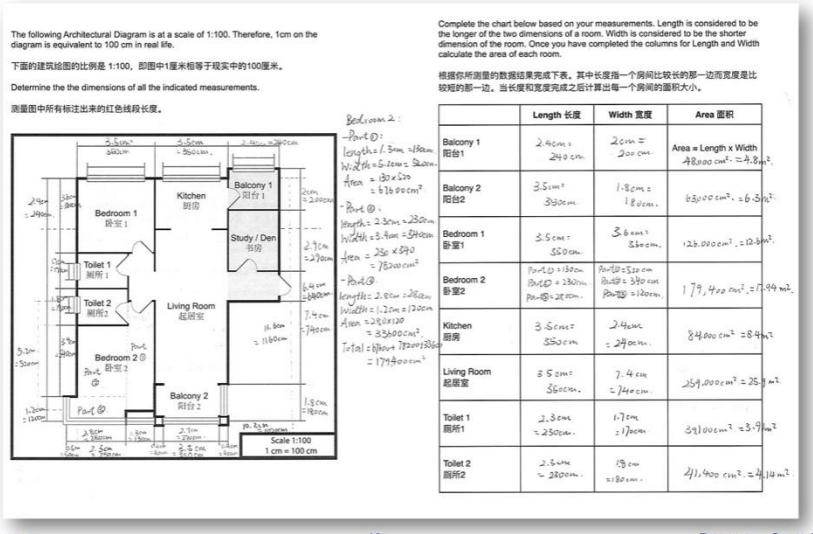


Now the reason for these practice problems was ensure that everyone has a basic understanding of scale before moving on. Much like the land survey, this assignment will have students reverse engineering structures which have been designed by professional designers, while allowing them to getting plenty of practice measuring objects and performing scale calculations.	现在，这些练习问题的原因是确保每个人在继续之前都对比例有基本的了解。就像土地调查一样，这项作业将让学生对由专业设计师设计的结构进行逆向工程，同时让他们获得大量测量物体和执行比例计算的练习。



However, I always use Standard International (SI) units and simple scales in lower grade levels. This way the students can focus on learning key concepts while reducing confusion from formal technicalities. For instance, Imperial measurements involve odd fractions and irregular scales ratios which can be very confusing at first, and while concepts are important for a professional, they are not necessary for a student learning the basics of design and engineering.	然而，我总是在低年级使用标准国际单位制和简单的量表。通过这种方式，学生可以专注于学习关键概念，同时减少正式技术细节带来的困惑。例如，英制测量涉及奇数分数和不规则比例，这一点一开始可能非常令人困惑，虽然概念对专业人士来说很重要，但对学习设计和工程基础的学生来说却没有必要。

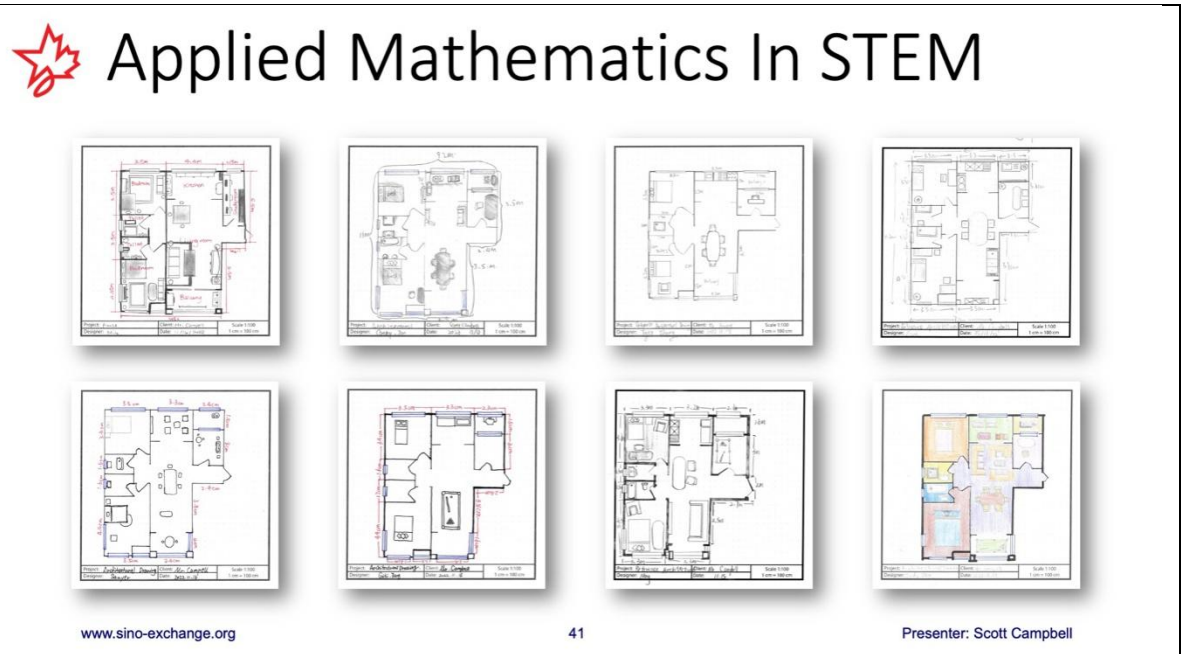
Applied Mathematics In STEM



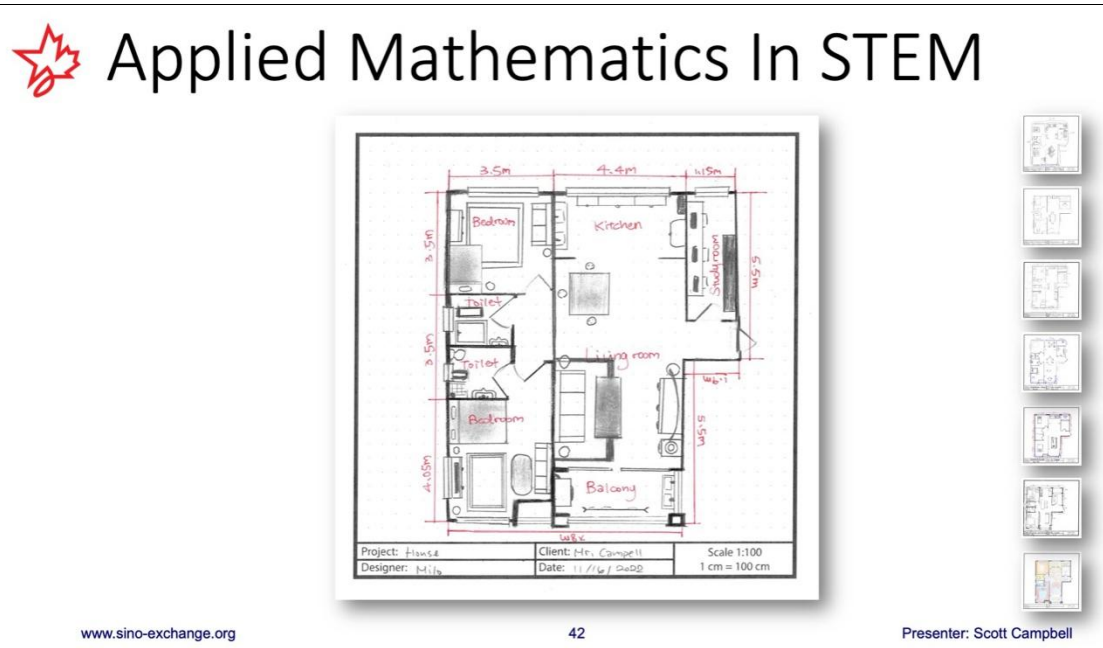
www.sino-exchange.org 40 Presenter: Scott Campbell

After completing all the measurements, students can then calculate the area and perimeter of each room as needed. Moreover, while some rooms are simple shapes, other rooms in this project have irregular shapes which builds differentiation into the project. While most students in grade 7 should be able to determine the area of each room on their own, more advance students will still be challenged by the more difficult problems. Moreover, the teacher can spend their time to identify students that are struggling with the activity and provide direct one-on-one interventions as necessary. And finally, to finish this project off, you can have your students recreate this drawing at scale which will reinforce a wide range of skills.

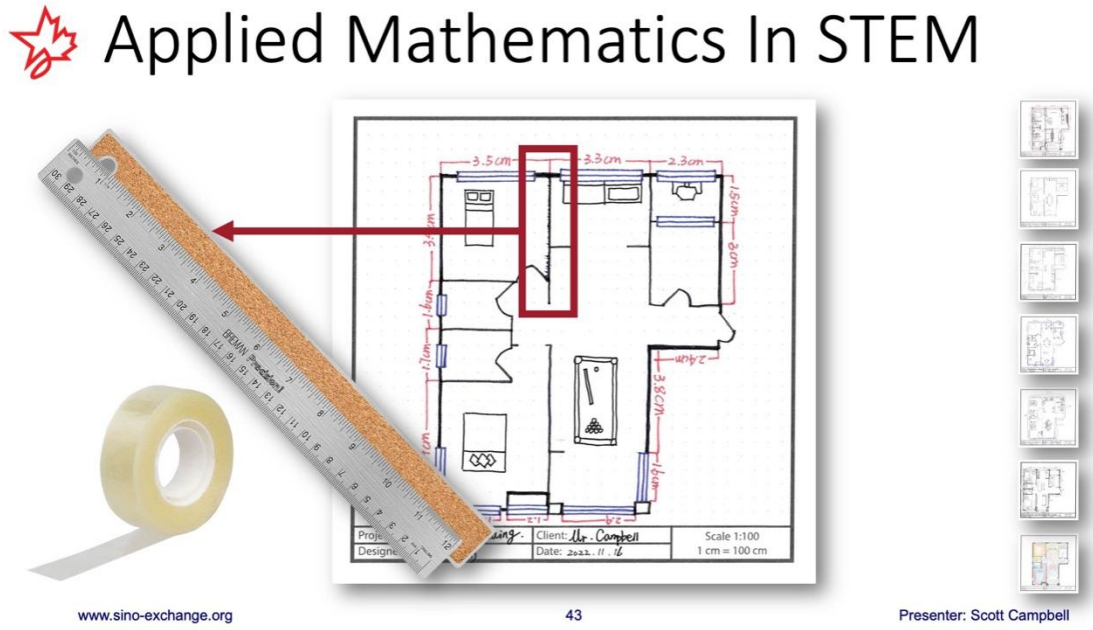
在完成所有测量之后，然后，学生可以根据需要计算每个房间的面积和周长。此外，虽然一些房间的形状很简单，但本项目中的其他房间的形状不规则，这为项目带来了差异。虽然大多数七年级的学生应该能够自己确定每个房间的面积，但更多的高年级学生仍然会受到更难的问题的挑战。此外，教师可以花时间识别在活动中遇到困难的学生，并在必要时提供直接的一对一干预。最后，为了完成这个项目，你可以让你的学生按比例重新绘制这幅画，这将加强广泛的技能。



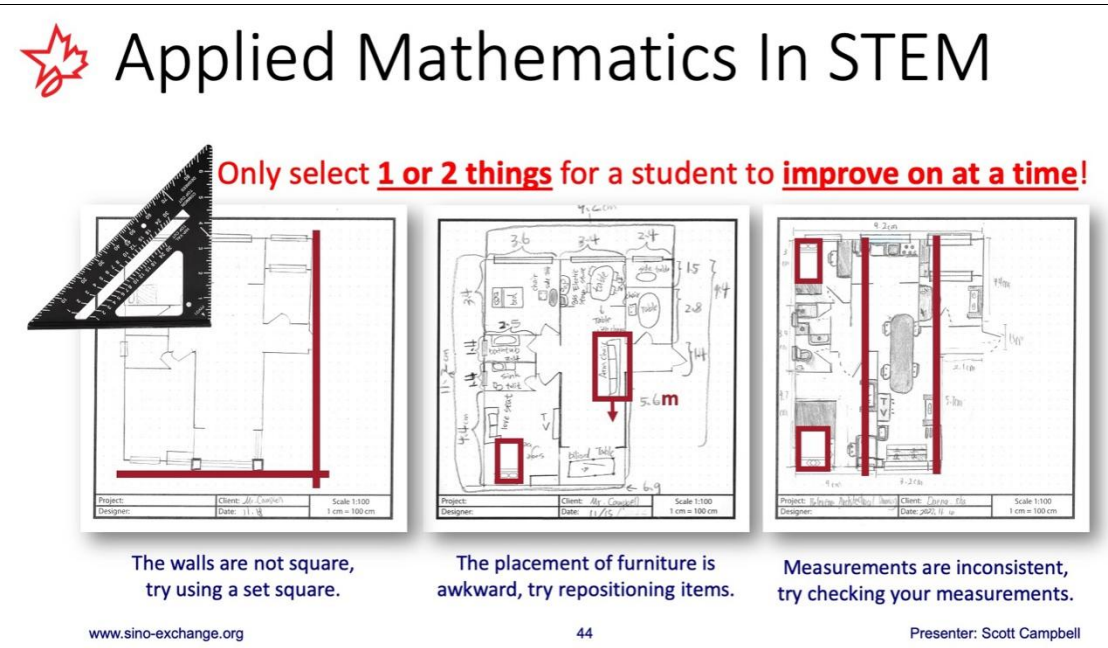
Another thing that makes a huge difference is showcasing your students work. While this can be difficult to do if you do not have your own classroom, I have always created my activities in a way that they can be scanned in bulk. This allows me to add student work to my presentation for the following day and send parents evidence of their child's ongoing progress when necessary.	另一件非常重要的事情是展示你的学生作品。虽然如果你没有自己的教室，这可能很难做到，但我一直以可以批量扫描的方式创建我的活动。这让我可以在第二天的演讲中添加学生作业，并在必要时向家长发送孩子正在进步的证据。



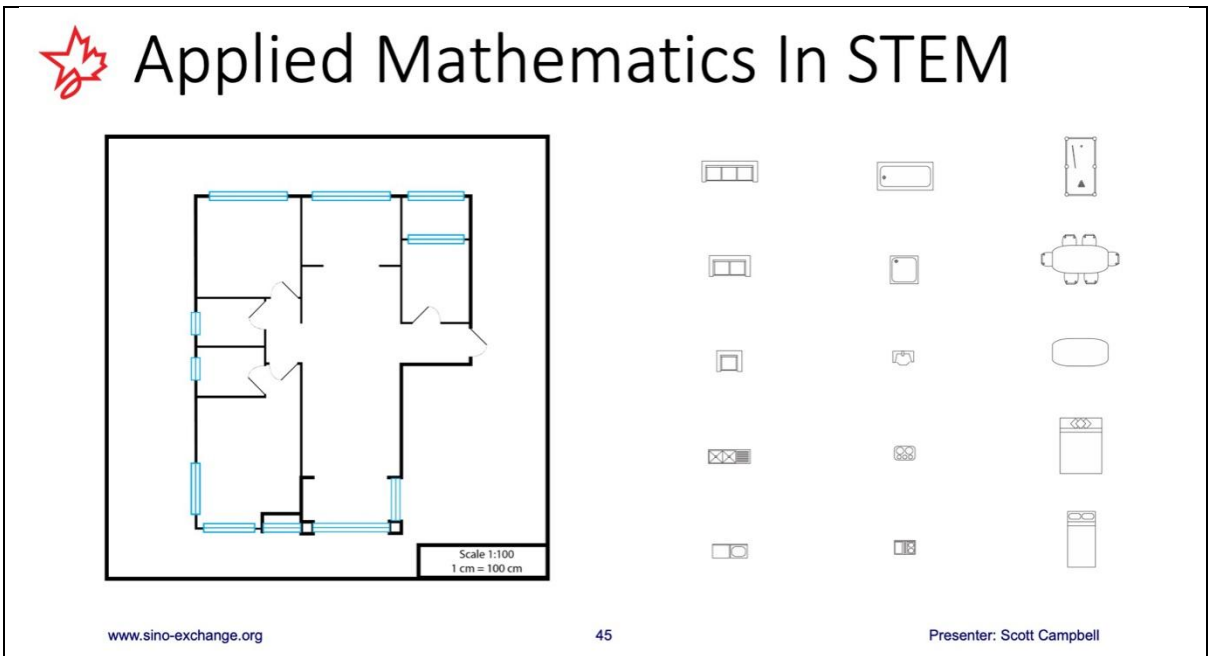
I won't show every project, but I will select the best student work to show in class. This also helps to creates a friendly competition within the class as everyone wants to try to get their work featured. This results in a drastic increase in the quality of student work, while also reducing behavioral issues at the same time.	我不会展示每一个项目，但我会选择最好的学生作品在课堂上展示。这也有助于在课堂上创造一个友好的竞争，因为每个人都想尝试让自己的作品成为特色。这导致学生作业质量的大幅提高，同时也减少了行为问题。



This method also allows you to address common issues through group critiques, allowing you to quickly and easily provide effective and timely feedback to your students. For instance, this project is relatively well done. However, the student could avoid smudges if, they used cork backed ruler or put some tape on the back of a standard ruler to create an air pocket.	这种方法还允许您通过小组批评来解决常见问题，使您能够快速、轻松地向学生提供有效、及时的反馈。 例如，这个项目做得比较好。然而，如果学生使用软木背尺或在标准尺的背面贴上一些胶带来形成一个气穴，他们就可以避免弄脏。

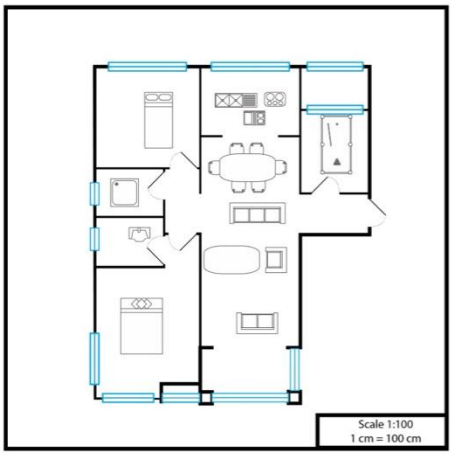


You can also use this method to provide anonymous feedback to students as well, but make sure you hide the student's name to avoid embarrassing the student in front of their peers.	你也可以使用这种方法向学生提供匿名反馈，但一定要隐藏学生的名字，以免在同龄人面前让学生尴尬。



Here we can see that same apartment with properly scaled furniture samples.	在这里，我们可以看到同样的公寓与适当比例的家具样品。

Applied Mathematics In STEM



Common Mistakes

When learning how to draw architectural schematics students will often make the following mistakes:

- Place furniture in odd locations, such as a bed in the middle of the room rather than up against a wall.
- Place large objects like billiard tables in spaces or rooms that are far too small for it.
- Place large furniture items such as a couch in a in front of a door, hallway, or other high-traffic area.
- Will often omit important amenities in rooms such as bathrooms, or kitchens. For example, a bathrooms should have a sink, toilet and bath / shower.

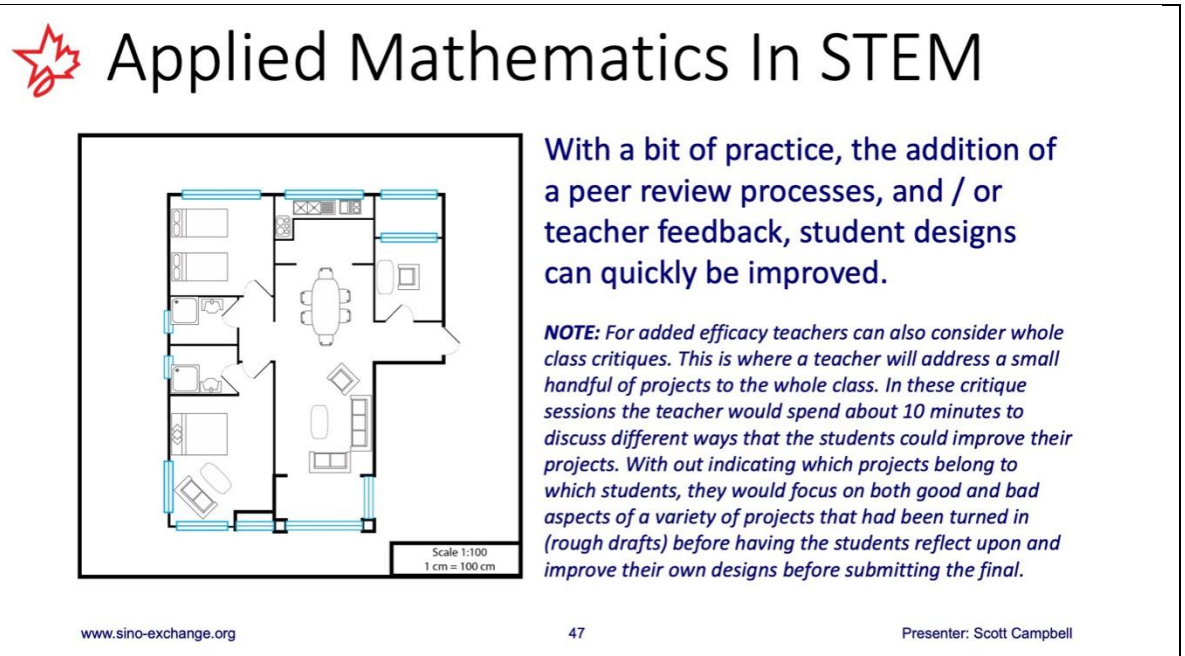
www.sino-exchange.org 46 Presenter: Scott Campbell

While it seems simple, placing furniture and appliances is far more difficult than it sounds!

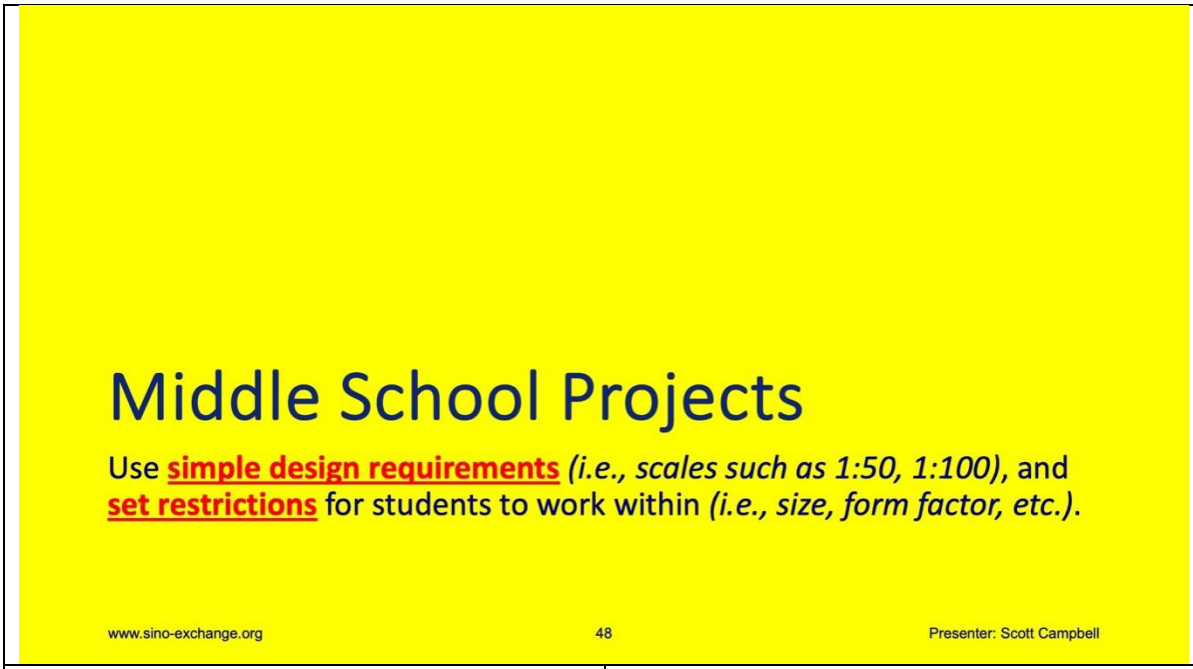
- We often see things like beds place randomly in the center of the room.
- Large objects placed in small rooms.
- Furniture being placed in high-traffic walkways.
- And some rooms not even having the necessary appliances or fixtures.

虽然这看起来很简单，但放置家具和电器远比听起来困难!

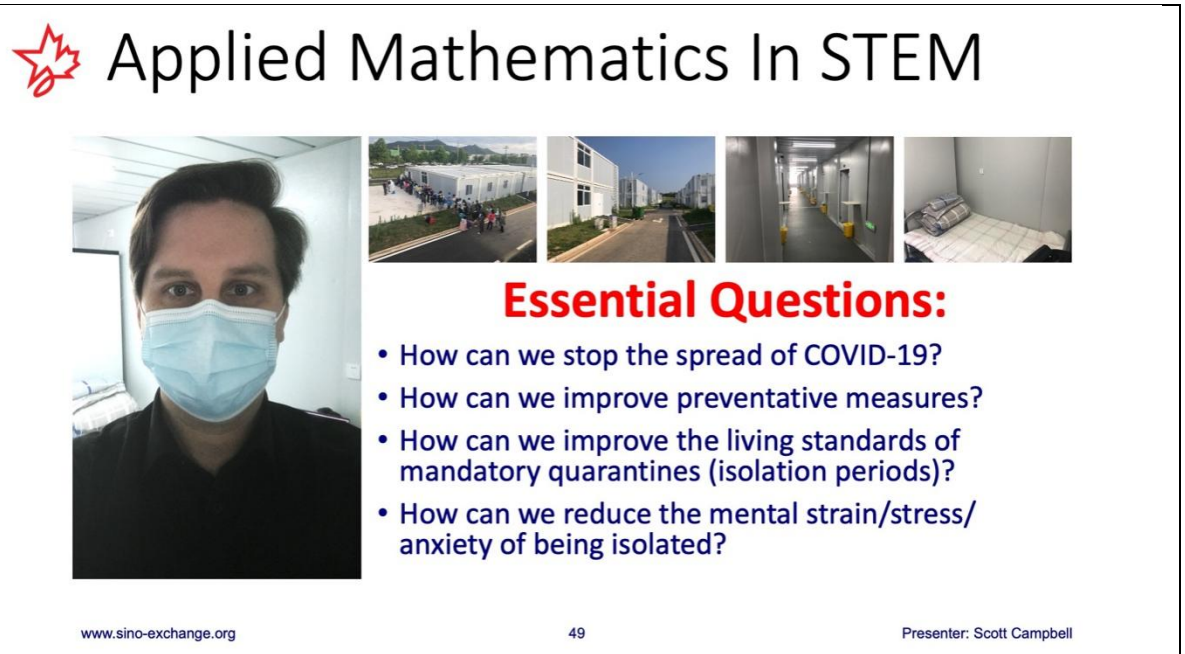
- 我们经常看到像床这样的东西随意地放在房间的中央。
- 放置在小房间里的大型物品。
- 家具放置在交通繁忙的人行道上。
- 有些房间甚至没有必要的电器或固定装置。



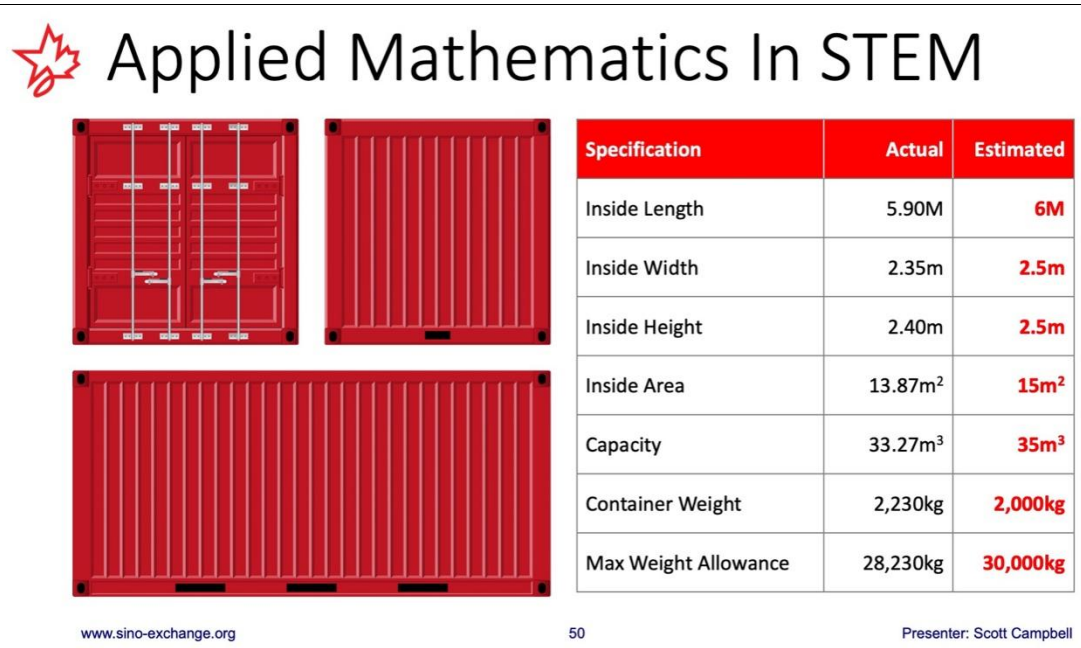
However, these problems can be resolved with group critiques and continued practice.	然而，这些问题可以通过小组批评和持续的练习来解决。



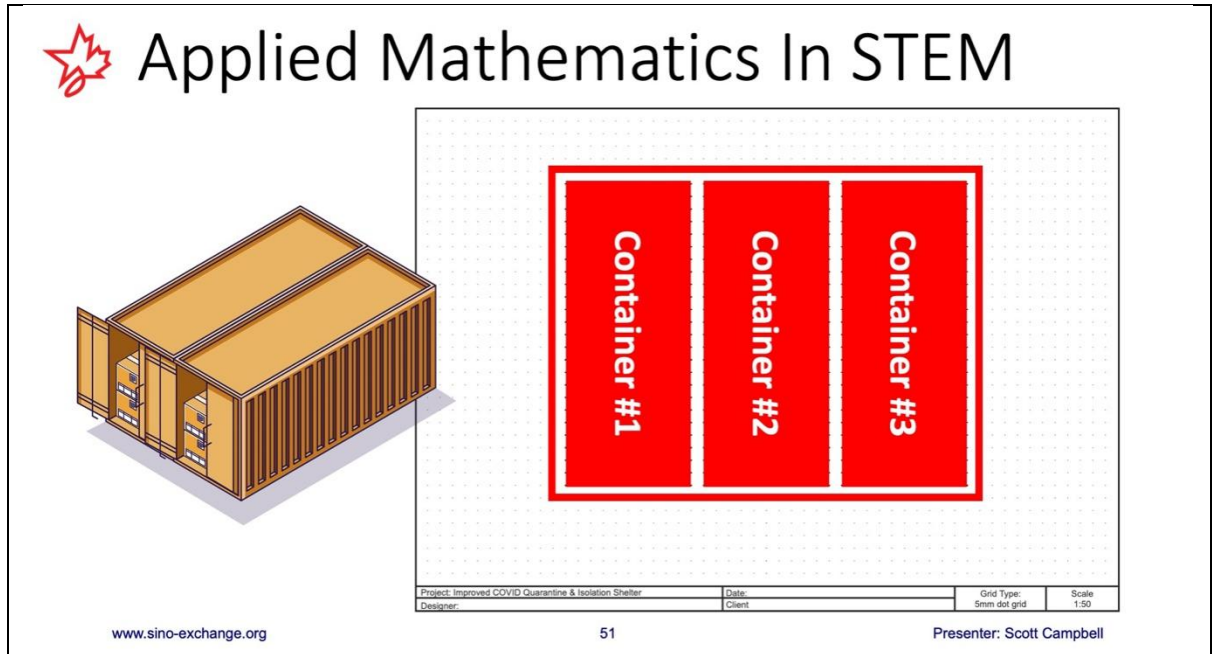
Architectural design projects can also be differentiated for use in different grade levels quickly and easily. For younger students start with easily to use scale ratios and lots of restrictions to help guarantee success. Then as students get older provide them with more freedom to explore more complex ideas.	建筑设计项目也可以进行区分，以便快速方便地在不同级别中使用。对于年龄较小的学生来说，从易于使用的比例和许多限制开始，以帮助确保成功。然后，随着年龄的增长，学生们有了更多的自由来探索更复杂的想法。



As mentioned before, STEM projects should solve real-world problems. Therefore, you should consider the nature of the challenge, and what type of restrictions engineers would face in the real-world. In this example, I have challenged my students to design a better quarantine shelter.	如前所述，STEM 项目应该解决现实世界中的问题。因此，你应该考虑挑战的性质，以及工程师在现实世界中会面临哪些类型的限制。在这个例子中，我要求我的学生设计一个更好的隔离避难所。



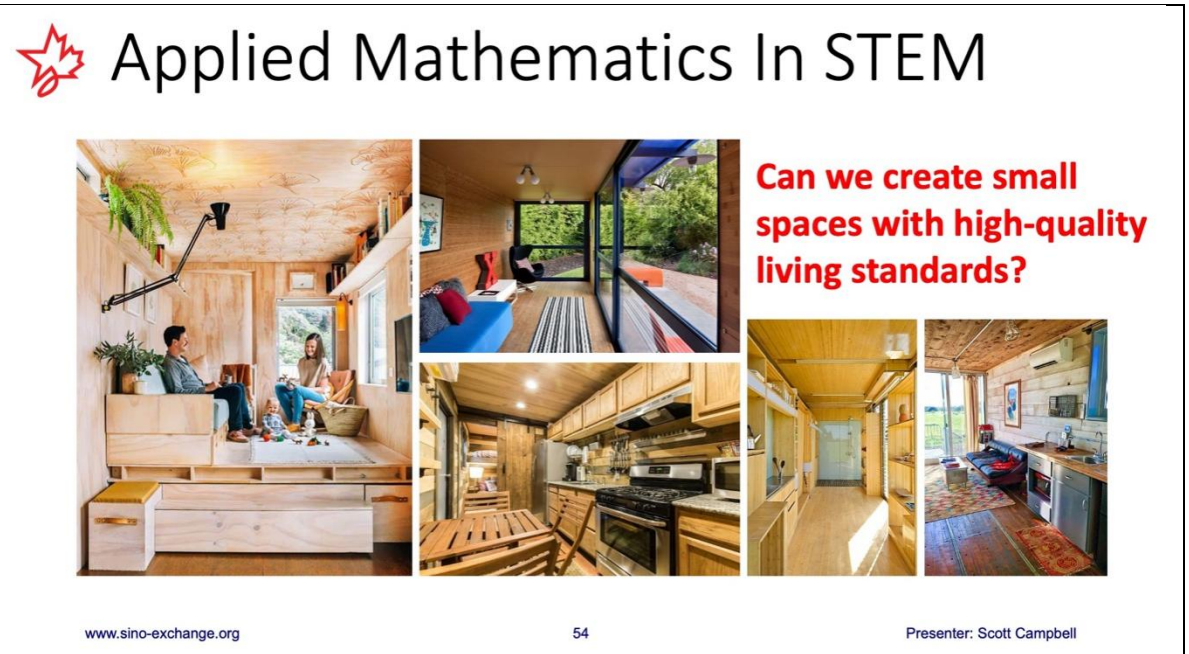
However, there were restrictions placed on the engineers who designed the first rapid response shelters. Therefore, our students should have to work with the same limiting factors.	然而，设计第一批快速反应避难所的工程师受到了限制。因此，我们的学生应该在同样的限制因素下工作。



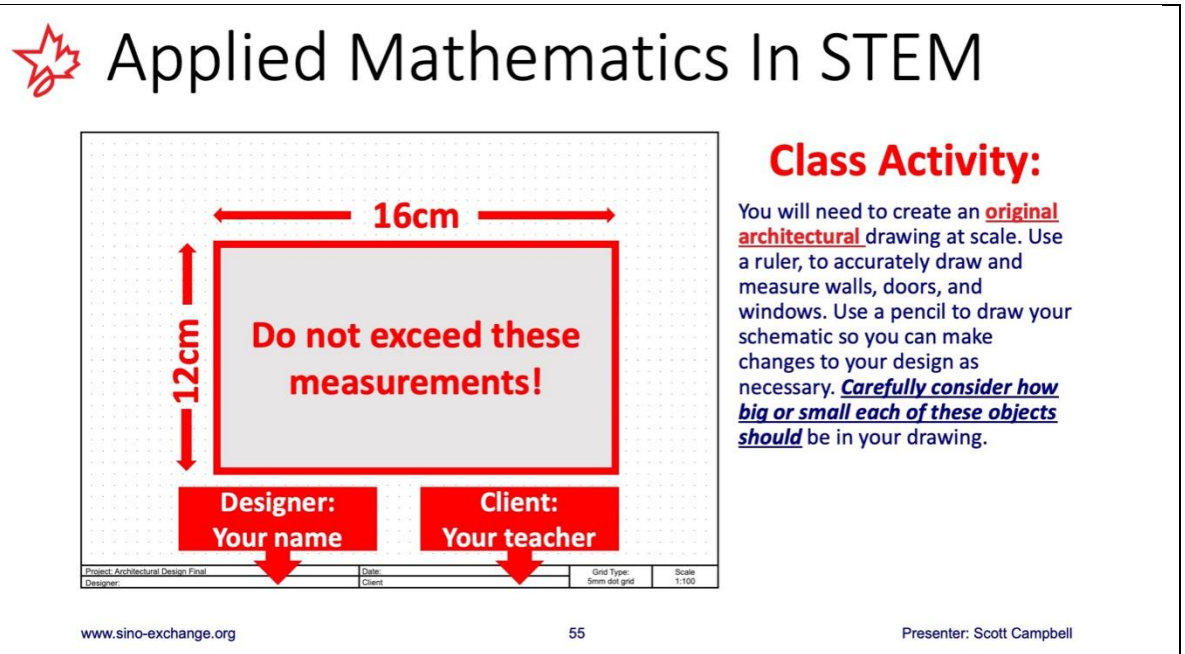
However, I did provide my students with one variable to provide them with some flexibility. I allowed them to use 3 containers! That way they could create a combination of individual or family sized quarantine shelters.	然而，我确实为我的学生提供了一个变量，为他们提供了一些灵活性。我允许他们使用 3 个容器！这样，他们就可以创建一个个人或家庭规模的隔离避难所。

I presented the students with guiding questions such as: “Will simple changes make a difference?”	我向学生们提出了一些指导性问题，比如：“简单的改变会有所不同吗？”

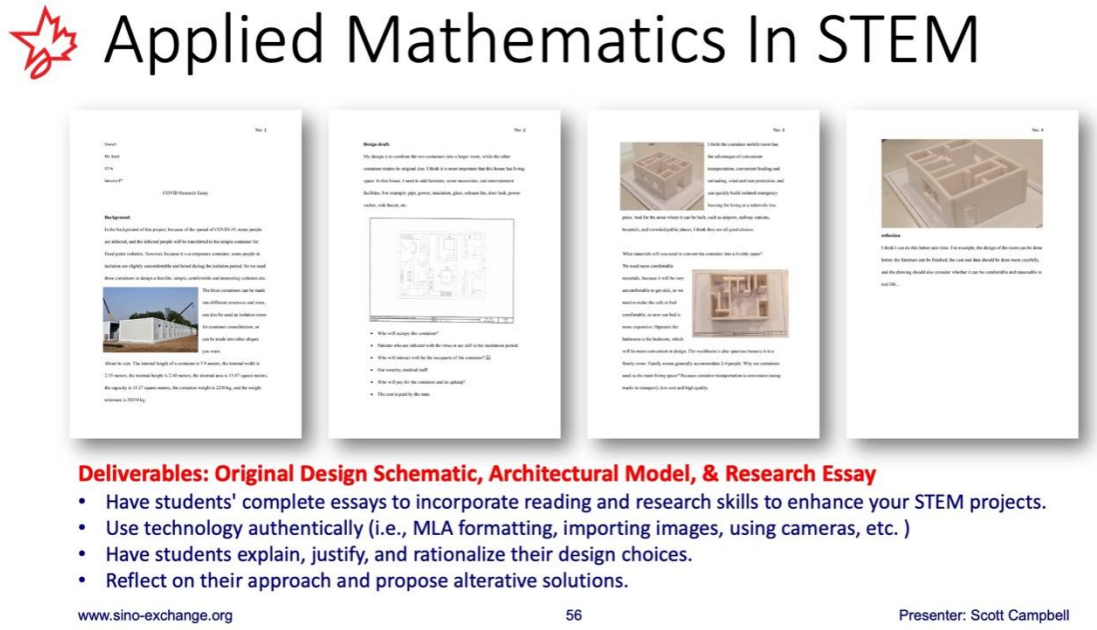
Can we optimize the space that we have?	我们能优化现有的空间吗？



And can we create small spaces with high-quality living standards?	我们能否创造出高质量生活标准的小空间？



And I provided my students with ongoing support to help them create designs that effectively used industry standard design templates.	我为我的学生提供了持续的支持，帮助他们创建有效使用行业标准设计模板的设计。



Finally, to have the project reinforce as many learning standards as possible, and to model real-world practices I had the students submit the following:

- A research essay in addition to their physical model,
- And this essay applied ICT skills that are covered on the grade 7 Huikao ICT exam,
- While also adhering to MLA guidelines for document formatting.
- The students also had to explain, justify, and rationalize their design choices. Which is the same thing a professional designer would have to do during a design brief.
- And we included a personalize reflection on what improvements could still be made to the design.

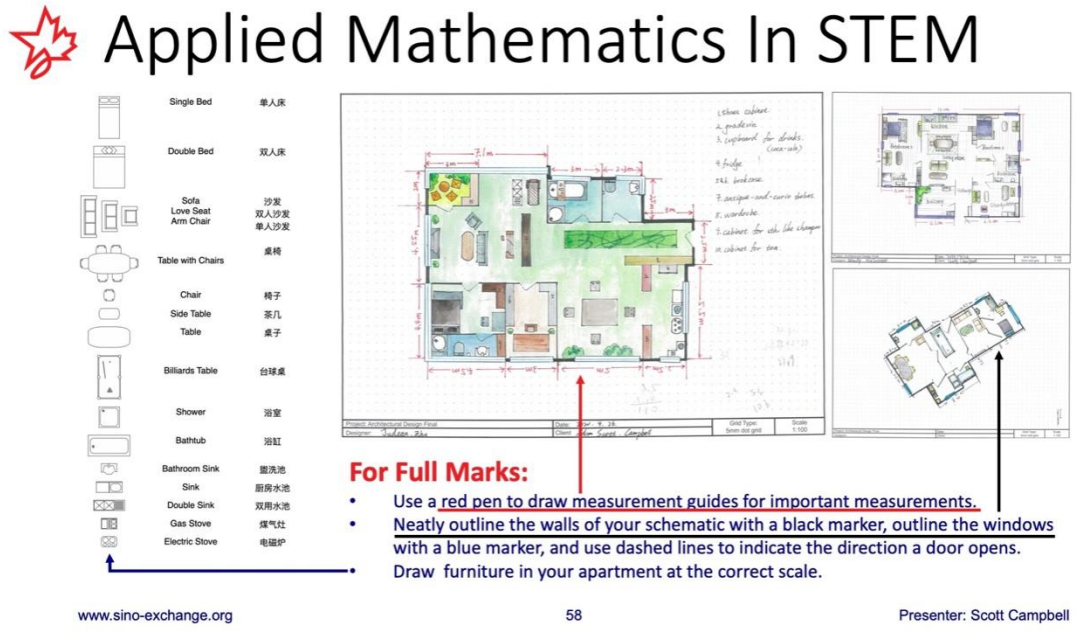
Moreover, while this project example focused on COVID disaster response, this idea of modular construction could be applied to ecofriendly living, or to research capsules for space exploration. Therefore, the physical project requirements can stay the same form year to year, but the challenge prompt can easily be updated to keep the project new and exciting for each new cohort.

最后，为了让这个项目加强尽可能多的学习标准，并为现实世界的实践建模，我让学生们提交了以下内容：

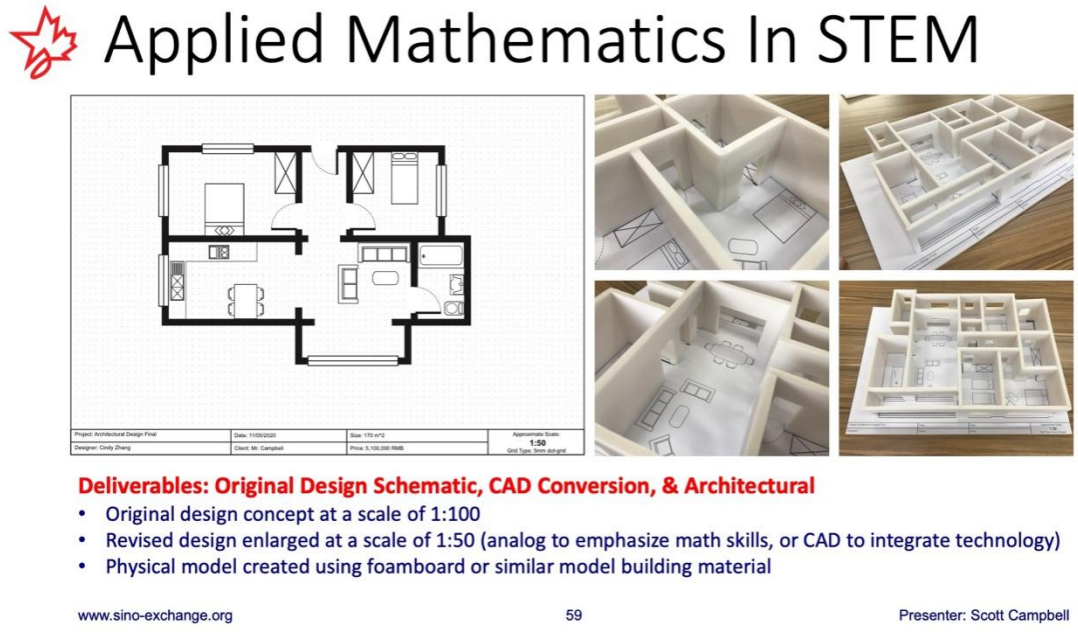
- 除了他们的物理模型之外，还有一篇研究论文，
- 本文应用了七年级会考信息通信技术考试中涵盖的信息通信技术技能，
- 同时遵守 MLA 关于文件格式的指导方针。
- 学生还必须解释、证明和合理化他们的设计选择。这与专业设计师在设计简报中必须做的事情是一样的。
- 我们还对设计还有哪些改进进行了个性化思考。

此外，虽然本项目的例子侧重于新冠肺炎灾难应对，这种模块化结构的想法可以应用于生态友好型生活，也可以应用于太空探索的太空舱研究。因此，物理项目需求可以每年保持不变，但挑战提示可以很容易地更新，以保持项目的新颖性和对每个新团队的兴奋性。

With intermediate students, the project would remain relatively the same; however, we would remove some of the restrictions to allow students to explore more complex ideas.	对于中级学生，项目将保持相对不变；然而，我们会取消一些限制，让学生探索更复杂的想法。



In these examples you can see the students have designed more sophisticated living spaces. • However, they still applied stand design conventions such as guidelines and measurement, • Properly indicated doors, windows, and walls, • And added furniture at the appropriate scale.	在这些例子中，你可以看到学生们设计了更精致的生活空间。 • 然而，他们仍然采用了支架设计惯例，如指南和测量， • 正确安装的门、窗和墙壁， • 并以适当的比例增加家具。



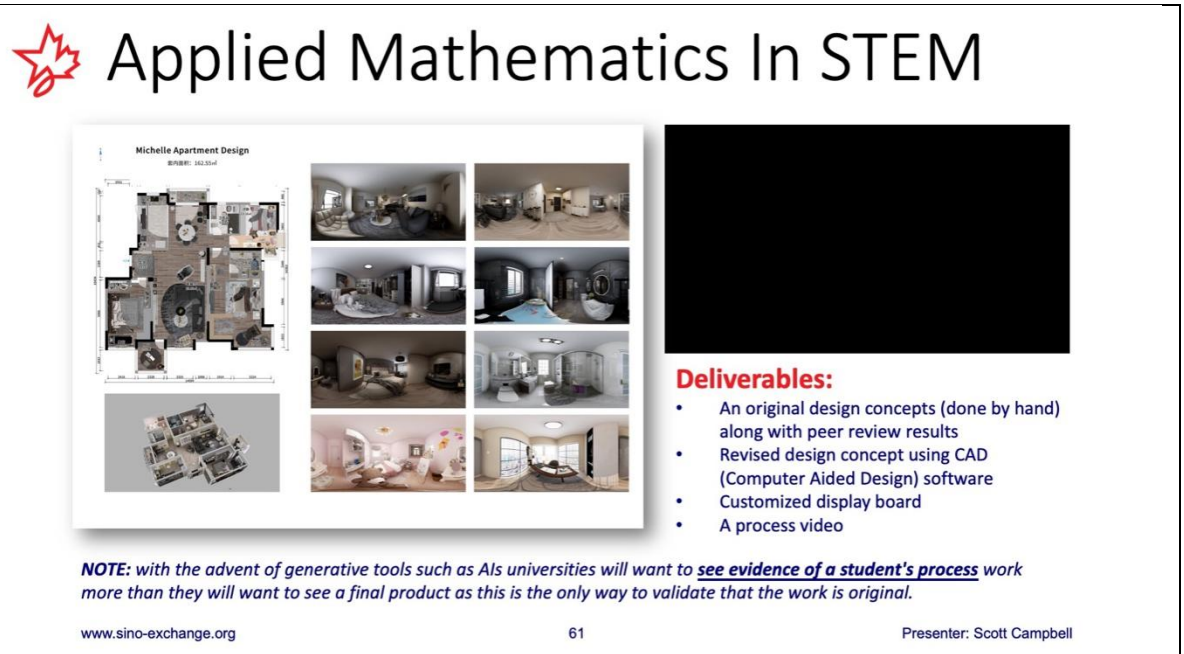
As for deliverables:

- I would have the students work at different scales as the smaller designs are quicker and easier to make.
- I would then have the students enlarge those designs, either by hand or using the computer so they could make a model at a larger scale,
- And this is what that project might look like when it is finished.

关于可交付成果：

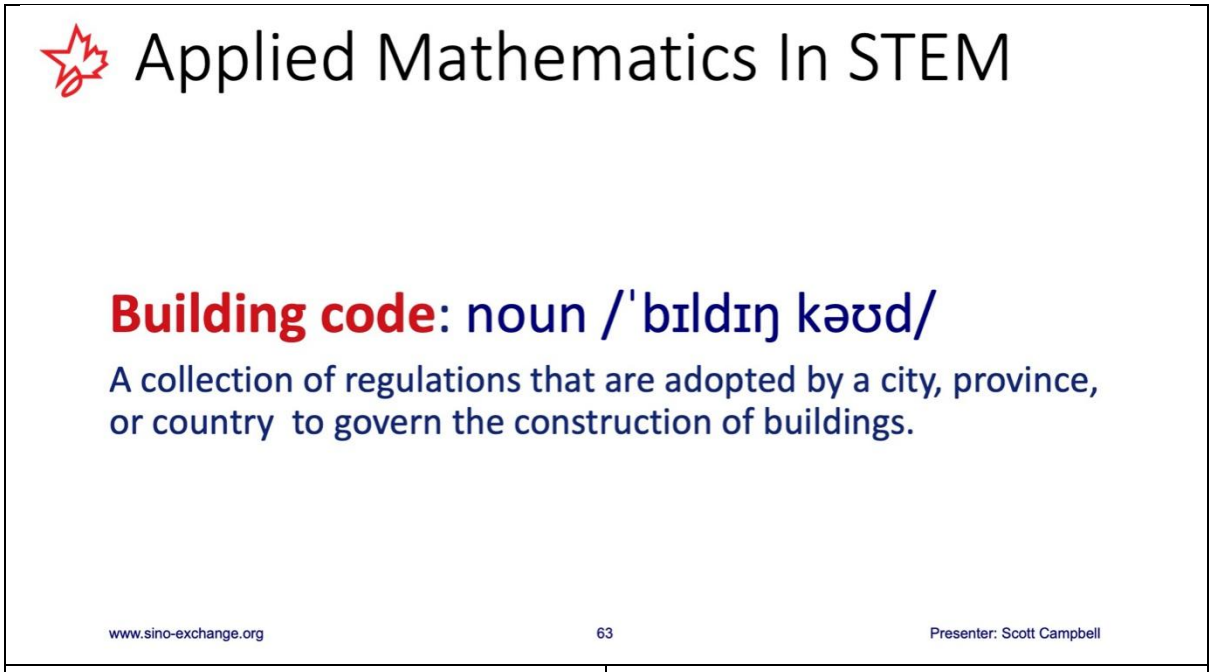
- 我会让学生们在不同的规模上工作，因为较小的设计更快更容易。
- 然后，我会让学生们用手或电脑放大这些设计，这样他们就可以制作更大规模的模型，
- 这就是项目完成后的样子。

And for students in senior school, who are just about ready to go off to university, that is when I would focus heavily on technology. They have already mastered the basics, and they will be ready to learn the same software platforms that they would be using at university, or at a design firm if they landed a summer internship.	对于高中生来说，他们正准备上大学，那时我会把重点放在技术上。他们已经掌握了基础知识，如果他们获得了夏季实习机会，他们将准备学习在大学或设计公司使用的相同软件平台。

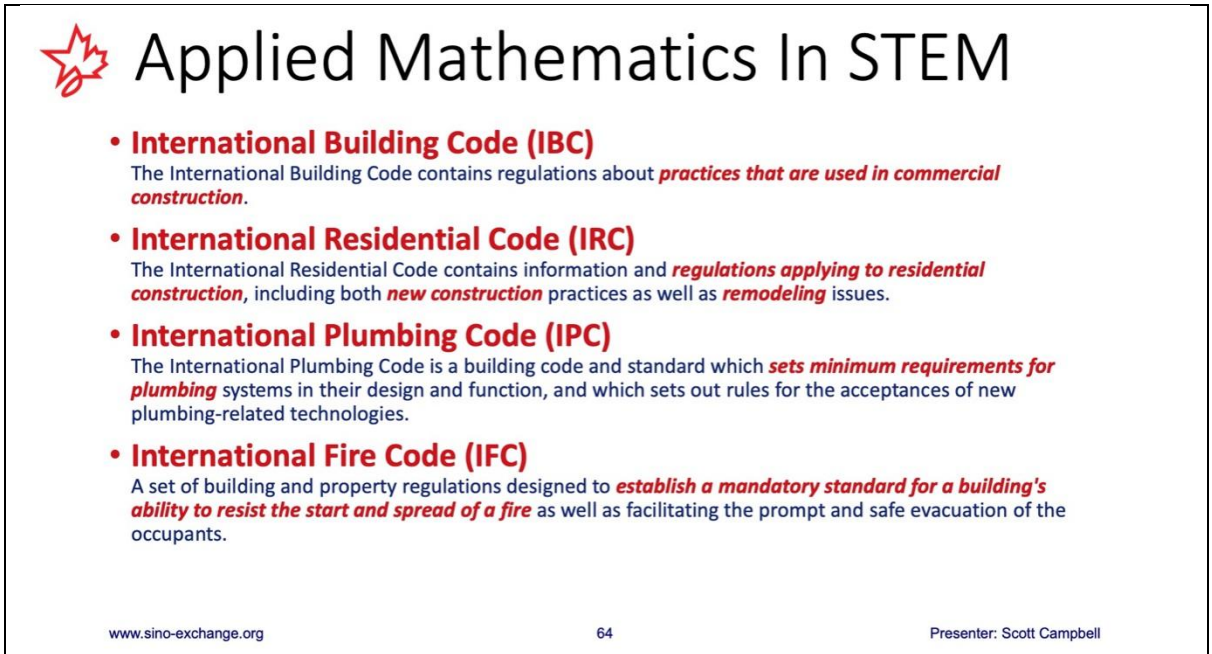


In this final example you can see the student finished display board, and I should also note that all these photographs are not photos from a real apartment. Instead, they are computer generated images based on their computerized design model. Finally, with the advent of generative AI tools, universities will want to see evidence of a student's process work as this is the only way that universities can validate that the work has been done by the student and not an AI algorithm.	在最后一个例子中，你可以看到学生完成的展示板，我还应该注意到，所有这些照片都不是来自真实公寓的照片。相反，它们是基于计算机化设计模型的计算机生成的图像。 最后，随着生成人工智能工具的出现，大学将希望看到学生过程工作的证据，因为这是大学验证学生完成工作的唯一途径而不是 AI 算法。

Aspiring engineers must also be aware of design regulations as well. These commonly agreed-upon set of standards form a ***general building code*** which are not specific to any one region or country.	有抱负的工程师也必须了解设计法规。这些共同商定的一套标准形成了一个通用的建筑规范，并不针对任何一个地区或国家。

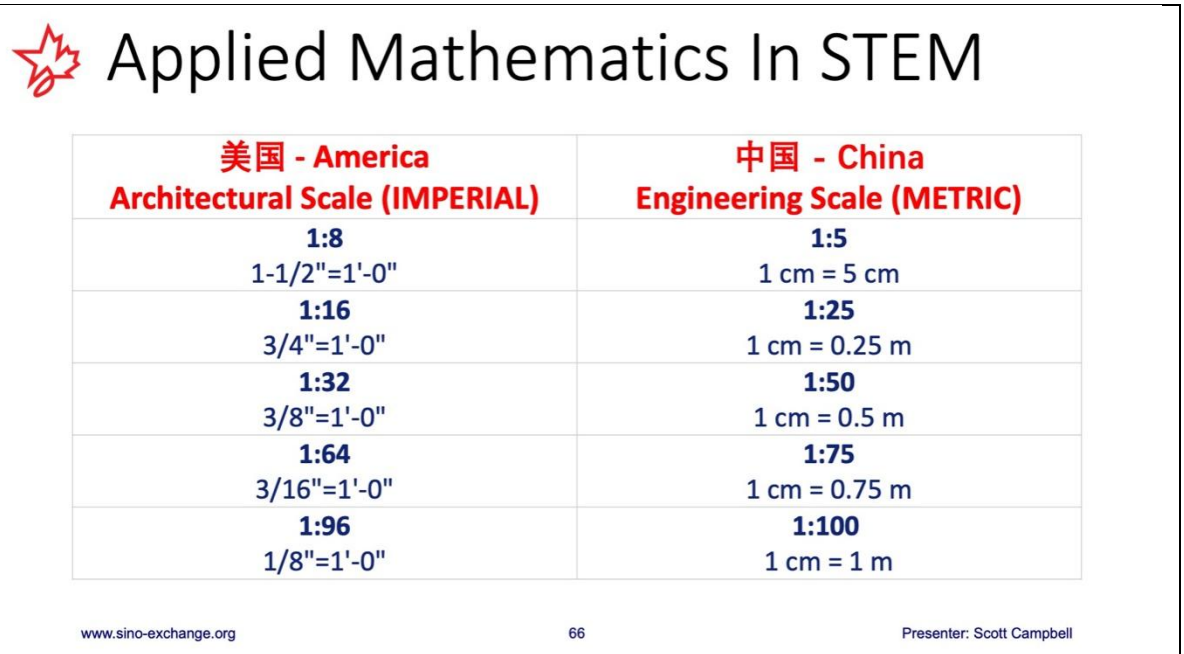


Now what's the purpose of a building code? Well, building codes ensure that all structures either meet or exceed safety standards, and this could include but is not limited to the construction of homes, schools, hospitals, and bridges.	现在，建筑规范的目的是什么？ 建筑规范确保所有结构都符合或超过安全标准，这可能包括但不限于房屋、学校、医院和桥梁的建设。



And depending on your course you could explore concepts from the: • International Budling Code, • International Residential Code, • International Plumbing Code, • And the International Fire Code, Which all include practical examples of mathematics being used to solving legitimate problems in the real-world.	根据您的课程，您可以从以下方面探索概念： • 国际建筑规范， • 国际住宅规范， • 国际管道规范， • 国际消防规范， 其中包括数学在现实世界中被用来解决合法问题的实际例子。

Therefore, if you don't want to focus on technology, you could emphasize engineering practices instead. In this case you could consider implementing the following residential design project.	因此，如果你不想专注于技术，你可以转而强调工程实践。在这种情况下，您可以考虑实施以下住宅设计项目。

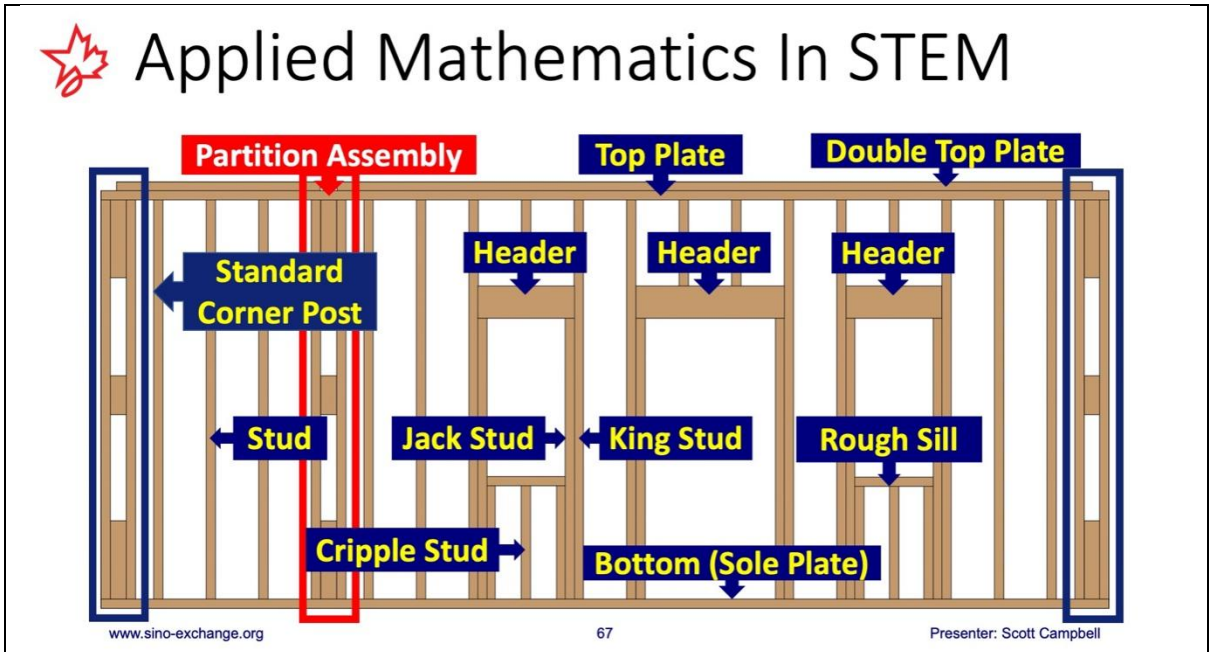


First, while I had avoided imperial measurements in the lower grades, students who have decided to purse civil engineering will need to learn all the different industry standards.

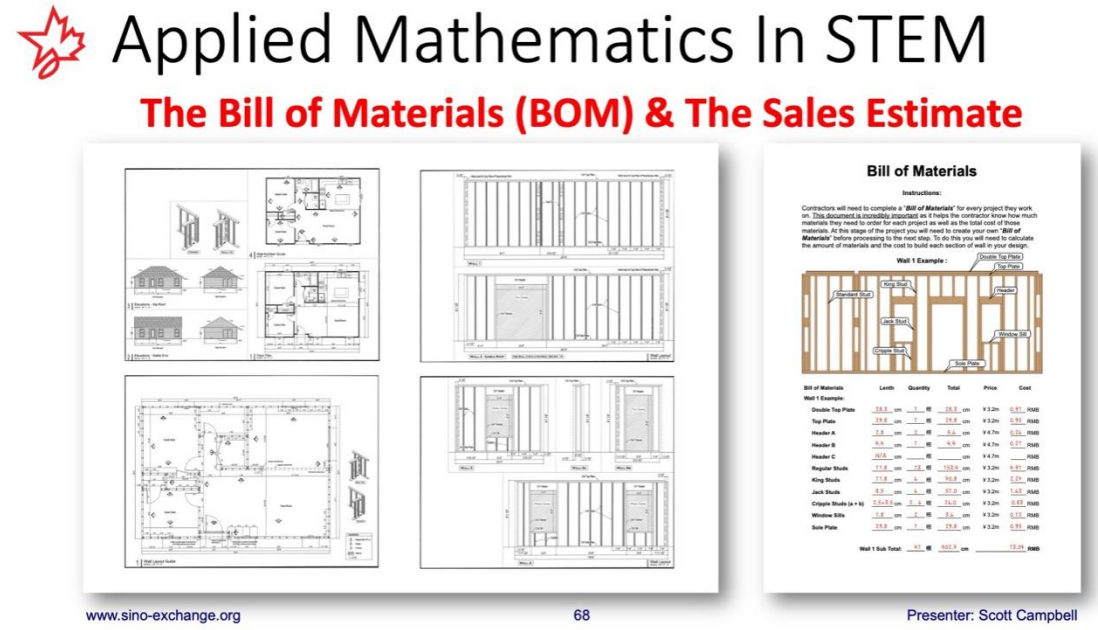
While China has adopted the Metric System, the International Building Code (IBC) using yards, feet, and inches, and as you can see from the provided table, Imperial conversions are not as logical or straight forward as they are with Standard International Units.

首先，虽然我在低年级避免了英制计量，但那些决定学习土木工程的学生需要学习所有不同的行业标准。

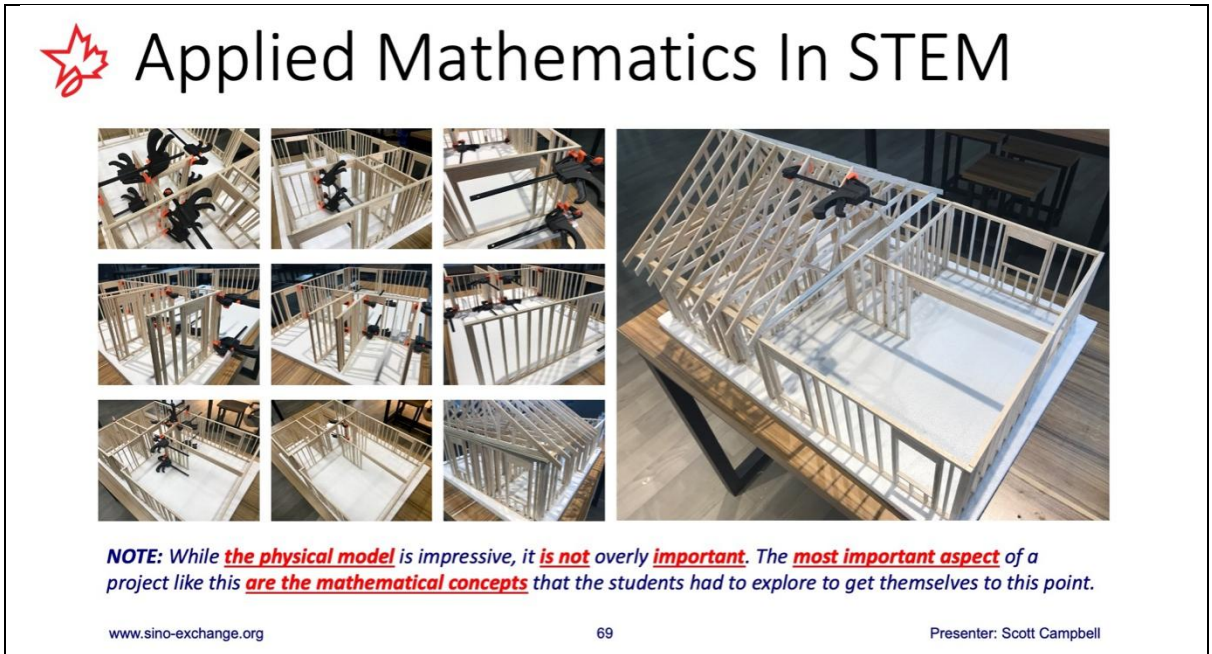
虽然中国采用了公制，国际建筑规范（IBC）使用码、英尺和英寸，正如你从提供的表格中看到的那样，英制转换不像标准国际单位那样合乎逻辑或直接。



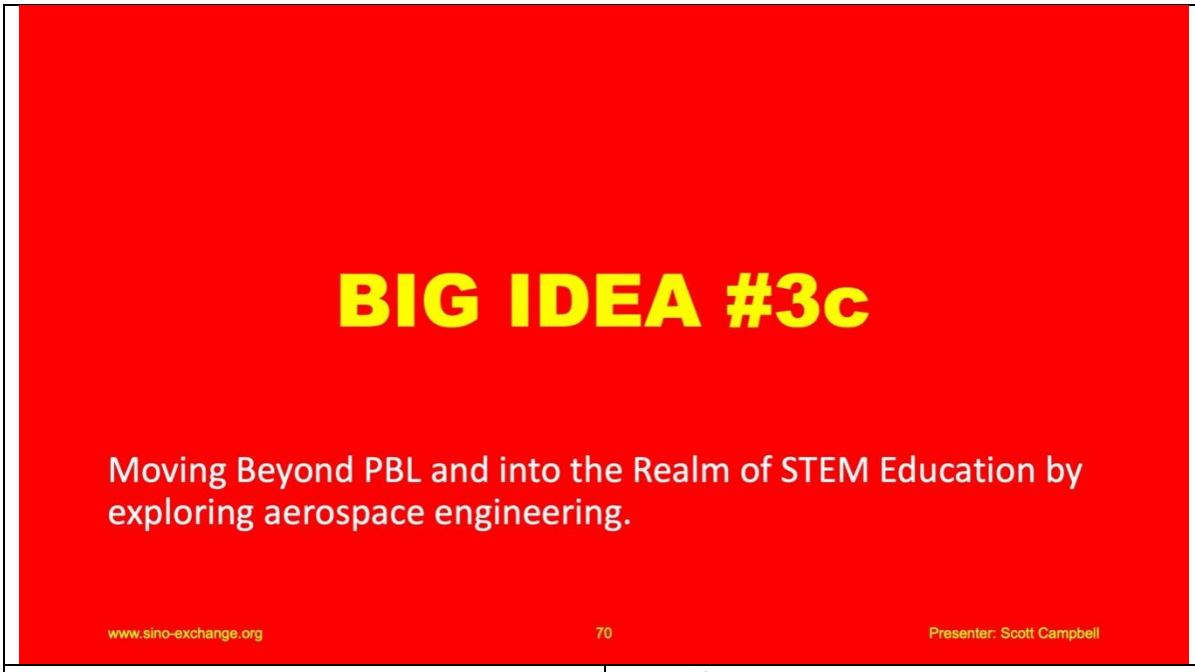
Therefore, these types of projects will require students to learn new numerical concepts, and vocabulary terms which are specific to the field of civil engineering.	因此，这些类型的项目将要求学生学习新的数值概念和土木工程领域特有的词汇。



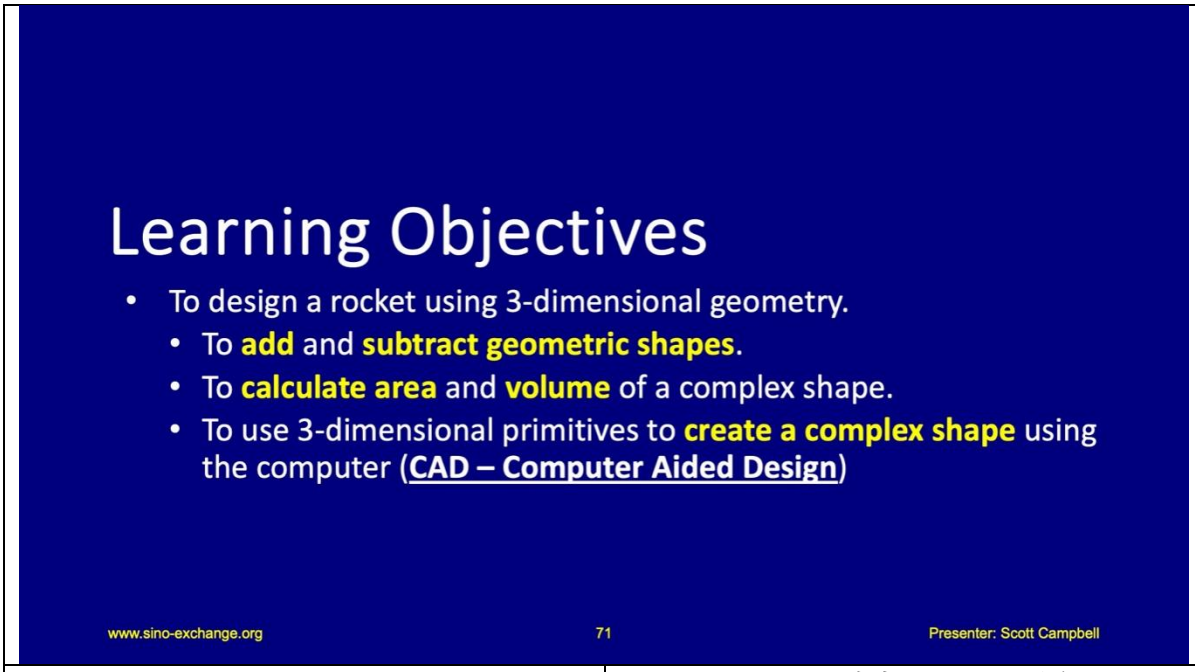
Another great application of math in this project is what's known as the “Bill of Materials”. This document will require students to convert their original designs to a structural plan that meets standard international building codes. From there, the students will need to create an inventory of everything that is needed to build the house. This is known as the “Bill of material” which is a critical component in creating a sales estimate and the subsequent client contract.	数学在这个项目中的另一个伟大应用是所谓的“材料清单”。该文件将要求学生将其原始设计转换为符合标准国际建筑规范的结构平面图。从那里开始，学生们将需要创建一个清单，列出建造房子所需的一切。这被称为“物料清单”，是创建销售估算和后续客户合同的关键组成部分。



And finally, this is what that project would look like when finished. However, the physical model is not what's important. The most important thing behind this kind of project is the mathematical concepts that the students explored to get to this point.	最后，这就是该项目完成后的样子。然而，物理模型并不是最重要的。这类项目背后最重要的是学生们为达到这一点而探索的数学概念。

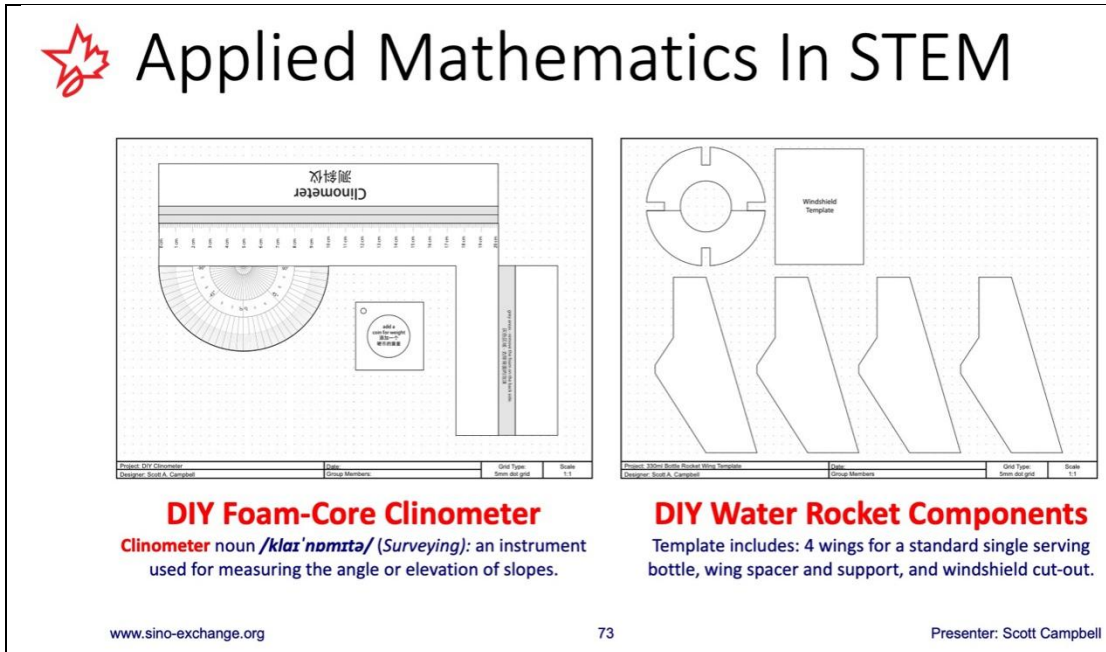


While I've spent a lot of time on Civil Engineering so far, Aerospace Engineering allows us to move away from a predominantly 2-dimensional design construct and into the real-world application of 3-dimensional thinking.	到目前为止，我在土木工程上花了很多时间，但航空航天工程使我们能够摆脱主要的二维设计结构，进入三维思维的现实世界应用。



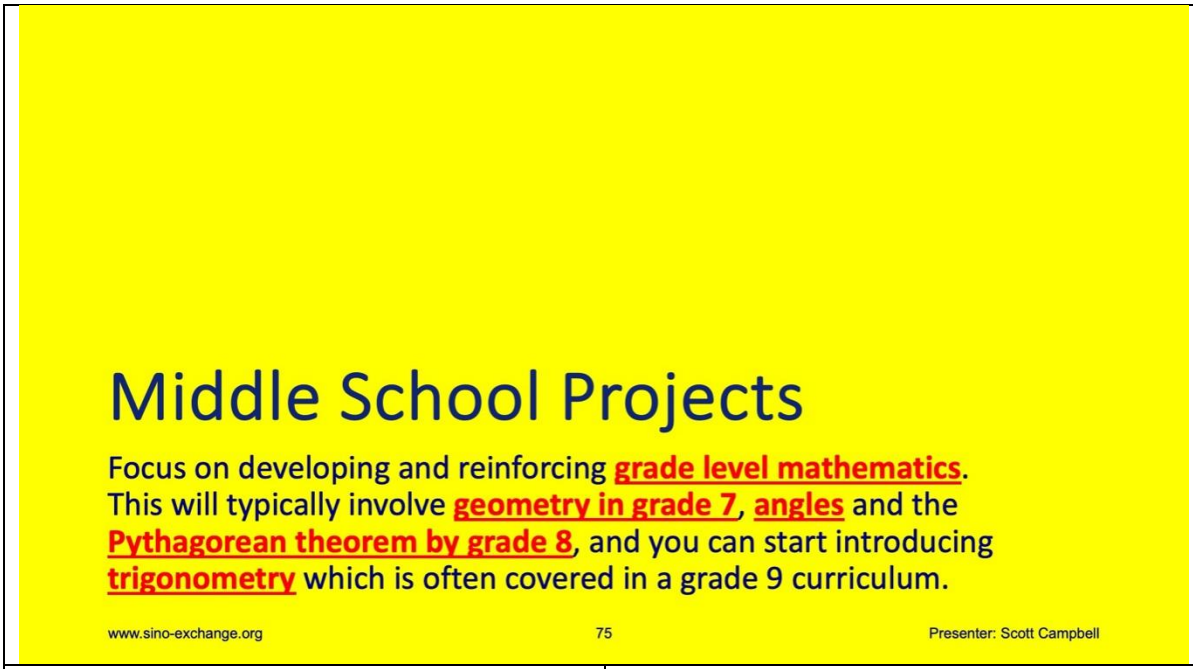
While building rockets is a lot of fun, my primary focus for teaching rocketry has nothing to do with the rocket itself. Instead, the primary focus should always be about targeting specific and relevant math skills.	虽然制造火箭很有趣，但我教授火箭学的主要重点与火箭本身无关。相反，主要关注点应该始终是针对特定和相关的数学技能。

While primary students typically won't have the math skills need for this kind of project. They are at a great age to develop an interest in rocketry, while also starting to learn how to use their hands to build a working model.	而小学生通常不具备这类项目所需的数学技能。他们正处于对火箭技术产生兴趣的大好年龄，同时也开始学习如何用手建立工作模型。

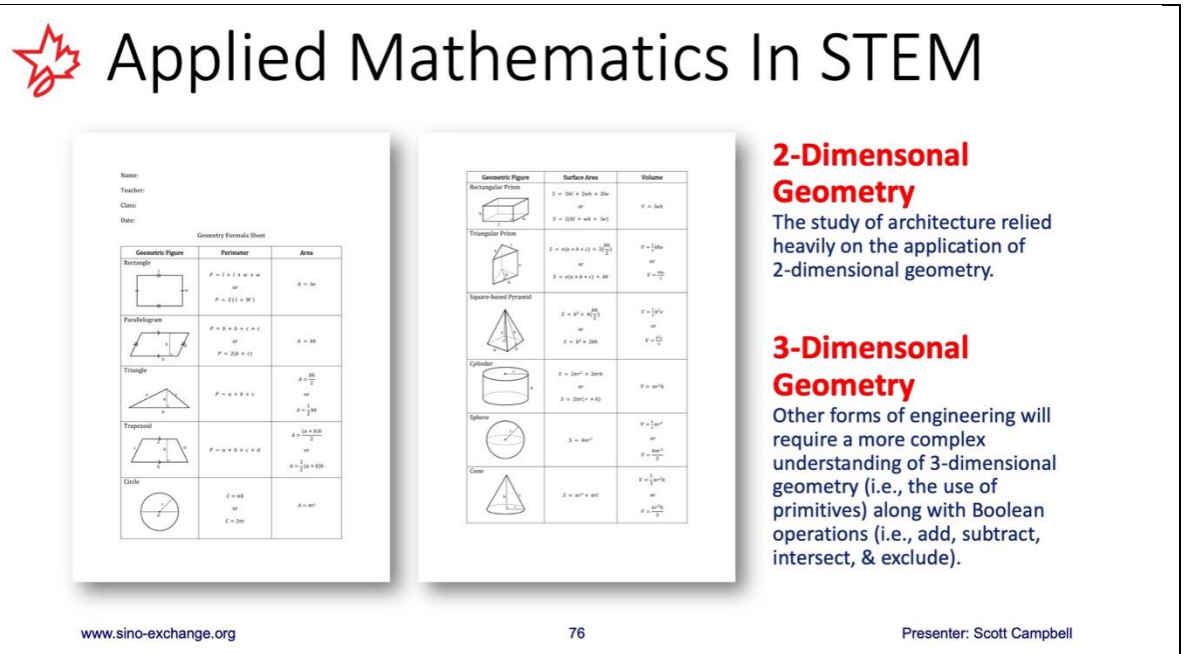


For this age group, I like to use a highly structured approach to learning and will use simple “Do It Yourself” templates. For instance, here I have a simple Clinometer that we can use to gauge the height the rocket flew, and some basic wing templates to help get the students started.	对于这个年龄段，我喜欢使用高度结构化的学习方法并将使用简单的“自己动手”模板。例如，这里我有一个简单的倾斜器，我们可以用来测量火箭飞行的高度，还有一些基本的机翼模板，可以帮助学生开始学习。

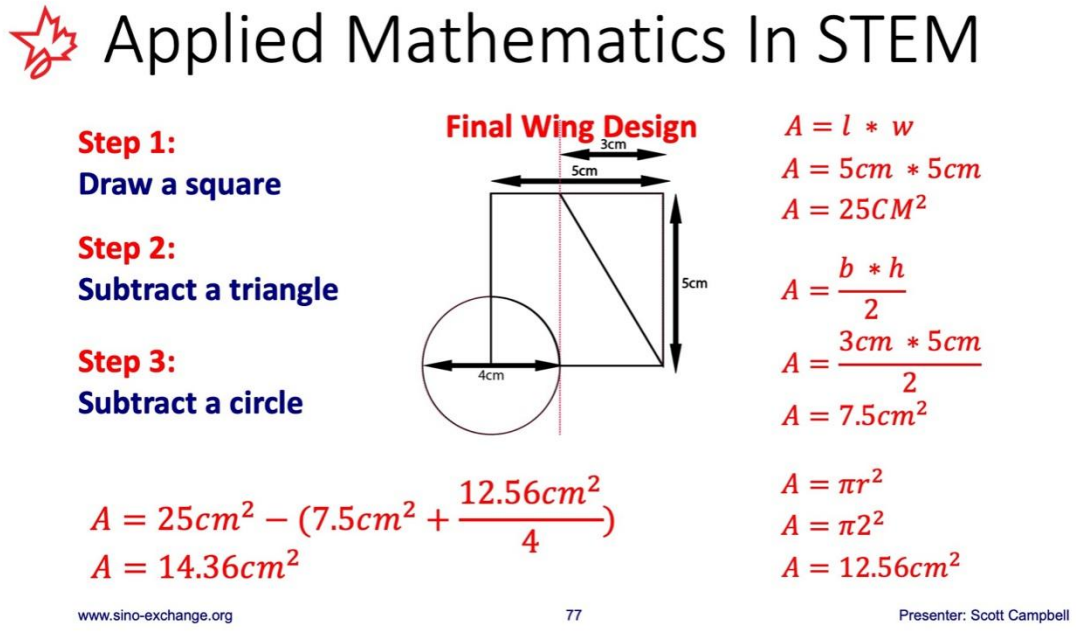
And here you can see how students at this age quickly come together, collaborate with one another, and start having lots of fun in the process.	在这里，你可以看到这个年龄段的学生是如何迅速走到一起，相互合作，并在这个过程中开始享受很多乐趣的。



However, I find that grade 7 is a prefect age group to get students exploring the mathematics of rocketry as they will have learnt, or are in the process of learning, key mathematical concepts that we can apply to the study of rocketry.	然而，我发现 7 年级是让学生探索火箭数学的最佳年龄段，因为他们已经或正在学习我们可以应用于火箭学研究的关键数学概念。



To start, I always give my students this formula sheet. It reviews the equations for the primitive shapes that the students would have learnt in most middle school curriculums. Therefore, I will reinforce the use of these equations in my STEM projects.	首先，我总是给我的学生这个公式表。它回顾了学生在大多数中学课程中会学到的原始形状的方程。因此，我将在 STEM 项目中加强这些方程的使用。



Let's start by using these equations to design a customized wing for our rocket. In engineering we always start with primitive shapes. Which are your squares, triangles, and circles. Then through a series of Boolean operations, we add and subtract those shapes to create new complex objects. In this example we will start with a perfect square.

The formula for the area of a square or rectangle is length * width. We substitute the known values, and we get 25 square centimeters. We are then going to subtract a triangle from this shape and then solve for the area of that triangle. Then we are going to subtract the partial area of this circle.

This whole process used series of Boolean operations to manipulate a series of primitive shapes, and this has allowed us to design a customized wing that we can use for our rocket.

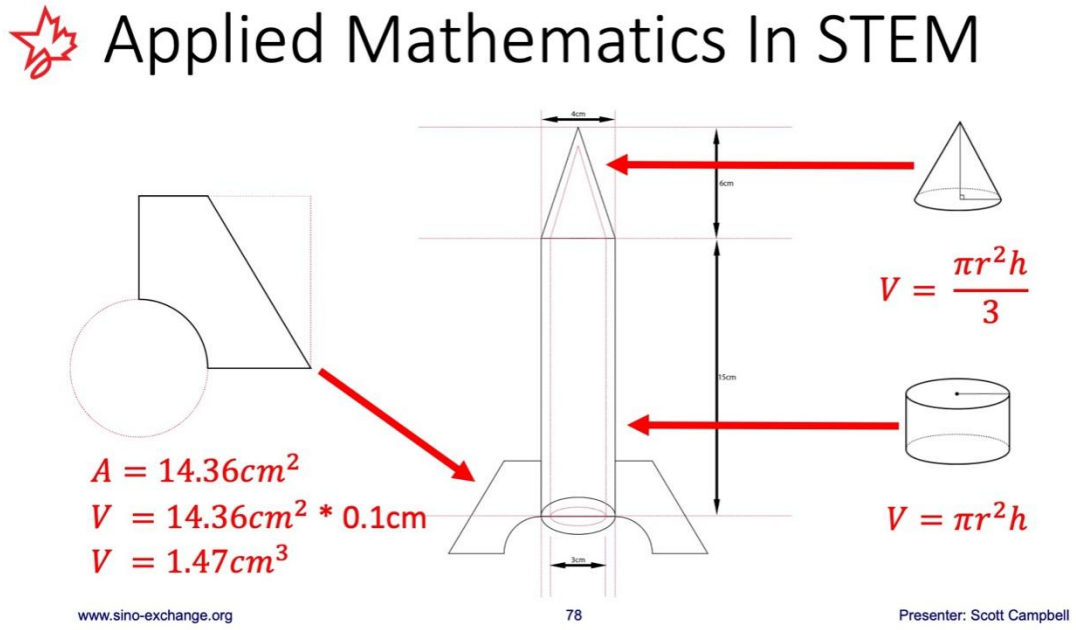
Finally, we can determine the resulting surface area of the wing by adding and subtracting our component values.

让我们从使用这些方程开始为我们的火箭设计一个定制的机翼。在工程学中，我们总是从原始形状开始。那是你的正方形、三角形和圆形。然后通过一系列布尔运算，我们添加和减去这些形状来创建新的复杂对象。在这个例子中，我们将从一个完美的正方形开始。

正方形或矩形的面积公式是长度*宽度。我们代入已知的值，得到 25 平方厘米。然后我们要从这个形状中减去一个三角形，然后求出这个三角形的面积。然后我们要减去这个圆的部分面积。

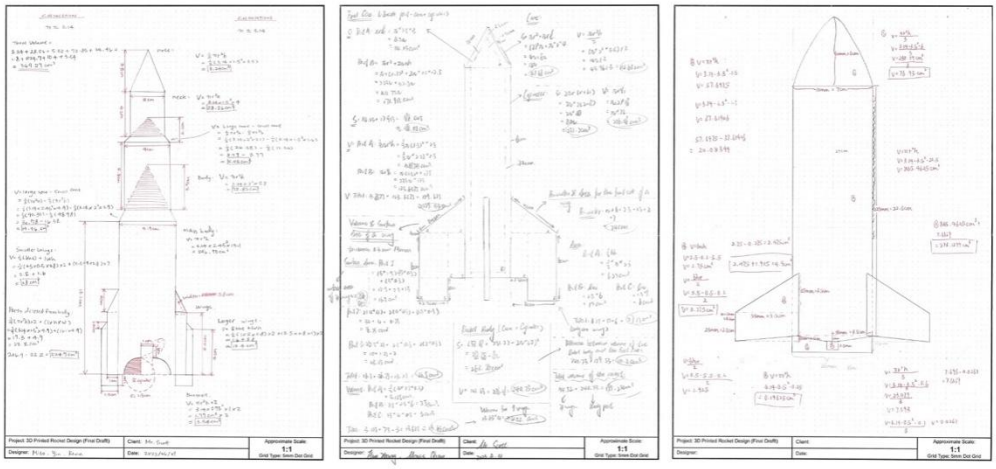
整个过程使用了一系列布尔运算来操纵一系列原始形状，这使我们能够设计出一种可以用于火箭的定制机翼。

最后，我们可以通过加减分量值来确定机翼的最终表面积。



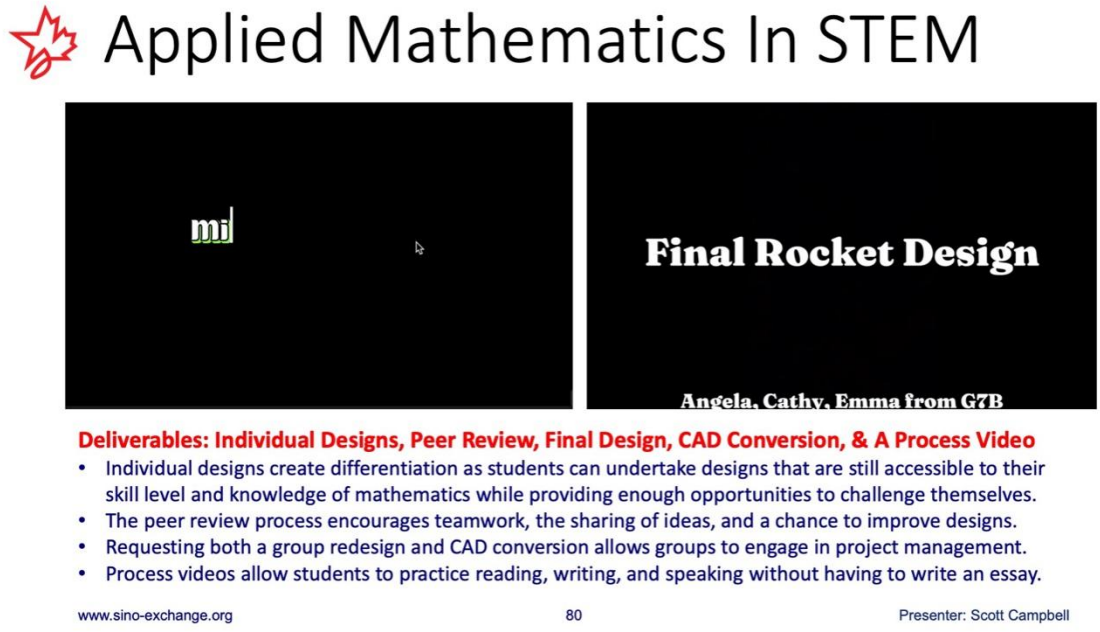
Then we can determine the volume of the entire rocket. We will need to break the rocket down into simple shapes, starting with the nose cone, and the body which is just a simple cylinder. Finally, we will need to subtract the volume of the inner fuel chamber.	然后我们可以确定整个火箭的体积。我们需要将火箭分解成简单的形状，从鼻锥和机身开始，机身只是一个简单的圆柱体。最后，我们需要减去内部燃料室的体积。

Applied Mathematics In STEM



www.sino-exchange.org 79 Presenter: Scott Campbell

After modeling your expectations with the students, have each student in the class create their own design. As the possibilities are nearly limitless, differentiation is inherently built into this kind of project. Students with advanced math skills will undertake designs that push them to their limits, while students who struggle with math will explore simpler concepts. However, this does not mean that one rocket is going to be better than others. Meanwhile, all your students will explore aspects of 3-dimensional geometry regardless of how simple or complex their designs were.	在与学生建立期望模型后，让班上的每个学生创建自己的设计。由于可能性几乎是无限的，差异化在这种项目中是固有的。具有高级数学技能的学生将进行将他们推向极限的设计，而与数学作斗争的学生将探索更简单的概念。然而，这并不意味着一枚火箭会比其他火箭更好。同时，你的所有学生都将探索三维几何的各个方面，无论他们的设计有多简单或复杂。



As for deliverables:

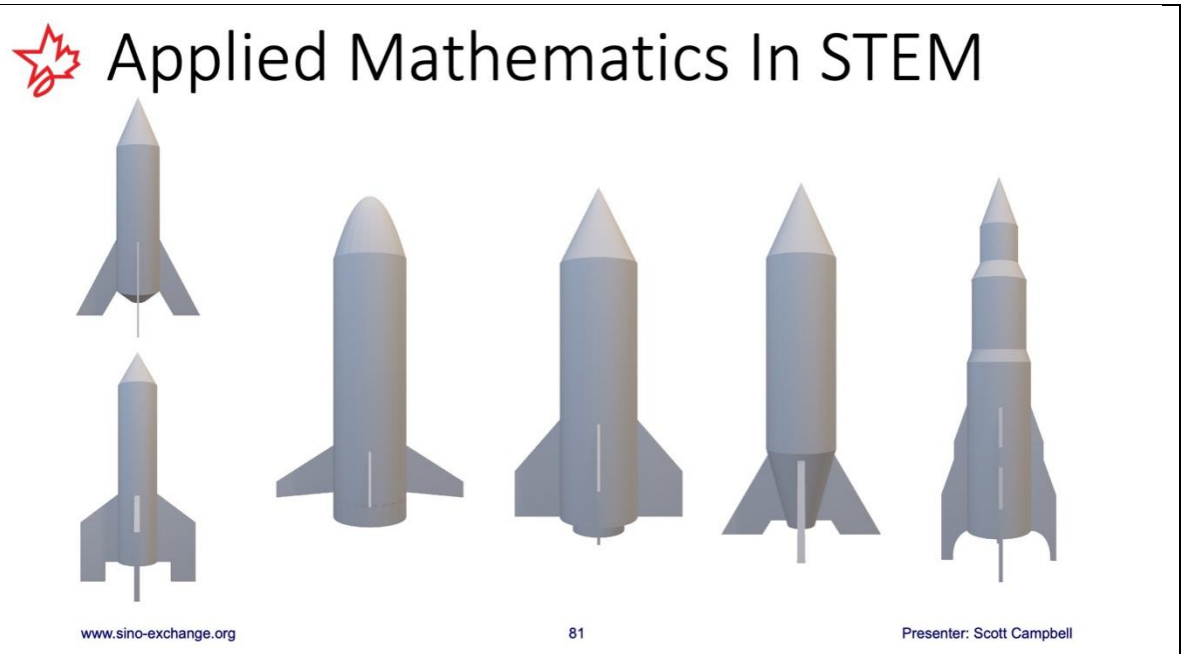
- Have each student in your class create their own original rocket design.
- Then have your students form groups and critique each other's work.
- During this process they should select best elements from design in their group
- Before creating an improved rocket design for their final project submission.
- Have students submit a revised paper design with accurate measurements and calculations,
- Along with a CAD rendering of that same rocket design.

And process videos like these can be a great way to help even your shiest students become better presenters as they can practice and rehearse what they want to say in a safe environment.

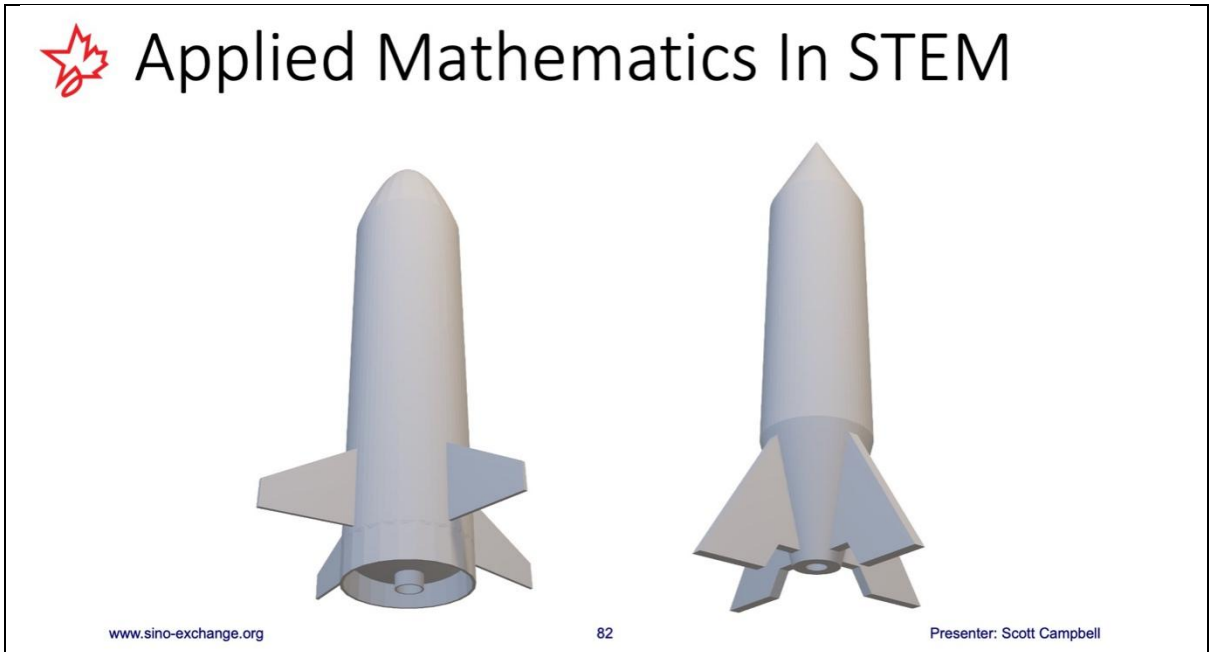
关于可交付成果：

- 让班上的每个学生创建自己的原创火箭设计。
- 然后让你的学生组成小组，互相批评对方的工作。
- 在此过程中，他们应从小组设计中选择最佳元素
- 在为最终项目提交创建改进的火箭设计之前。
- 让学生提交一份经过修订的论文设计，其中包含准确的测量和计算，
- 以及同一火箭设计的 CAD 渲染图。

处理这样的视频是一个很好的方法，可以帮助你最害羞的学生成为更好的演讲者，因为他们可以在安全的环境中练习和排练他们想说的话。

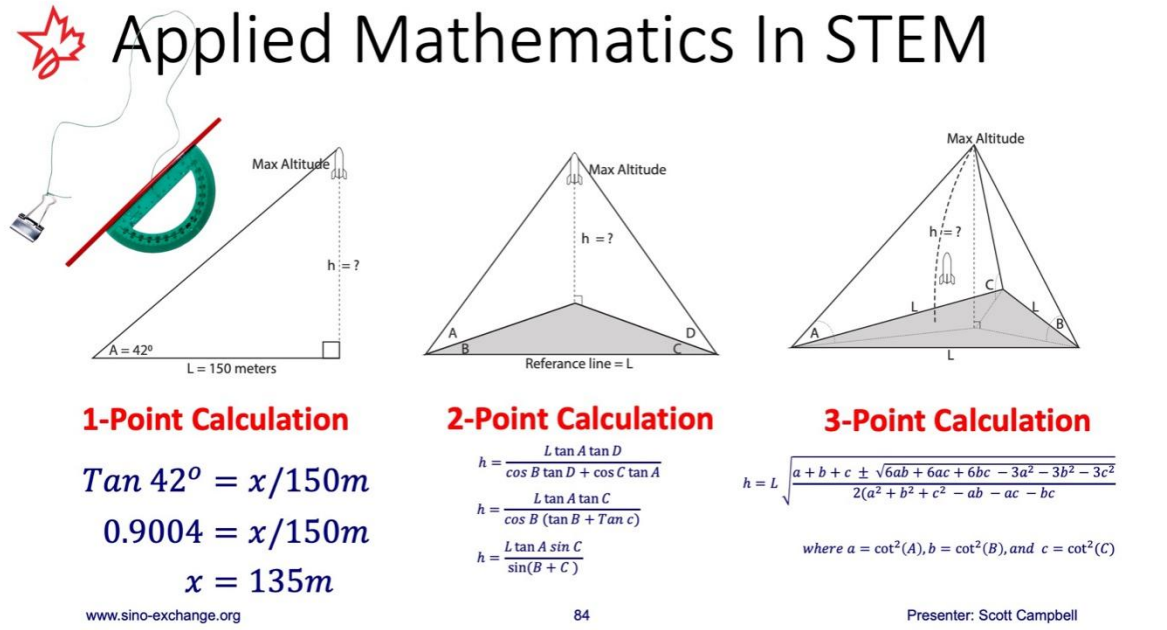


As you can see, given then same requirements, the students have produced vastly different rocket designs that they could go on and test in the real-world.	正如你所看到的，在同样的要求下，学生们制作了截然不同的火箭设计，他们可以在现实世界中进行测试。



And these 2 rocket designs performed particularly well during testing.	这两种火箭的设计在测试中表现特别好。

While I like to focus on the real-world application of geometry in middle school, I like to focus more on more advanced concepts with the older students.	虽然我喜欢在中学时关注几何在现实世界中的应用，但我更喜欢和年长的学生一起关注更先进的概念。



Even though students in elementary school have not learnt trigonometry, I will have students in primary try their best to calculate the height of their rocket, and this helps to challenge the gifted students in the class; However, I will require students in secondary school to do this as part of their projects.

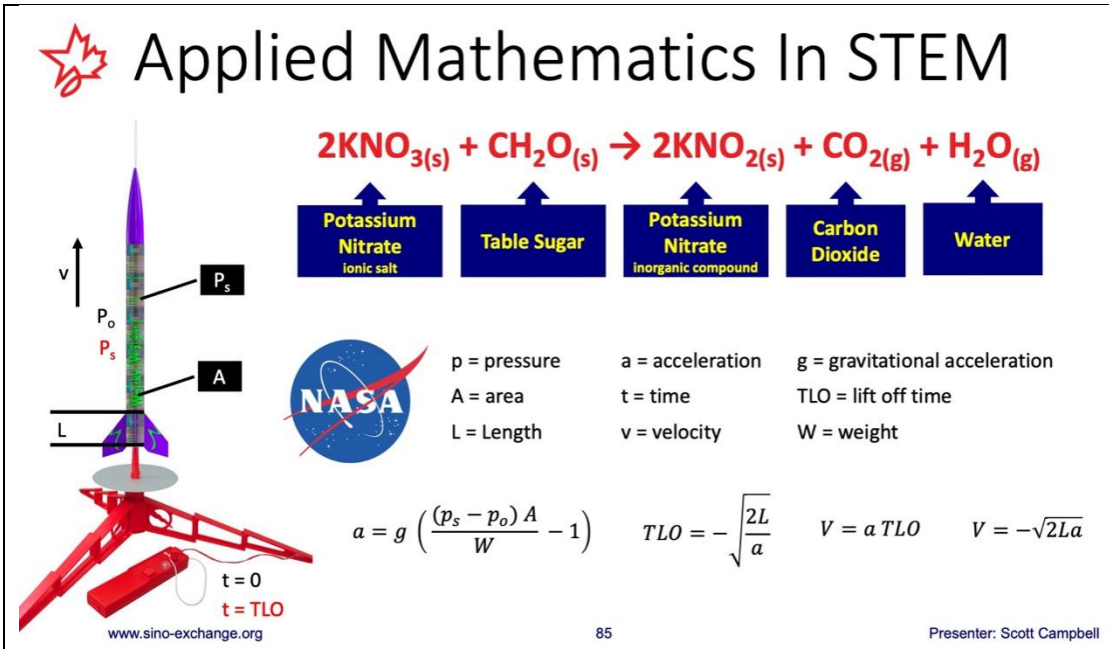
That said, 1-point calculations are not difficult to do. All you need is a homemade clinometer and trigonometry. In this example we substitute the value for “Angle A” and the “Adjacent” so that we can solve for the “Opposite” which represents the height the rocket flew.

2-Point calculations will provide even more accuracy as your rockets seldomly fly in a straight line. These are just some of the equations that you can try using, and additional methods can be found on NASA student website. And for those who are interested, this is what a 3-point calculation would look like.

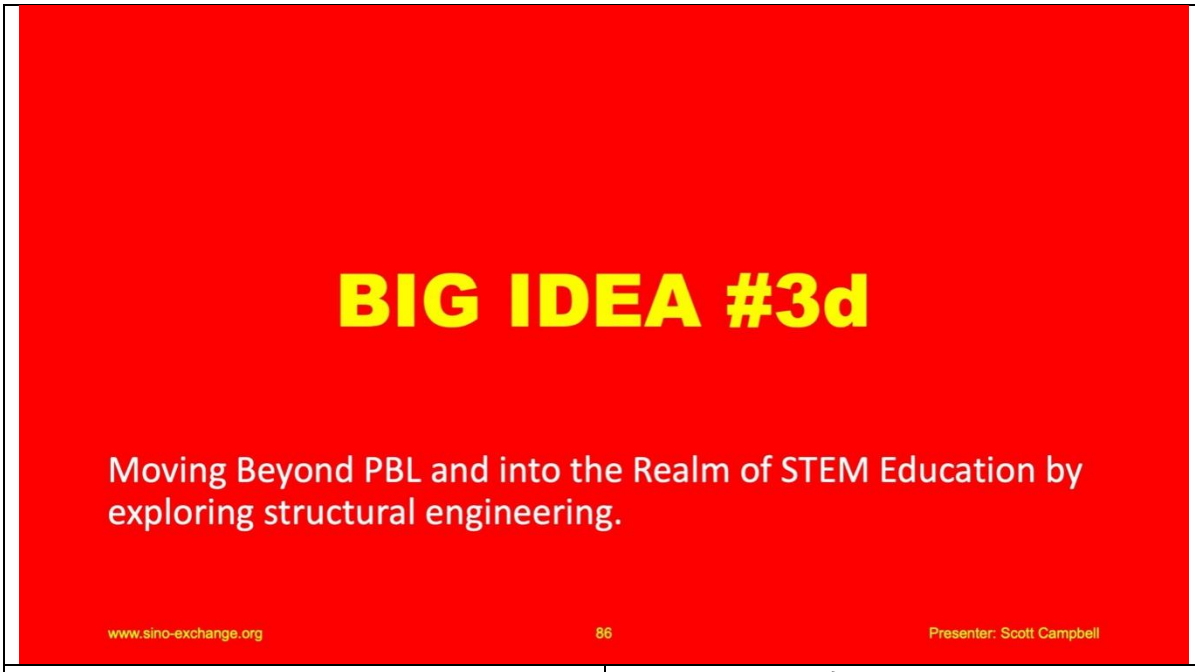
尽管小学的学生还没有学会三角，但我会让小学的学生尽力计算火箭的高度，这有助于挑战班上的天才学生；然而，我将要求中学生在他们的项目中这样做。

也就是说，一点计算并不难。你只需要一个自制的倾斜仪和三角仪。在这个例子中，我们用“角度 A”和“相邻”的值来代替，这样我们就可以求解代表火箭飞行高度的“相反”。

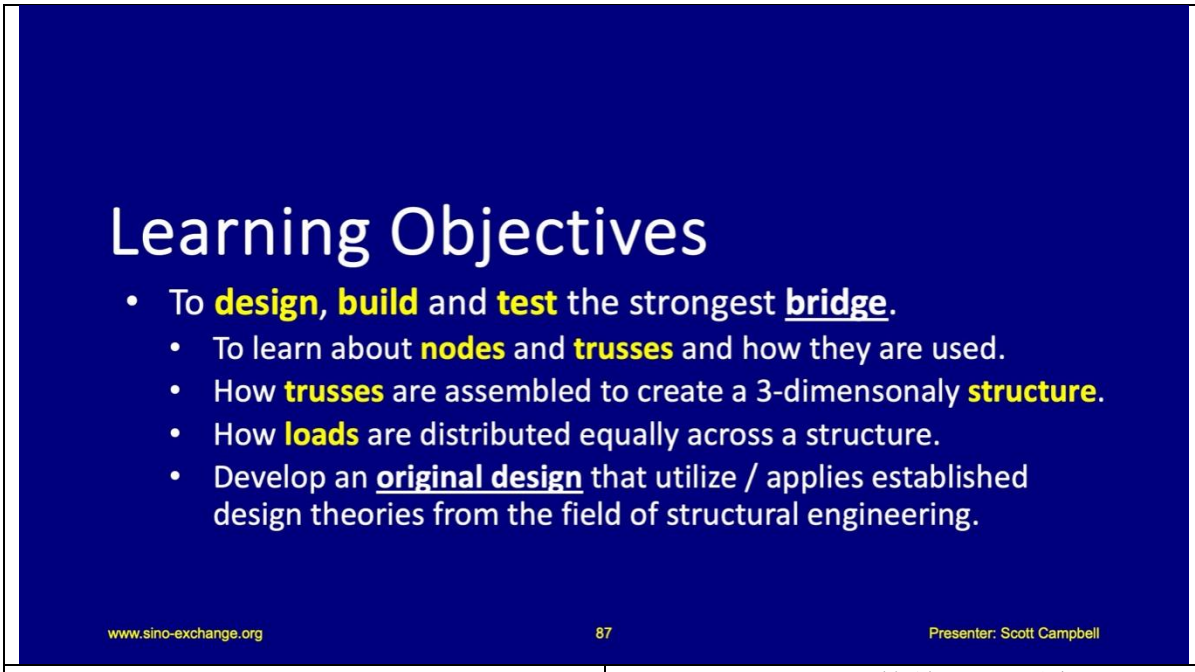
当你的火箭很少在直线上飞行时，两点计算将提供更高的精度。这些只是你可以尝试使用的一些方程，其他方法可以在 NASA 学生网站上找到。对于那些感兴趣的人来说，这就是三分球计算的样子。



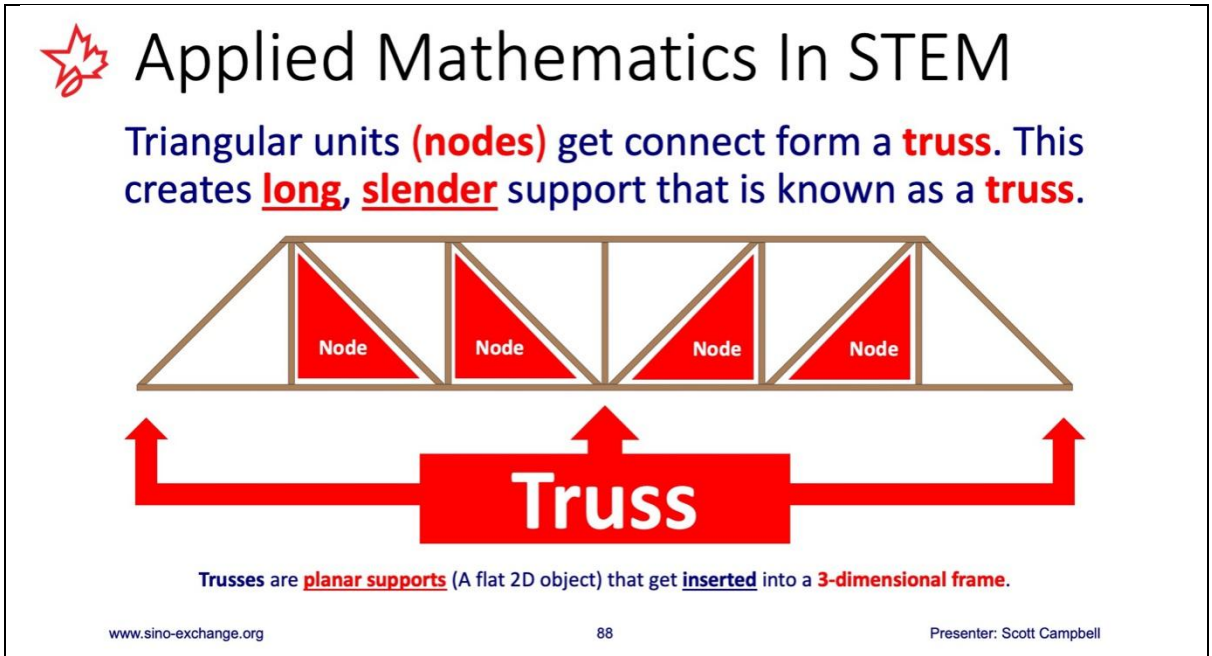
You can also explore chemical propulsion as well by creating your own rocket fuel, calculating the predicted thrust of the rocket, and comparing your predictions to data that you collect from testing your rocket in the real-world. However, I won't spend a lot of time on this concept as I have already covered during the "Applied Chemistry" workshop.	你也可以通过制造自己的火箭燃料来探索化学推进，计算火箭的预测推力，并将您的预测与您在现实世界中测试火箭时收集的数据进行比较。然而，我不会花太多时间在这个概念上，我已经在"应用化学"研讨会上介绍过了。



Much like the design of rockets, structural engineering projects provide students an excellent opportunity to explore what they are learning authentically.	就像火箭的设计一样，结构工程项目为学生提供了一个绝佳的机会，让他们真正探索自己所学的东西。

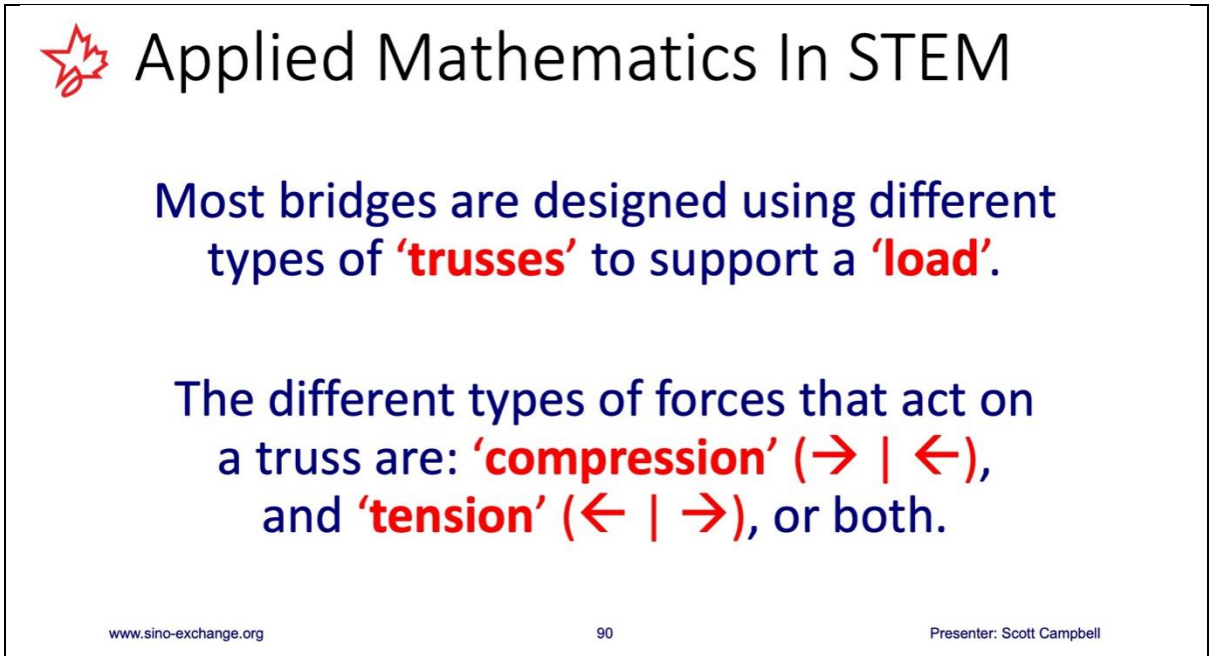


While lots of schools do simple popsicle stick bridges, we seldomly see quality connections being made with the math and science curriculums, and part of that has to do with the limitations of the chosen medium.	虽然很多学校都做简单的冰棍桥，但我们很少看到数学和科学课程之间的高质量联系，这在一定程度上与所选媒介的局限性有关。

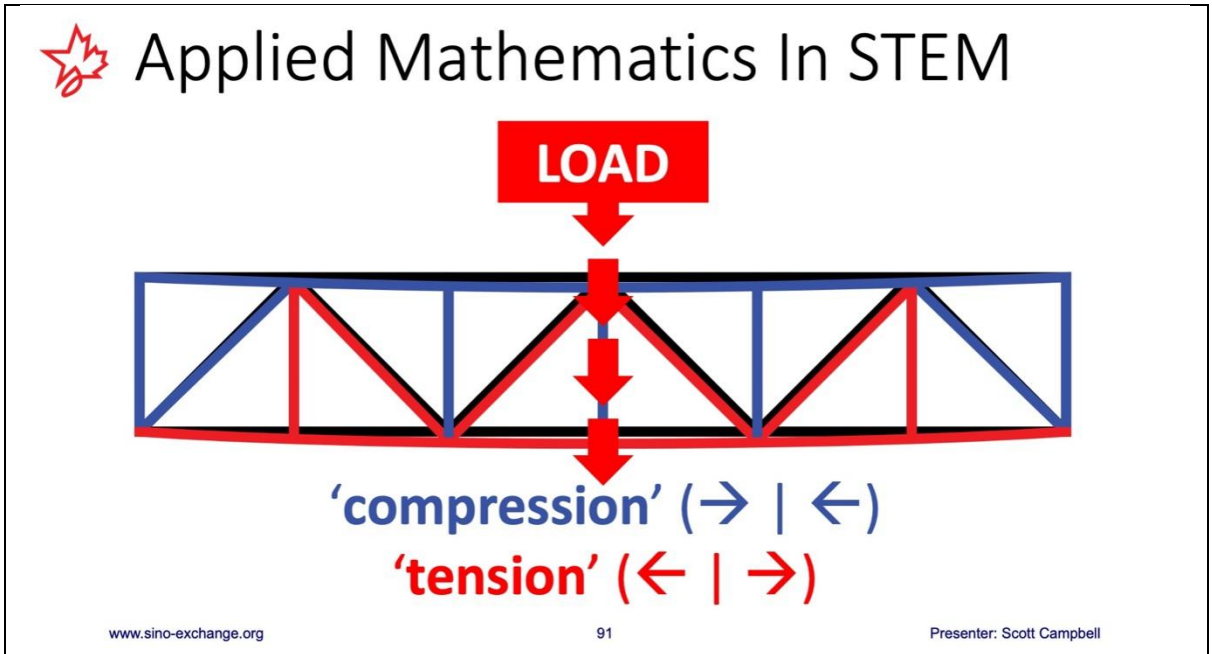


Therefore, I prefer working with pine-wood strips instead of popsicle sticks. Because at the end of the day, pine wood is more versatile, while also being cheaper, and more environmentally friendly than popsicle sticks. However, before I have students build anything, I always start by establishing meaningful connections to the curriculum. For examples, bridges are made using trusses, which are created using triangular sections that are called nodes.	因此，我更喜欢用松木条而不是冰棍。因为归根结底，松木更通用，同时也更便宜，而且比冰棍更环保。然而，在我让学生建立任何东西之前，我总是从与课程建立有意义的联系开始。 例如，桥梁是使用桁架建造的，桁架是使用称为节点的三角形截面创建的。

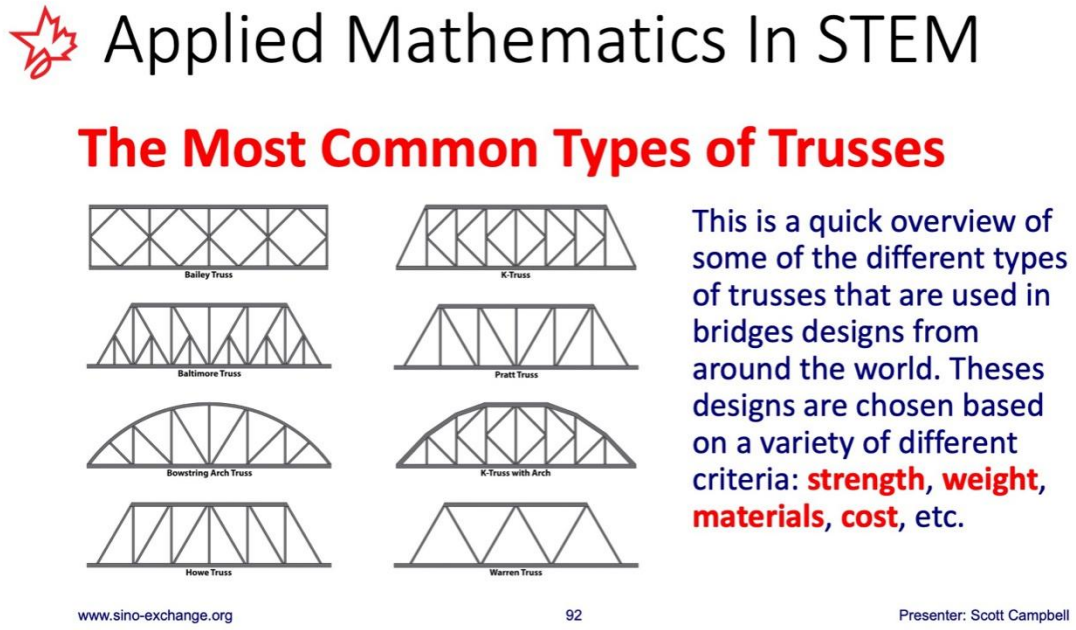
I will then have the students work in groups of 2 to create a small bridge. This simple bride concept will be based on a set of schematics that I have given them. Now the main reason for having the students build this mini bridge is to provide them with an opportunity to learn how multiple 2-dimensional trusses get assembled to create a frame or 3-dimensional structure, while also allowing them a chance to develop the tactile skills that they will need for the final project.	然后，我将让学生们以 2 人一组的方式建造一座小桥。这个简单的新娘概念将基于我给他们的一组示意图。现在，让学生们建造这座迷你桥的主要原因是为他们提供一个学习如何组装多个二维桁架以创建框架或三维结构的机会，同时也让他们有机会发展最终项目所需的触觉技能。



After that we can slowly introduce new ideas and concepts. Specifically, how loads and the force of gravity affect structures such as a bridge.	之后，我们可以慢慢引入新的想法和概念。具体而言，荷载和重力如何影响桥梁等结构。



In this example we can see what a simple truss looks like. Then if we apply a load, we can start identifying how different stress factors affect certain parts of the bridge. We can then use this information to make informed decisions when designing our own bridges.	在这个例子中，我们可以看到一个简单的特拉斯是什么样子。然后，如果我们施加荷载，我们可以开始识别不同的应力因素如何影响桥梁的某些部分。然后，我们可以在设计自己的桥梁时，利用这些信息做出明智的决定。

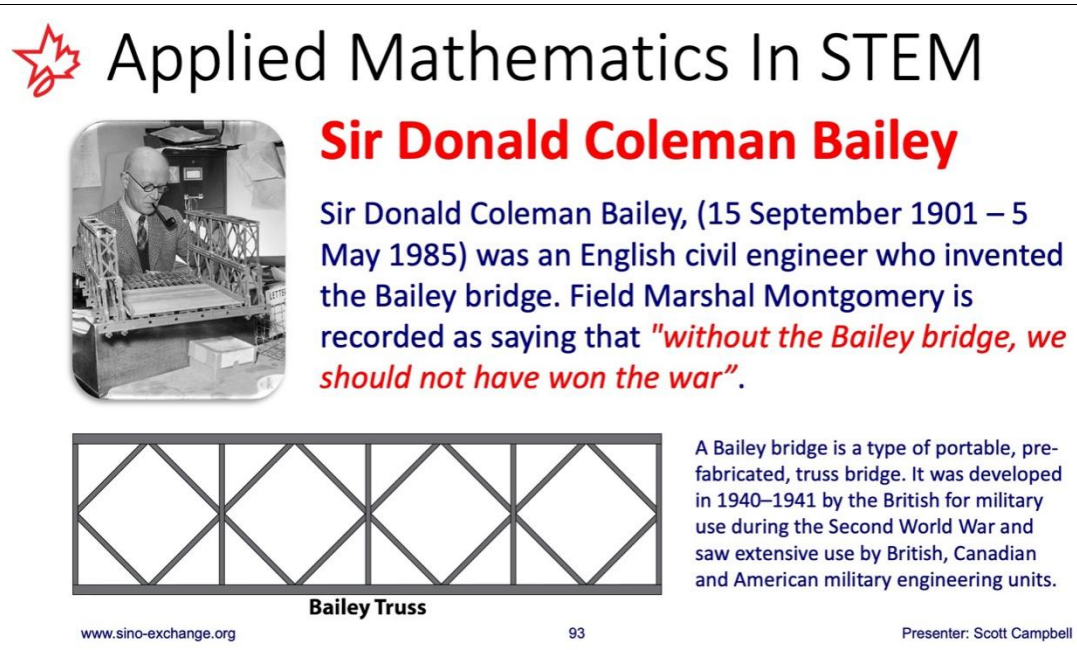


From there we can introduce students to a wide range of different truss designs. These design concepts will spark the student's interest and promote the idea of ask questions.

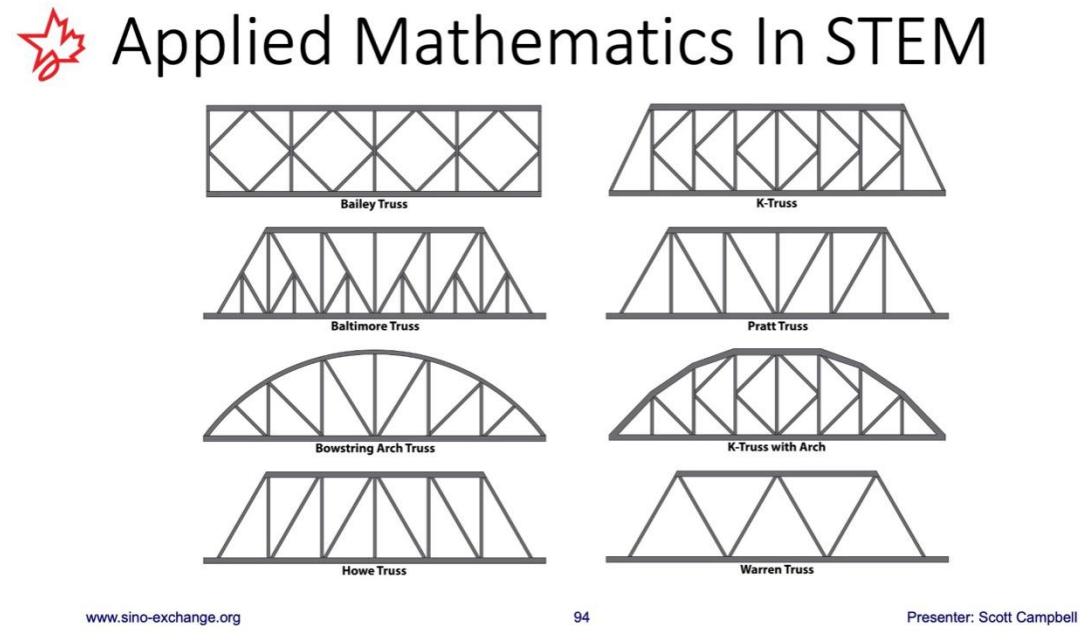
- What bridge design will be the strongest?
- Why do I believe this to be true?
- What evidence can I provide to support my hypothesis?
- How would I go about testing my idea?
- And, could I combine different ideas to make an even stronger bridge design?

在那里，我们可以向学生介绍各种不同的特拉斯设计。这些设计理念将激发学生的兴趣，并促进提问的想法。

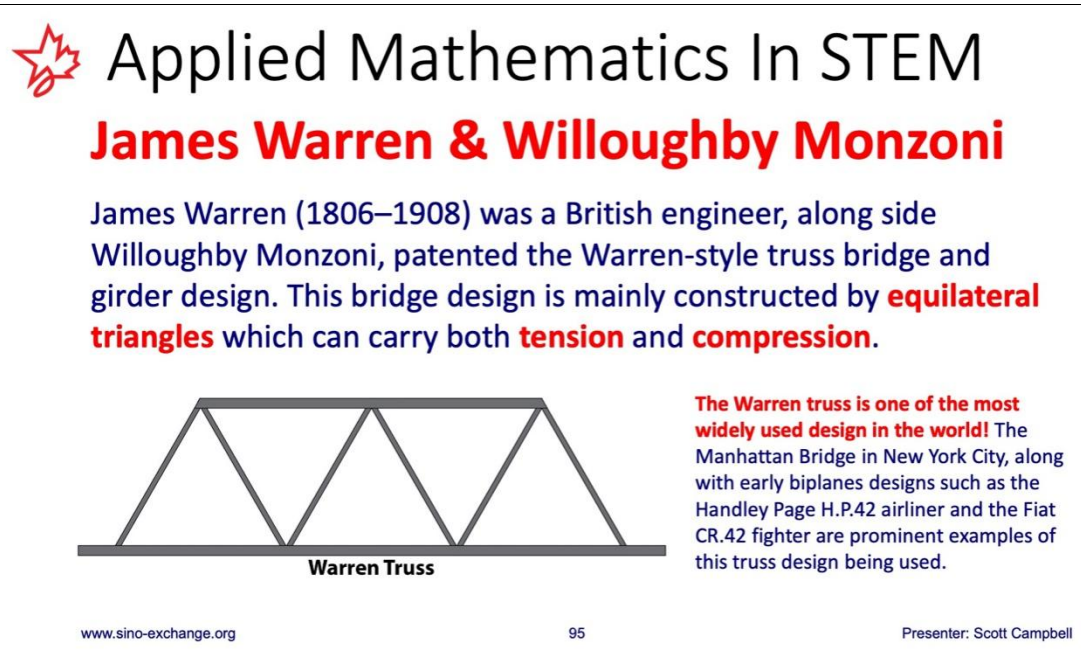
- 哪种桥梁设计最坚固？
- 为什么我相信这是真的？
- 我可以提供什么证据来支持我的假设？
- 我将如何测试我的想法？
- 我能把不同的想法结合起来，做出更坚固的桥梁设计吗？



Afterall, each design has its own unique advantages. For instance, the strong modular design of the Bailey truss was influential in supporting allied troop movements during World War 2.	毕竟，每种设计都有其独特的优势。例如，特拉斯的强大模块化设计在第二次世界大战期间对支持盟军部队的调动产生了影响。

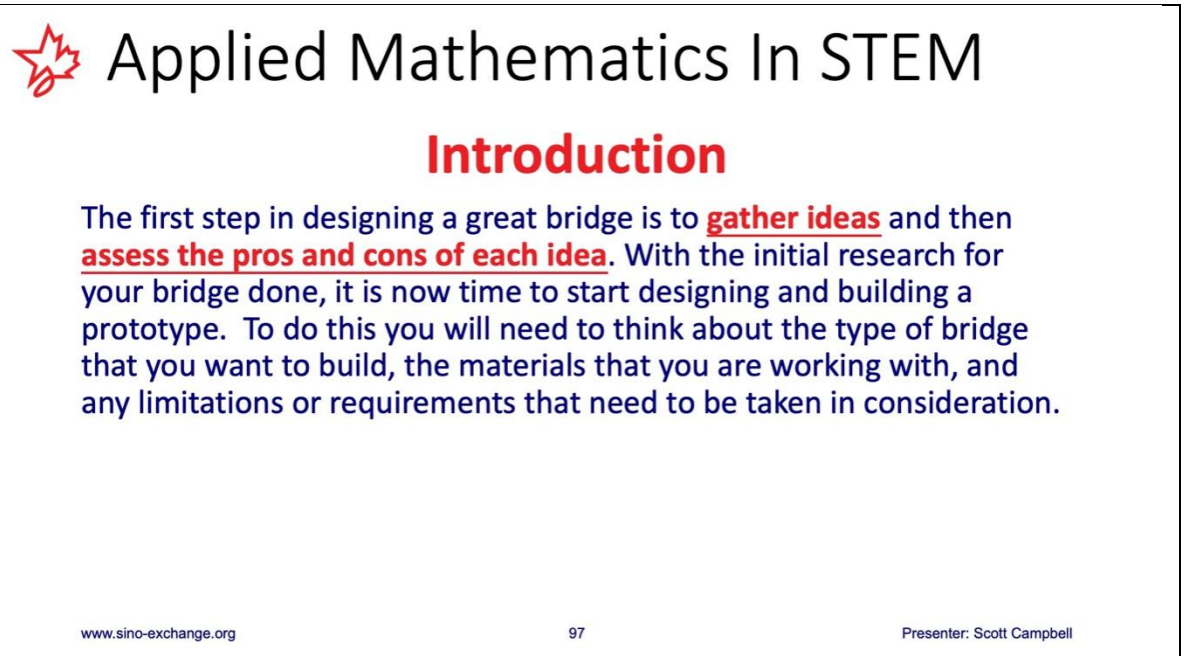


While I don't have time to go through the history and structural benefits of each design, I will jump ahead to the end of the list.	虽然我没有时间回顾每种设计的历史和结构优势，但我会跳到列表的末尾。

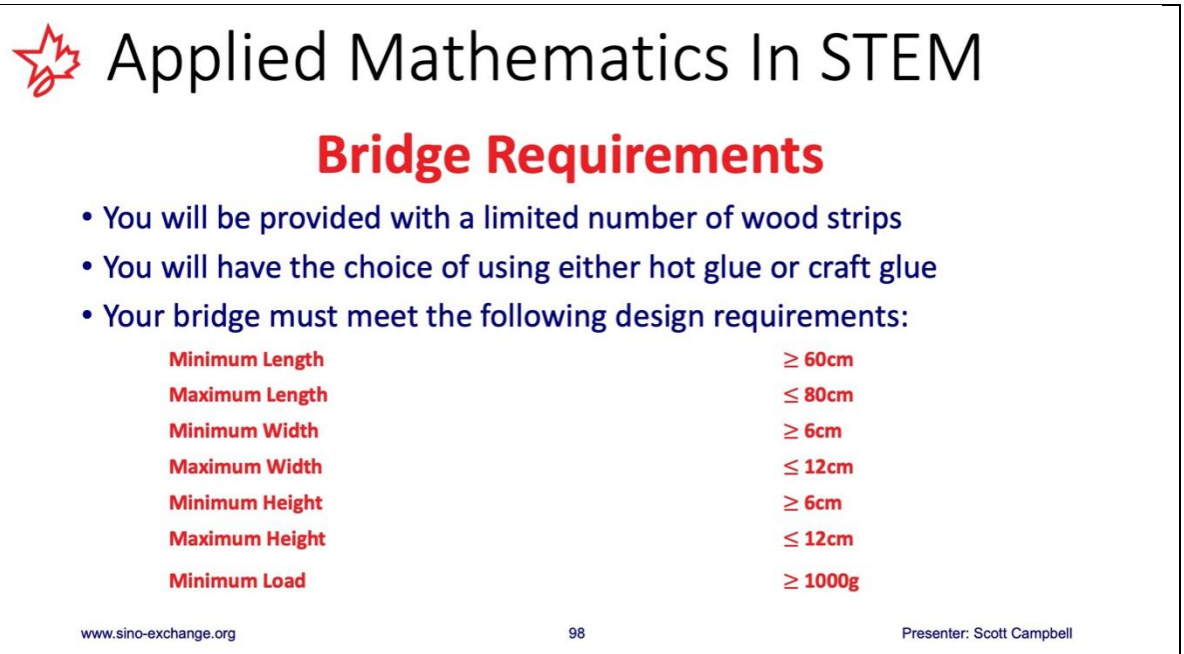


Because the Warren truss is one of the world's most widely used truss designs! It can be found in the designs of bridges, airplanes, cranes, and the roofs of most large open commercial structures such as your school gymnasium.	因为特拉斯是世界上使用最广泛的特拉斯设计之一！它可以在桥梁、飞机、起重机的设计中找到，也可以在大多数大型开放式商业结构的屋顶上找到，比如你学校的体育馆。

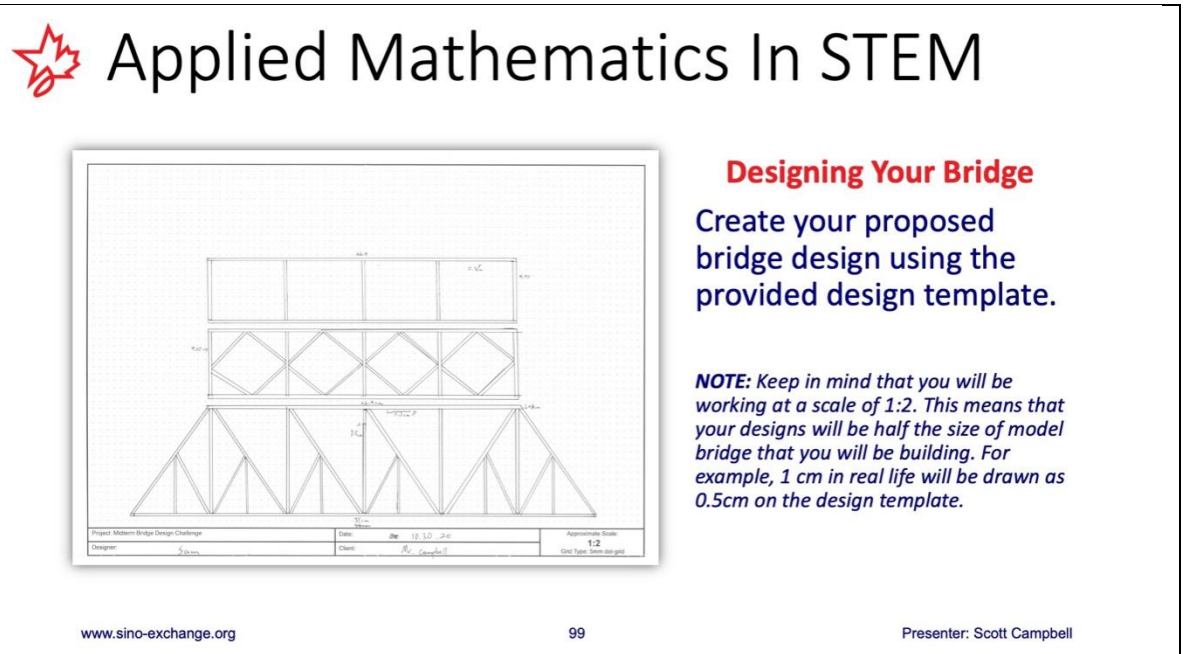
Now that we have developed some relevant background knowledge, our students will now be ready to make informed decisions when creating their own bridge designs. In this regard, they are not copying existing designs, instead, they are benefiting from understanding our historical advancements in bridge designs, so that they can take the next evolutionary step by creating new and innovative designs for the future! And that reminds me of another quote by Confucius, “Knowledge without practice is useless. Practice without knowledge is dangerous.”	既然我们已经掌握了一些相关的背景知识，我们的学生现在将准备好在创建自己的桥梁设计时做出明智的决定。在这方面，他们并不是在复制现有的设计，相反，他们受益于了解我们在桥梁设计方面的历史进步，以便他们能够通过为未来创造新的创新设计来迈出下一步！ 这让我想起了孔子的另一句名言：“知而不践，行而不知，险也。”



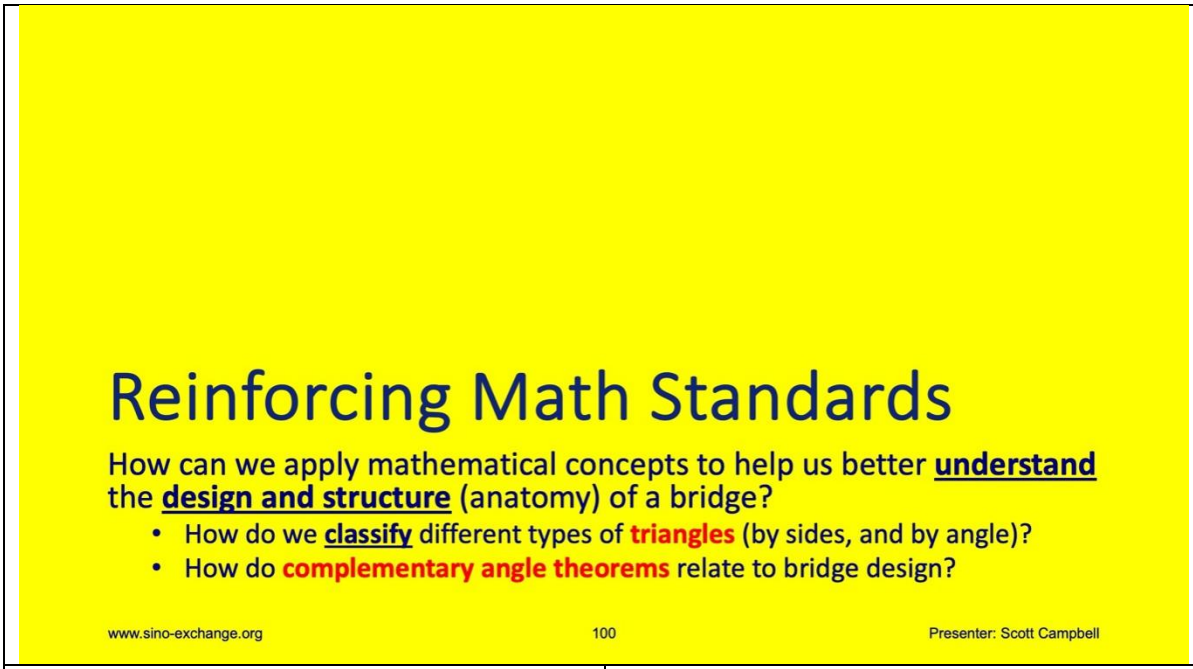
Therefore, now that we have given the students some ideas, it's up to them to start evaluating the pros and cons of different design approaches and strategies.	因此，既然我们已经给了学生一些想法，就由他们开始评估不同设计方法和策略的利弊。



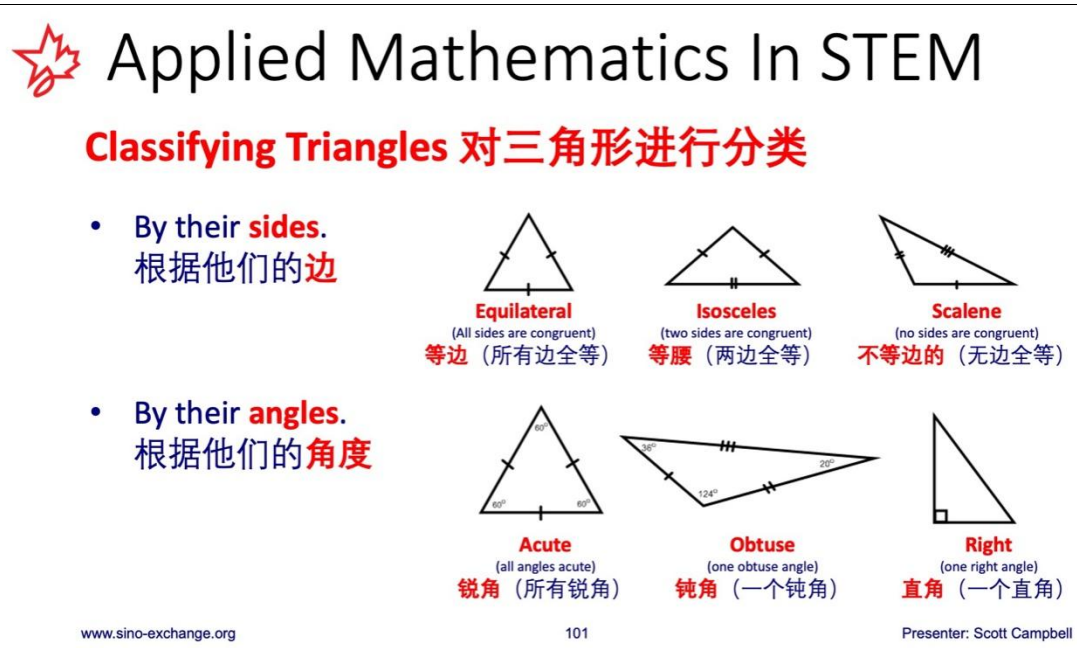
You will also want to establish reasonable limits for the students to work within. For instance, if the students were to design a Warren Truss they would only be working with equilateral triangles. If they made the length of each side 12cm they could build a bridge that is 72 cm long. With this simple calculation they have ensured that their project is within the stated limits, while also ensuring that their design will have easy to measure segments. However, other designs will require different calculations to optimize the design of the bridge based on the stated limitations.	你还需要为学生的工作设定合理的限制。 例如，如果学生要设计一个 Warren 特拉斯，他们将只使用正三角形。如果他们把每边的长度做成 12 厘米，他们就可以建造一座 72 厘米长的桥。通过这种简单的计算，他们确保了他们的项目在规定的限制范围内，同时也确保了他们设计的线段易于测量。然而，其他设计将需要不同的计算，以根据所述限制优化桥梁设计。



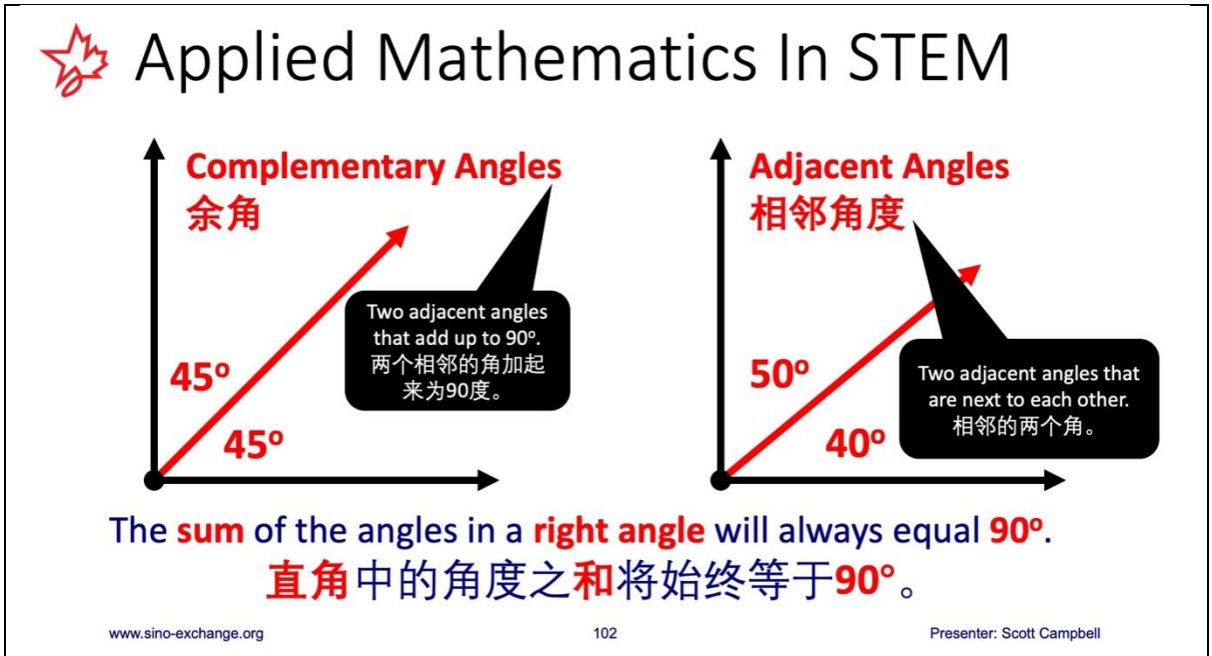
For instance, this combination of a Baltimore Bridge with a Baily Truss cross section would require more calculations than a bridge using a simple Warren truss design. Again, we can see how the students begin differentiation the projects for themselves. Therefore, differentiation doesn't need to be overly complicated or time consuming if you plan your projects accordingly.	例如，巴尔的摩大桥与 Baily 特拉斯横截面的组合将比使用简单的 Warren 特拉斯设计的桥梁需要更多的运算。再次，我们可以看到学生们是如何开始区分自己的项目的。因此，如果你相应地计划您的项目，区分并不需要过于复杂或耗时。



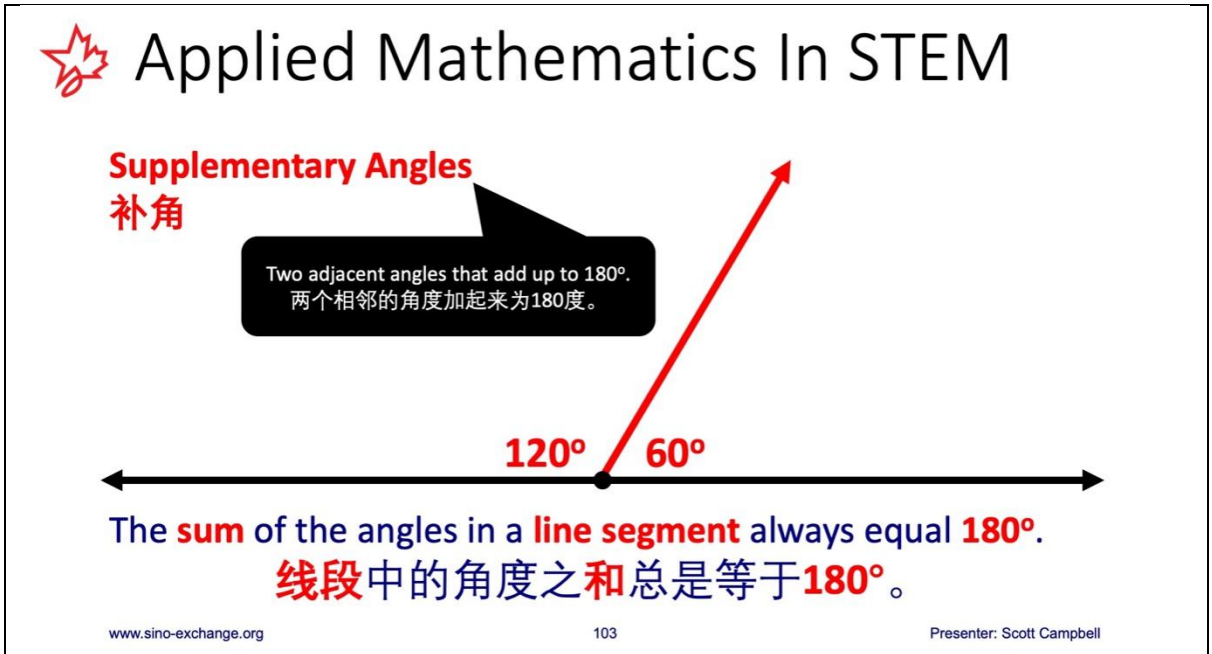
Much like all the other projects that I do, the project itself is just a way for me to reinforce mathematical concepts through an authentic, real-world learning activity. Therefore, I usually teach bridges in grade 8 because they are typically learning about complementary angle theorems at this age.	就像我做的所有其他项目一样，这个项目本身只是我通过真实的、真实的学习活动来强化数学概念的一种方式。因此，我通常在八年级教桥牌，因为他们在这个年龄段通常都在学习补角定理。



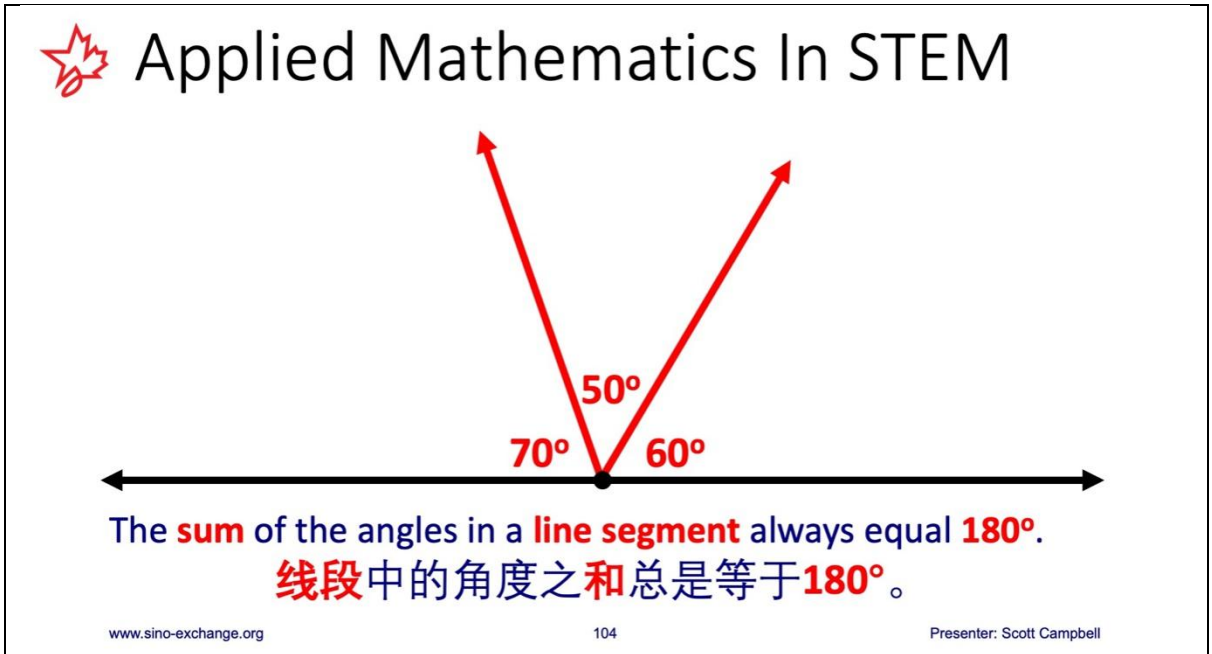
As the students are working on their bridge designs, I have them consider how they would classify the nodes in their designs. For instance, we could classify triangles by their sides: Equilateral, Isosceles, and Scalene. Or we can classify them by their angles: Acute, Obtuse and Right angles.	当学生们正在进行桥梁设计时，我让他们考虑如何在设计中对节点进行分类。例如，我们可以根据三角形的边对其进行分类：等边、等腰和角尺。或者我们可以根据它们的角度对它们进行分类：锐角、钝角和直角。



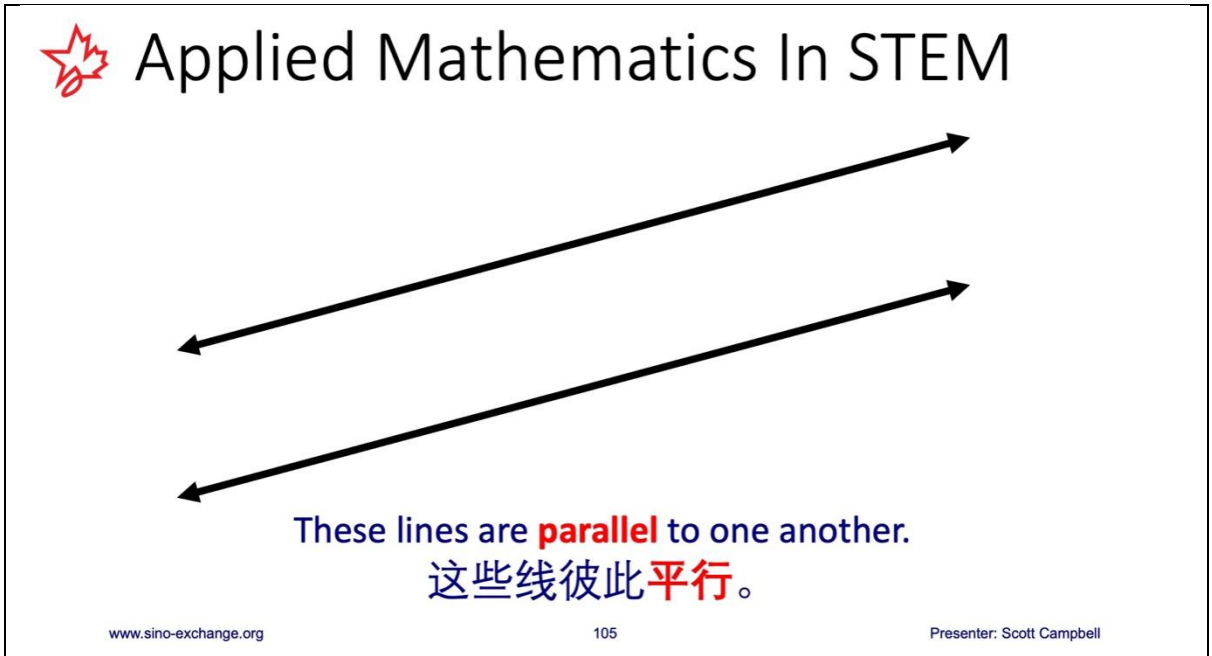
We can reinforce key concepts such as complementary and adjacent angles.	我们可以强化诸如互补和相邻角度等关键概念。



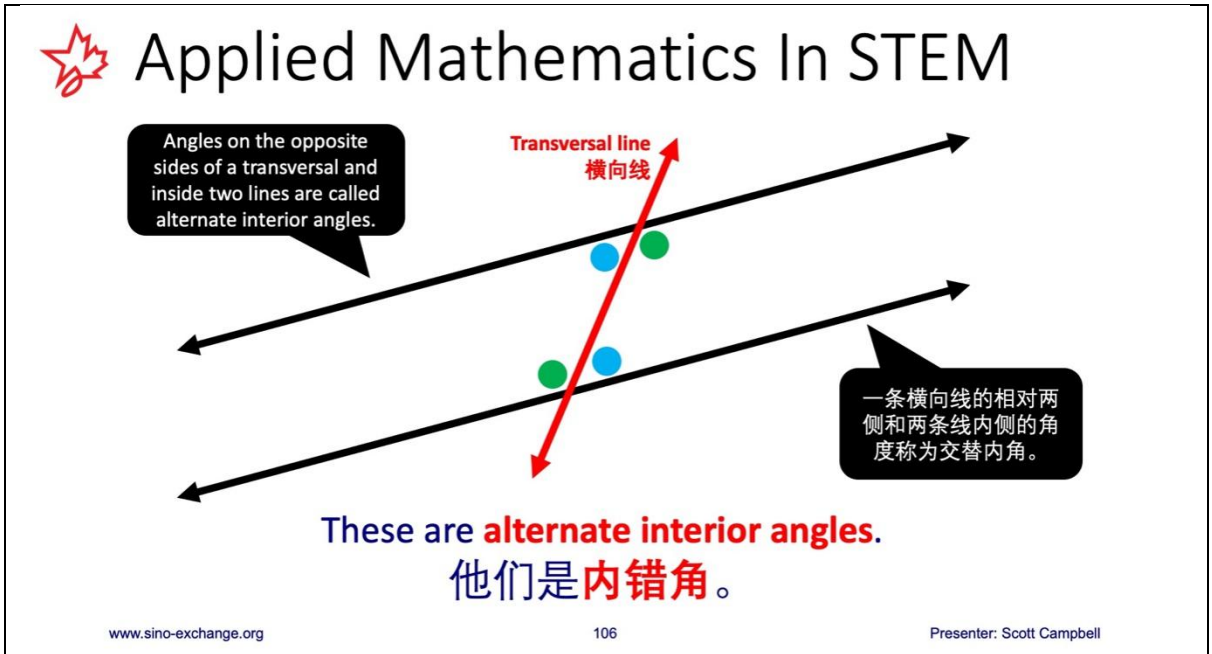
As well as Supplementary angles.	以及补充角度。



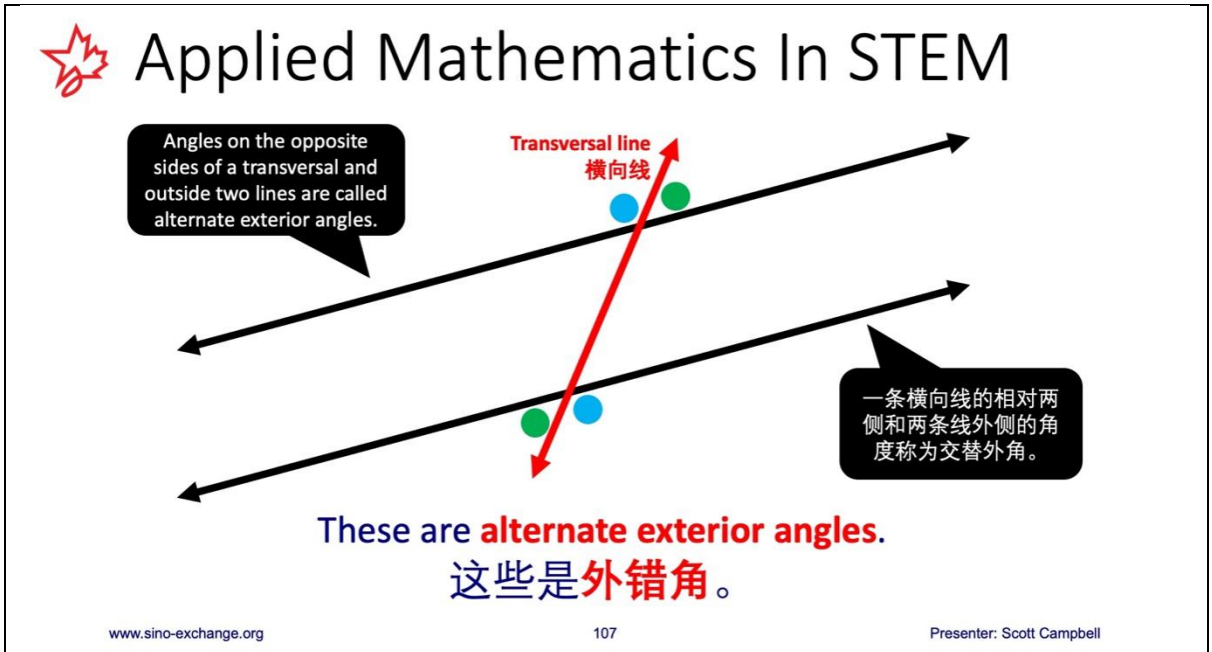
We can review concepts such as the sum of a line segment. For instance, the missing angle in this example was 50 degrees.	我们可以回顾一些概念，例如线段的和。例如，本例中缺失的角度为 50 度。



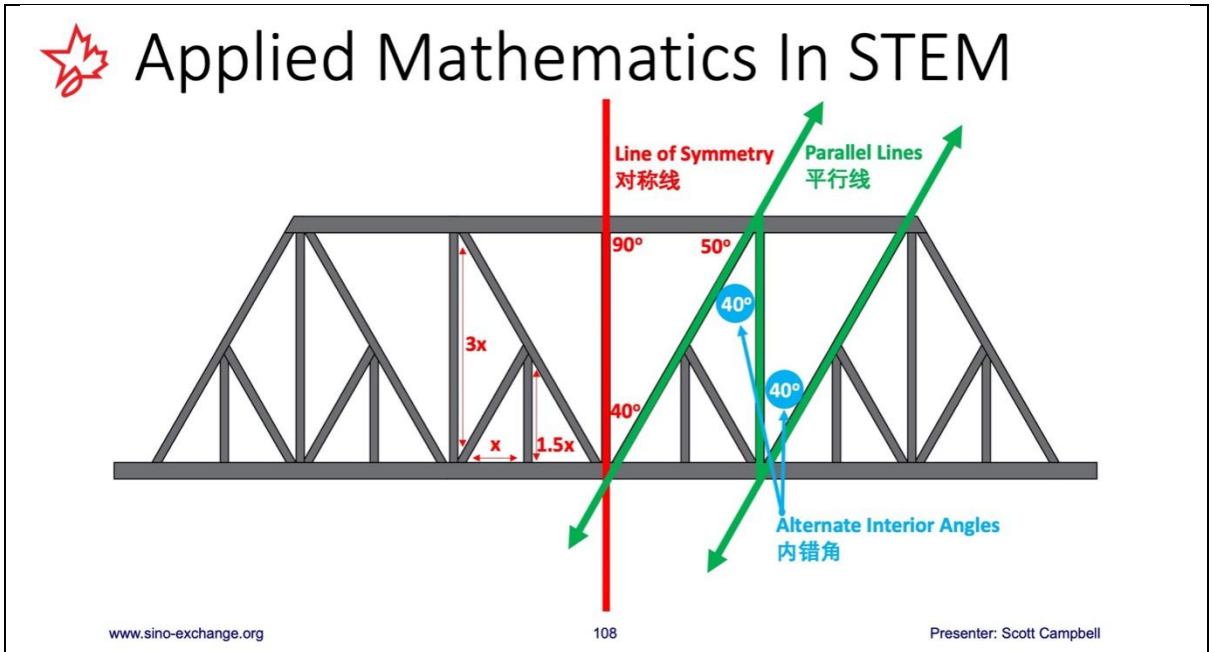
And parallel lines as well.	还有平行线。



Then we can discuss how transversal lines can intersect with parallel lines, which results in alternate interior angle pairings.	然后我们可以讨论横向线如何与平行线相交，从而产生交替的内角配对。



And alternate exterior angle pairings.	以及交替的外角配对。



However, the main reason why we want to review these math concepts is to have the students apply what they are learning to the designs of their bridges. And as you can see in this example, bridges are a great way to apply these concepts in an authentic real-world environment.	然而，我们想要复习这些数学概念的主要原因是让学生将他们所学的应用到桥梁的设计中。正如你在这个例子中看到的，桥接是在真实的现实世界环境中应用这些概念的好方法。

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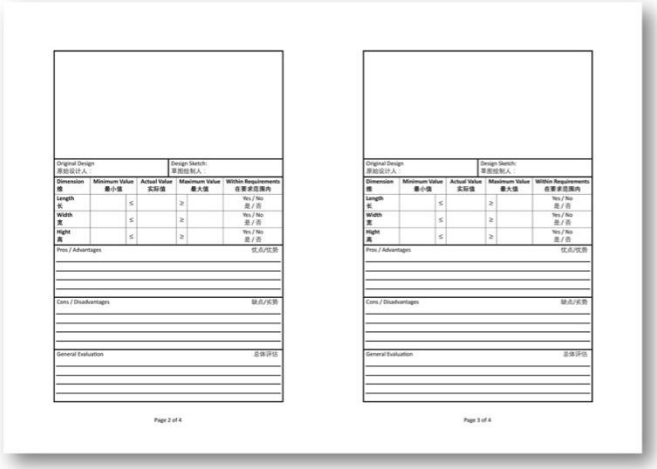

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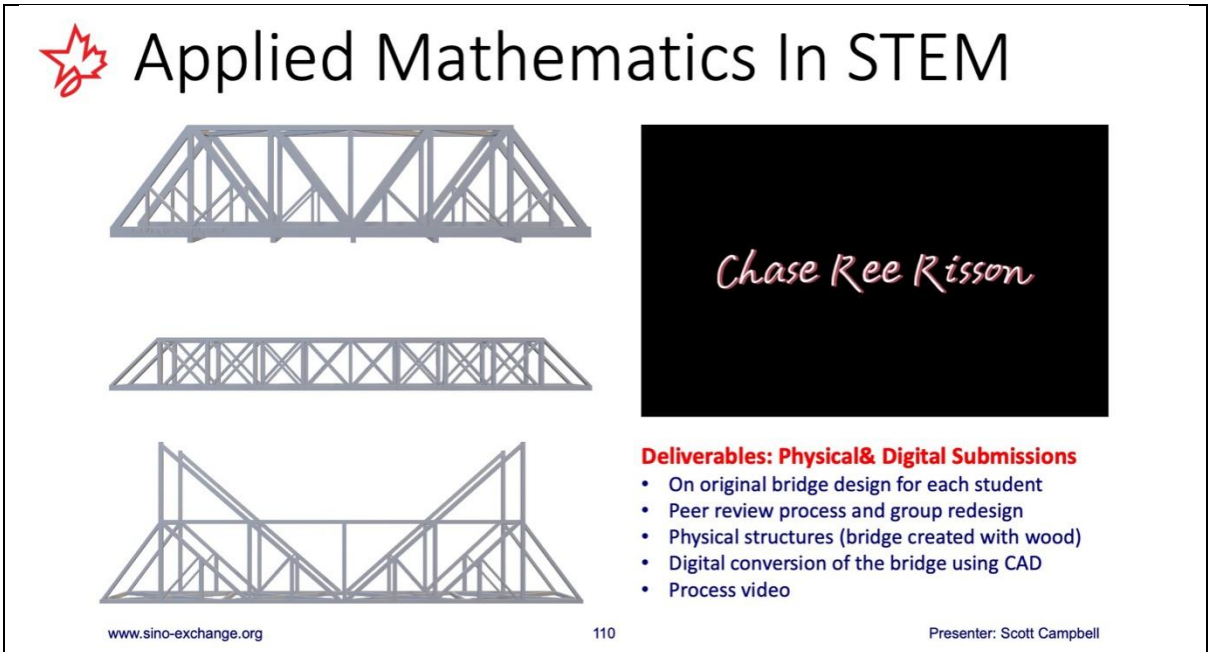
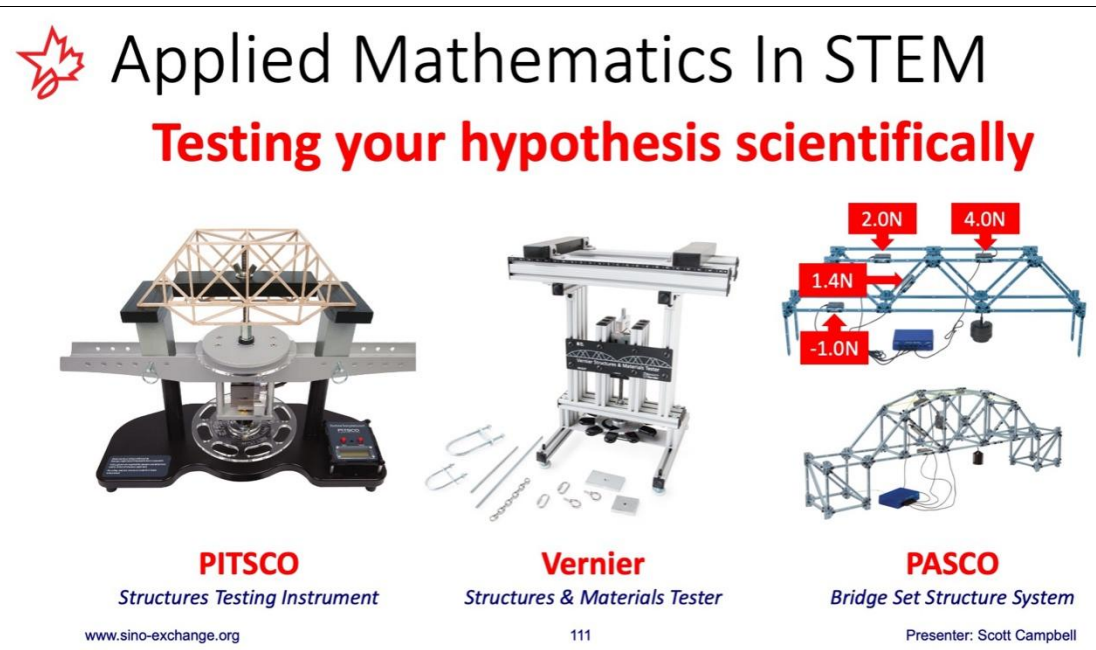
After completing individual designs, I then have students critique their partners' work. I then introduce a twist… which is the process of "talent scouting or poaching", I introduce this twist mid-project for a few reasons. It allows groups to disband and reformulate if they were not working well together, and it also allows students to explore the strategic and ethical aspects of trying to recruit or steal the best talent in the class, which is something that happens in the real-world. However, it also makes the project more sustainable. As the group sizes increase from 2 to 3 members, the number of full-sized bridges that are being made has been reduced. This reduces the material cost that is associated with the project. It also reducing the number of resources that are consumed and wasted in the process, which lowers the overall environmental impact of doing the project.	在完成个人设计后，我会让学生对他们合作伙伴的作品进行评论。然后我介绍一个转折点…这是"人才搜寻或挖角"的过程，我在项目中期介绍这个转折点有几个原因。它允许团队在合作不好的情况下解散和重组，还允许学生探索招募或窃取班上最优秀人才的战略和道德方面，这是现实世界中发生的事情。然而，这也使该项目更加可持续。 随着团队规模从 2 个成员增加到 3 个成员，正在制作的全尺寸桥接器的数量已经减少。这降低了与项目相关的材料成本。它还减少了在这个过程中消耗和浪费的资源数量，从而降低了执行项目对环境的总体影响。



Finally, after designing and building a physical prototype, I then have each group digitize their designs and making a process video to showcase their work.	最后，在设计和构建了一个物理原型后，我让每个小组将他们的设计数字化，并制作一个过程视频来展示他们的工作。



As for testing your bridges there are a few ways to do it.

You can always suspend pail from the center of the bridge and slowly fill it with sand until you hear a crack; However, if you want a more scientific approach to texting your bridges you could use these structure testers from either PITSCO or Vernier.

While these testers are great for the types of bridges that I have just shown you, the structure set from PASCO is a little bit different. It focuses less on the "Engineering & Design Process" and more on exploring more advanced mathematical concepts. Using this kit students can rapid porotype different truss designs. Then using different sensors your students can determine cross products of the different stress factors throughout the entire structure.

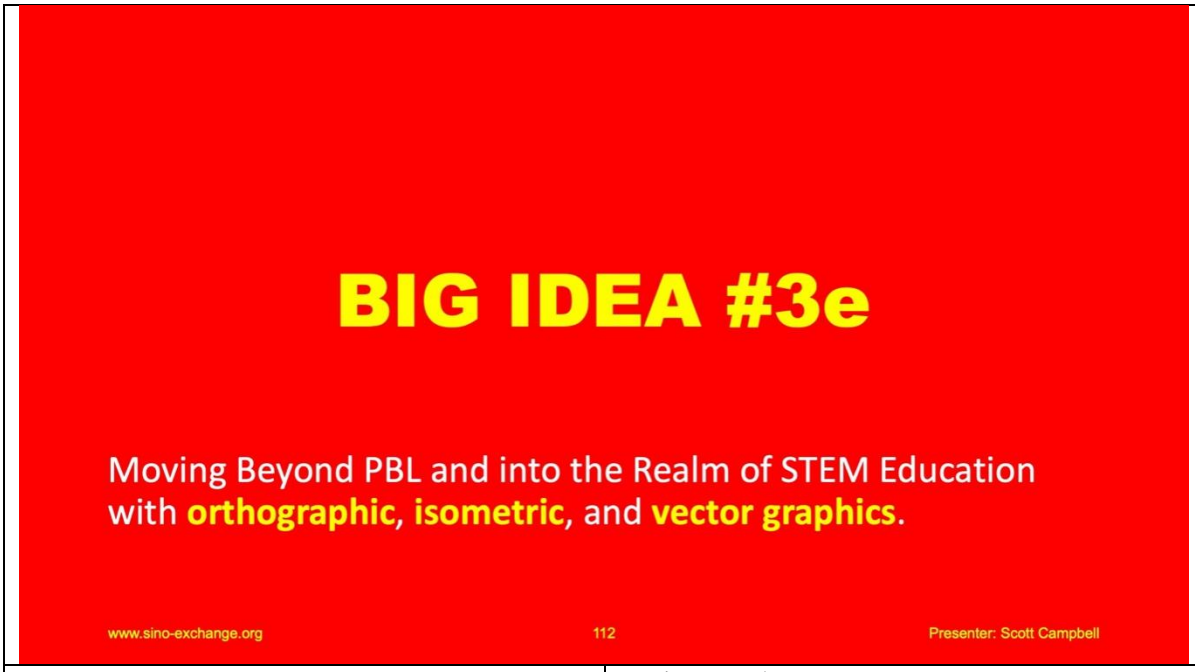
While the PITSCO and Vernier kits are perfect for middle school projects, PASCO has a truly unique structures kit that is well suited to iGCSE, IB, and AP test preparation.

至于测试你的桥梁，有几种方法可以做到。

你们总是可以把水桶挂在桥的中心，慢慢地往里面装沙子，直到听到裂缝；然而，如果你想用更科学的方法给你的桥梁发短信，你可以使用 PITSCO 或 Vernier 的这些结构测试仪。

虽然这些测试人员非常适合我刚刚向您展示的桥接类型，但 PASCO 的结构集有点不同。它较少关注"工程与设计过程"，而更多地关注探索更先进的数学概念。使用这个工具包，学生可以快速创建不同的特拉斯设计。然后，使用不同的传感器，学生可以确定整个结构中不同应力因素的交叉积。

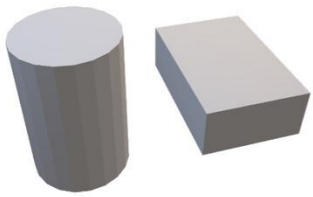
虽然 PITSSCO 和 Vernier 试剂盒非常适合中学项目，但 PASCO 有一个真正独特的结构试剂盒，非常适合 iGCSE、IB 和 AP 考试准备。



The last idea that I want to explore in today's presentation is to focus on the exploration of graphical representations that are based on mathematical concepts.	在今天的演示中，我想探讨的最后一个想法是专注于探索基于数学概念的图形表示。

Applied Mathematics In STEM

Booleans



Boolean operations, are common to most 3D modelers. Booleans allow you to **add**, **subtract**, and **intersect** solids. When applied to 3D modeling, *Boolean operations describe how volumes can be combined to create new solids*.

NOTE: *Boolean operations are named for the English mathematician George Boole.*

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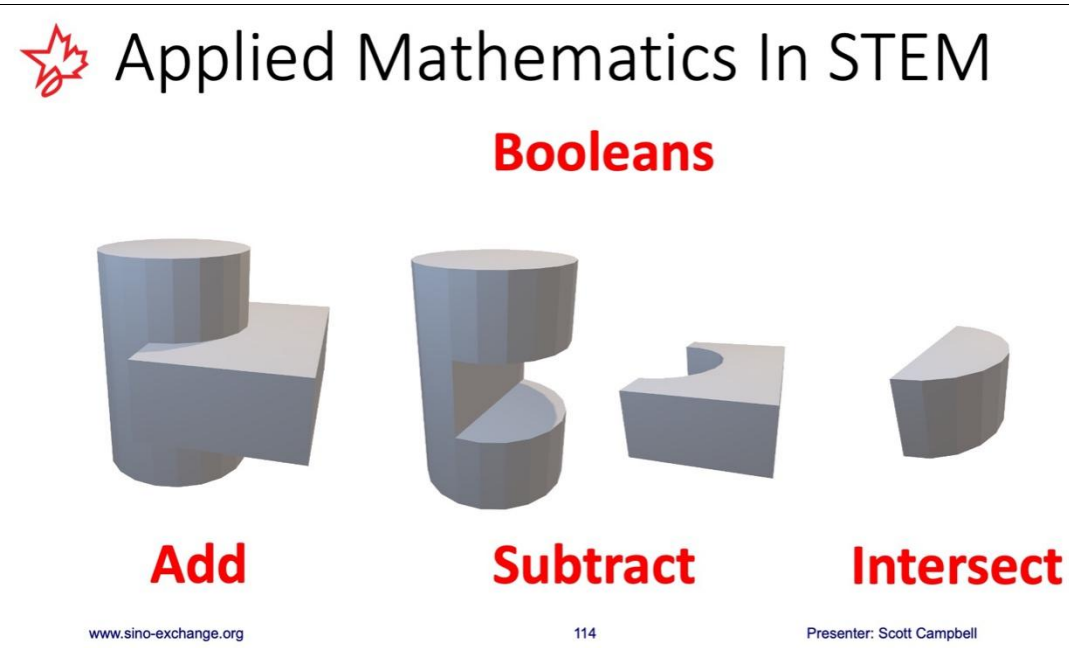
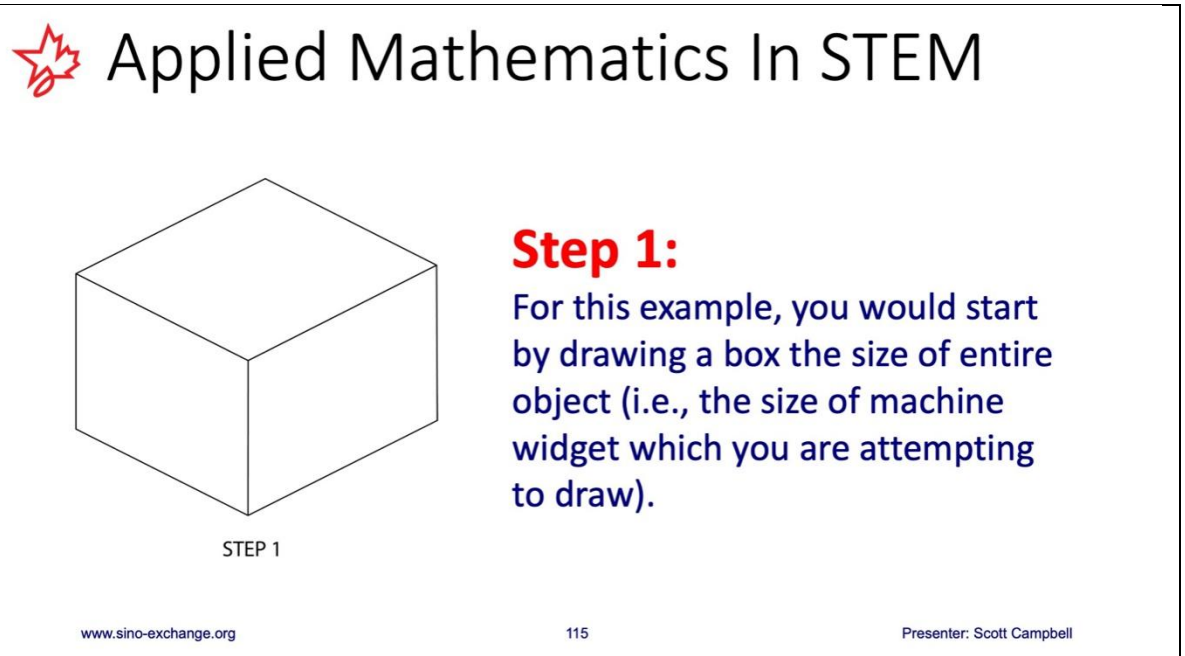
Whether you are designing objects by hand or on the computer, you need to understand “Booleans”! These are the basic operations of “adding, subtracting, and intersecting” object to create new shapes.	无论你是用手还是在电脑上设计物体，你都需要理解“布尔”！这些是“添加、减去和相交”对象以创建新形状的基本操作。



Here in these examples, we can see how: • shape A and B have been added together, • How B has been subtracted from A • How A has been subtracted from B • And where A and B intersect with one another.	在这些例子中，我们可以看到： •形状 A 和 B 已添加在一起， •如何从 A 中减去 B •如何从 B 中减去 A •A 和 B 相交的地方。



But how do we use Primitives to design objects? In this example we will design a machine part. We will start by drawing a rectangular prism.	但是我们如何使用基本体来设计对象呢？ 在这个例子中，我们将设计一个机器零件。我们将从画一个矩形棱镜开始。

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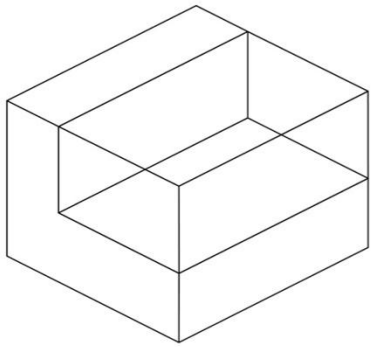

STEP 2

Step 2:

Then use the subtraction technique to remove unwanted material. Draw a second box inside the first box to remove any unwanted parts from the design of the widget.

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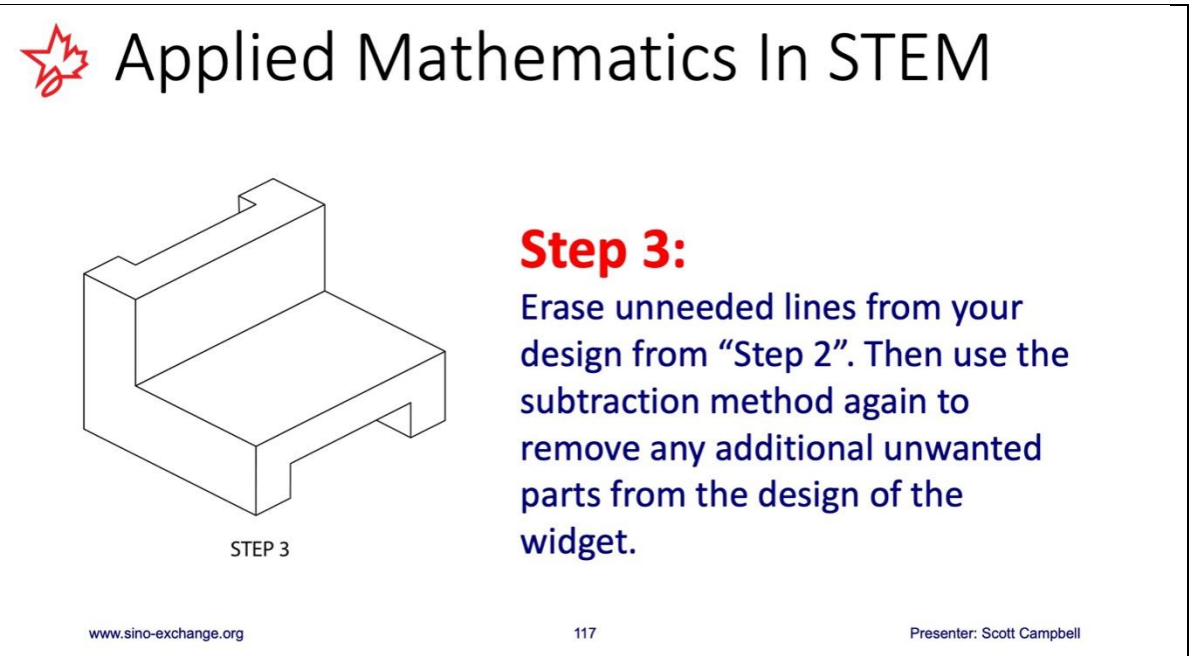
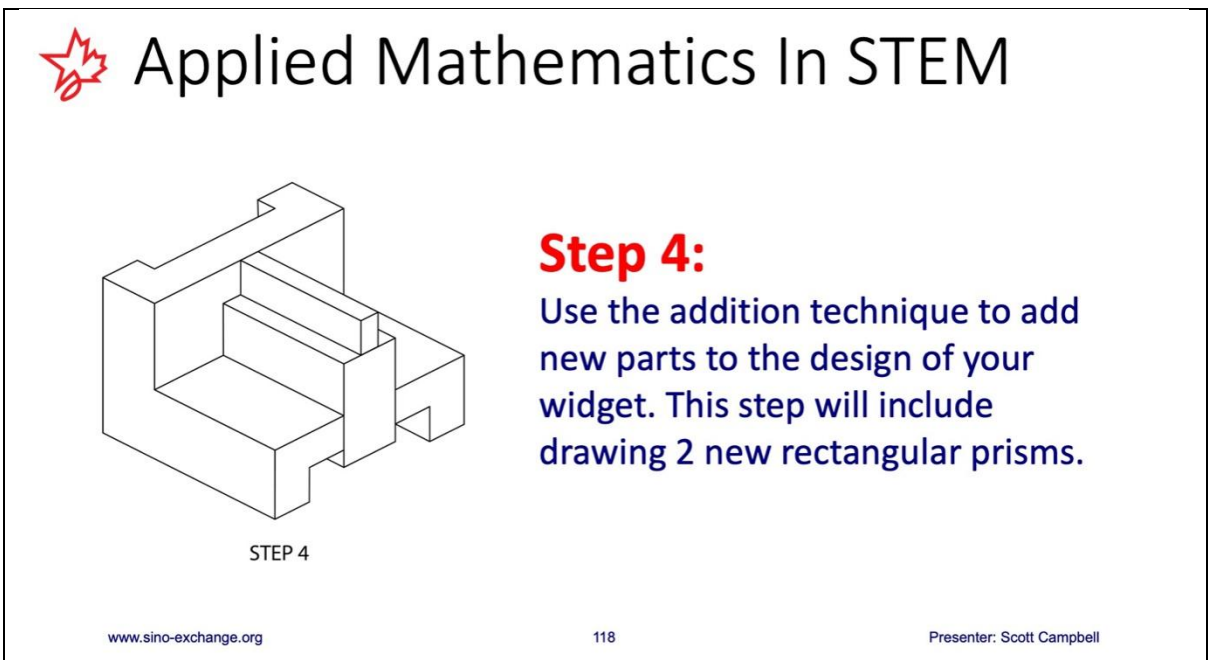
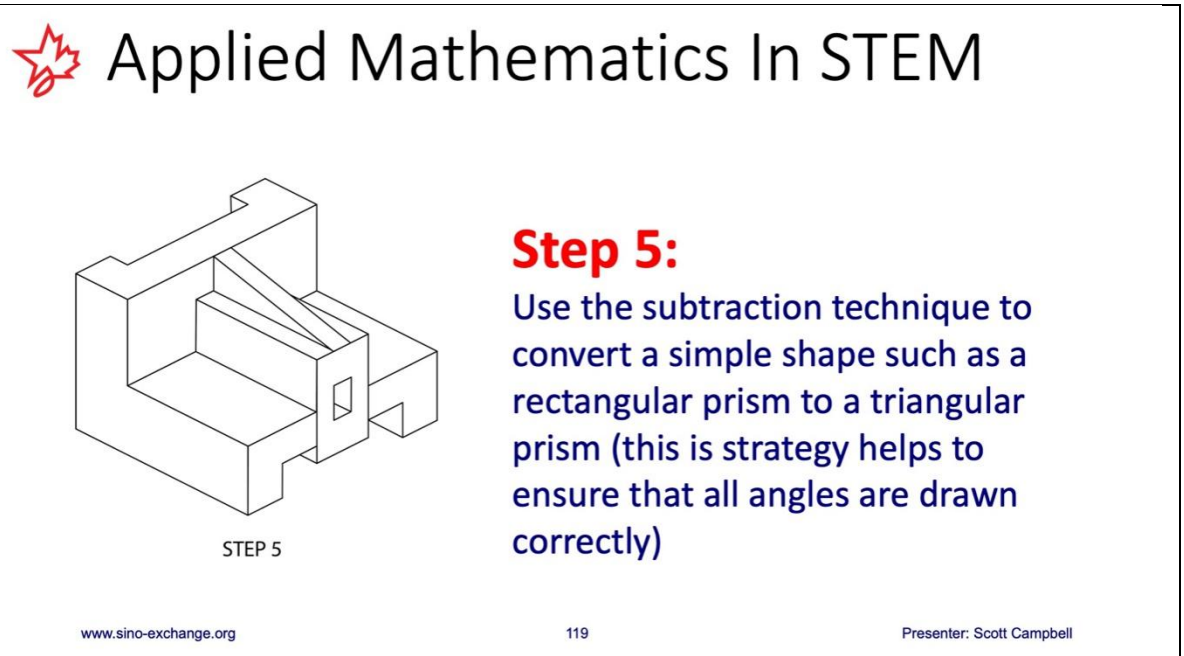
We will then subtract a smaller rectangle from the first object. This is known as a subtractive Boolean.	然后，我们将从第一个对象中减去一个较小的矩形。这被称为减法布尔运算。



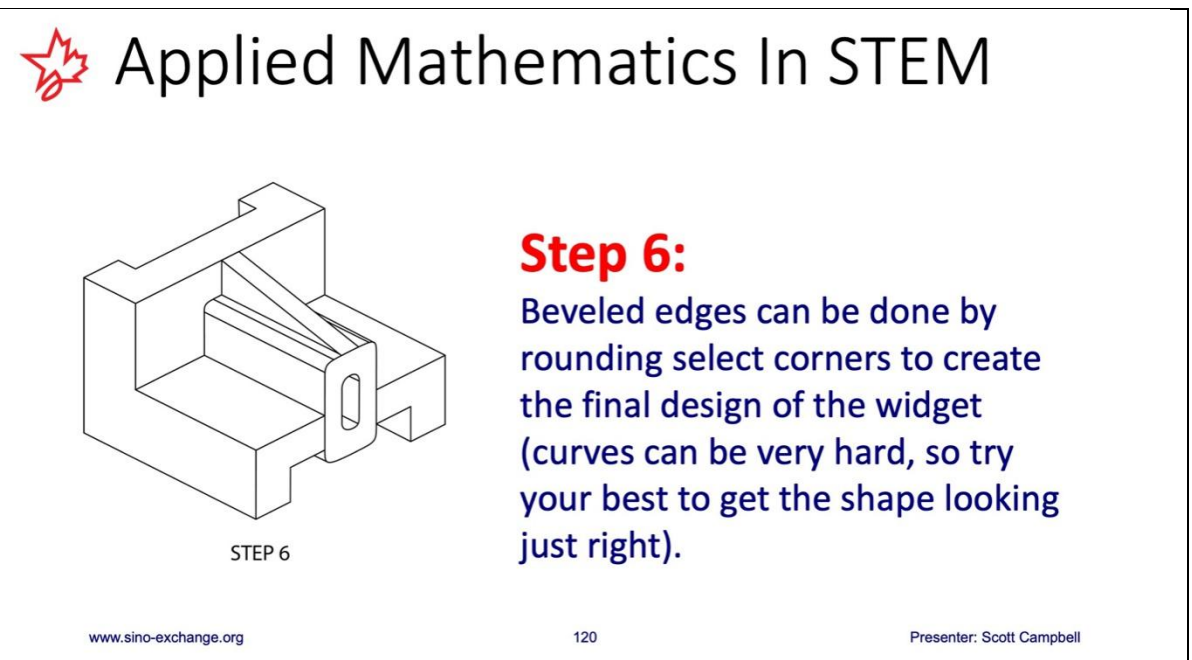
Next, we will repeat the process, removing another rectangle from the bottom and back of this shape. We now have a complex shape.	接下来，我们将重复该过程，从该形状的底部和背面移除另一个矩形。我们现在有一个复杂的形状。



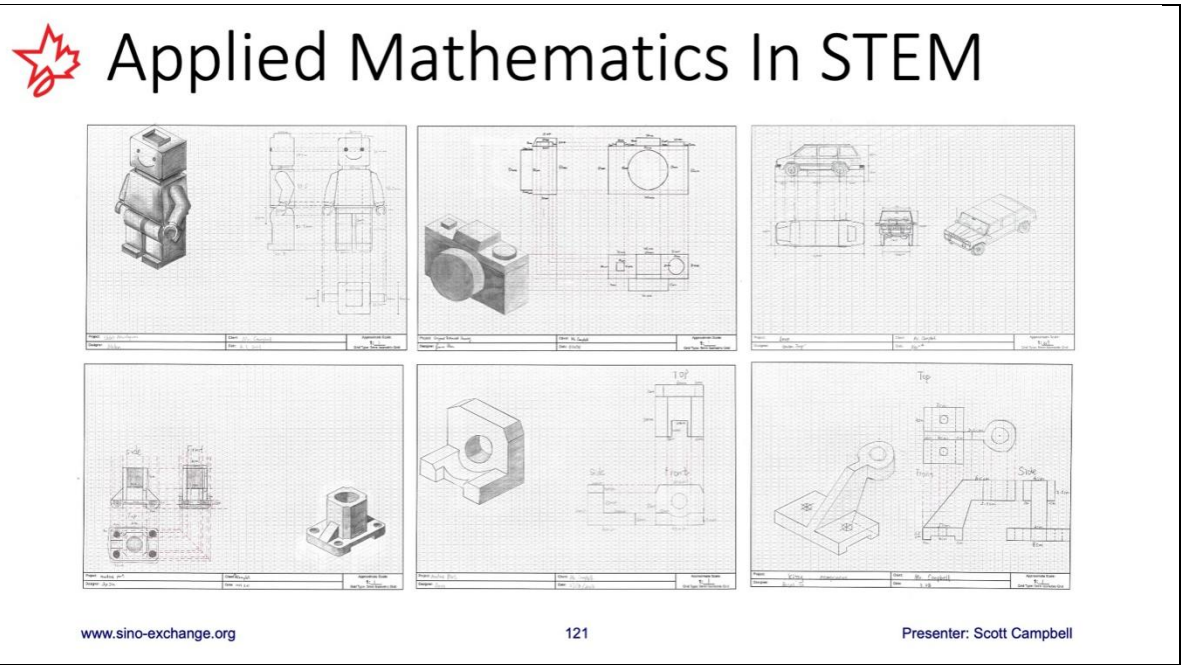
We are then going to add new elements to our design.	然后我们将在设计中添加新的元素。



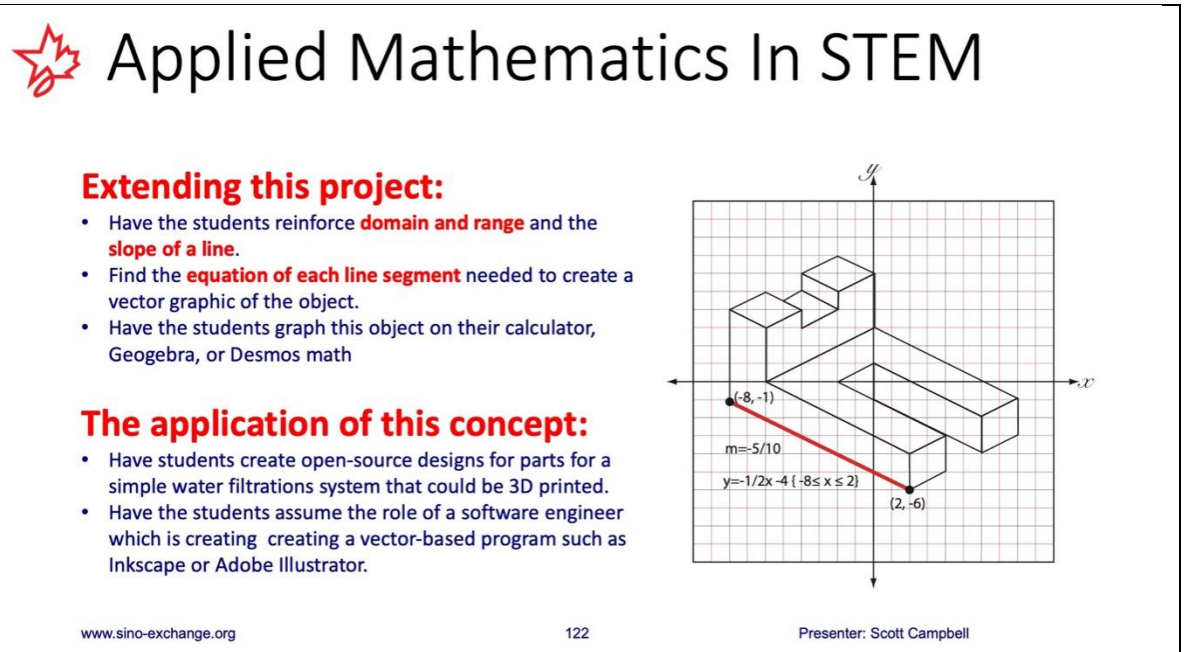
Modify those elements,	修改这些元素，



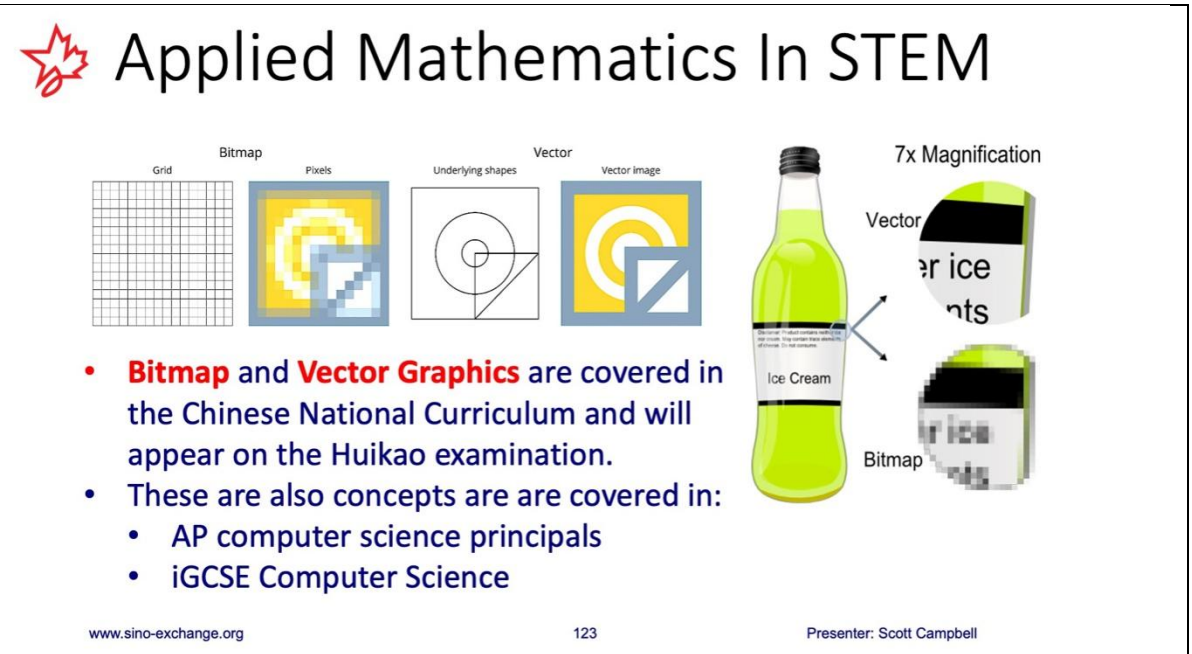
And then add what's called chamfer, which is the rounding of edges on an object. We are now left with a completed machine part that we have designed at scale using graph paper and Boolean operations.	然后添加所谓的倒角，也就是物体边缘的圆角。我们现在剩下的是一个完整的机器部件，我们使用图纸和布尔运算按比例设计。



And this is how your students can apply these techniques, as they design toys, consumer products, and even industrial machine parts.	这就是你的学生在设计玩具、消费品甚至工业机器零件时如何应用这些技术的方法。



However, another thing you could consider having your students calculate the slope and the domain and range of each line segment needed to create these objects. You could have them do this using pencil and paper, or you can even have them do this in applications such as Geogebra and Desmos Math. You might ask, how this activity is relevant or authentic?	然而，你可以考虑让学生计算创建这些对象所需的每个线段的斜率、域和范围。你可以让他们用铅笔和纸做这件事，或者你甚至可以让他们在地理和数学等应用程序中这样做。 你可能会问，这个活动相关性和真实性如何？



Well, vector applications create images using mathematical equations. This allows the image to be scaled indefinitely as the value for "X" can be adjusted by software. The software application then recalculates all the necessary values and displays the image at the new size. Therefore, this activity allows your students to explore the difference between "***Bitmap***" and "***vector graphics***".

Moreover, software engineers who are creating these kinds of programs need to develop software algorithms that can recognize and convert shapes to mathematical equations just like we have done in these examples. Therefore, there is a real-world application to what we have just reviewed as a project idea.

矢量应用程序使用数学方程创建图像。这允许图像无限缩放，因为"X"的值可以通过软件进行调整。然后，软件应用程序重新计算所有必要的值，并以新的尺寸显示图像。因此，此活动可以让您的学生探索"位图"和"矢量图形"之间的区别。

此外，创建这类程序的软件工程师需要开发软件算法，能够识别形状并将其转换为数学方程，就像我们在这些例子中所做的那样。因此，我们刚刚回顾的项目理念有一个现实世界中的应用。

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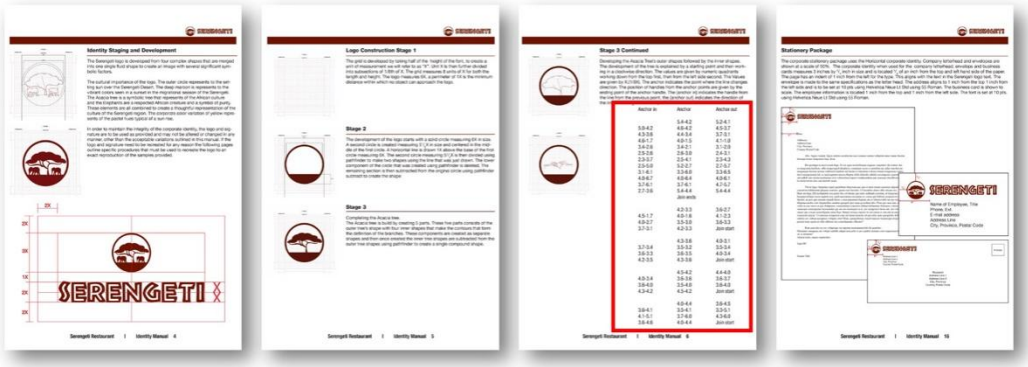

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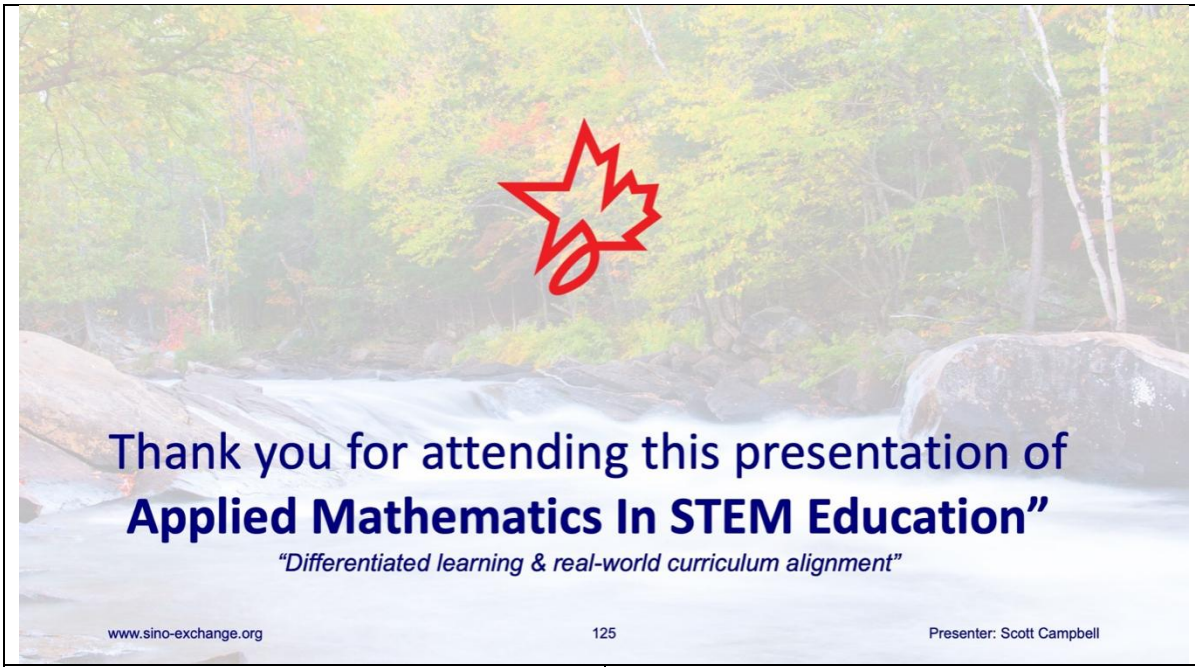
Finally, as you can see from this corporate identity manual, the entire logo design has been stated in values of “X”, and the domain and range for each line segment has been stated. Therefore, students will still need to understand math, even if they want to pursue a career in an artistic field of study such as graphic design.	最后，正如您从本公司标识手册中看到的，整个徽标设计都以“X”的值表示，并说明了每个线段的域和范围。因此，学生们仍然需要理解数学，即使他们想从事平面设计等艺术领域的研究。



And that brings us to the end of this presentation. I hope that you have found this presentation informative, and that you have been able to take away several ideas that you might consider trying in your own classroom. And with that said, I would like to thank all of you for attending this presentation on Applied Mathematics In STEM.	今天的演讲到此结束。我希望你已经发现这篇演讲提供了丰富的内容，并且你已经能够带走一些你可能会考虑在自己的课堂上尝试的想法。 话虽如此，我要感谢大家参加这次关于 STEM 应用数学的演讲。