Tuesday 19th October
Room 2
12.15 pm -1.05 pm
Seven Vinton

Helping students make informed predictions using simulation software

Making predictions is high in the order of cognitive skills needed for life long learning, however, successful and informed predictions require experience in the areas that the predictions are being made.

We often ask students to predict what might happen in a specific learning scenario, but as teachers, we sometimes forget that our learning and teaching takes place within a confined window of reality, which is restricted in time and real-life practical application.

This workshop provides an interactive insight into a curriculum model aimed at using experiences in virtual simulation software environments to backfill students' knowledge, to help inform their predictions.

We acknowledge that we are gathered on the traditional land, and honour and pay our respects to their Elders past and present.

About me

Seven Vinton

20+ years in education leadership
Current position: STEM Leader Oberon High School – Armstrong Creek Victoria

Undergraduate specialisations: Industrial Arts (ceramics, kiln and furnace construction, practical engineering); Multimedia & Telecommunications.

The ability of prediction is a highly prized workplace skill.

Although artificial intelligence is likely to one day exceed all human ability in the areas of prediction, prediction is still viewed as a key 21st Century skill, and is a key component of the scientific inquiry process and a foundation of Hypothesis.

Semantics:

In general, if it's discussing a future event or something that can be explicitly verified within the 'natural course of things,' it's a prediction. If it's a theory formed around implicit analysis based on evidence and clues, it's an inference.

Both inferences and predictions require students to combine clues, evidence, and background knowledge to form a theory.
https://www.teachthought.com/literacy/difference-between-inference-prediction/

Throughout this presentation I will be using the terms: prediction, inference, and hypothesis interchangeably

Bill Gates Warned Us About Covid-19 in 2015, Now He is Predicting Two More Disasters

Screenshot from a video uploaded by Veritasium on YouTube.

In a 2015 Ted talk titled 'The next outbreak? We're not ready,' Bill Gates talked about the spread of a potential virus, like COVID-19, and stressed the need for the world to be well-equipped to tackle the crisis.

- NEWS18.COM
- LAST UPDATED: FEBRUARY 05, 2021, 18:03 IST
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https://www.news18.com/news/buzz/bill-gates-warned-us-about-covid-19-in-2015-now-he-is-predicting-two-more-disasters-3394487.html

How was Bill Gates able to make this prediction?

He is not a trained medical expert.

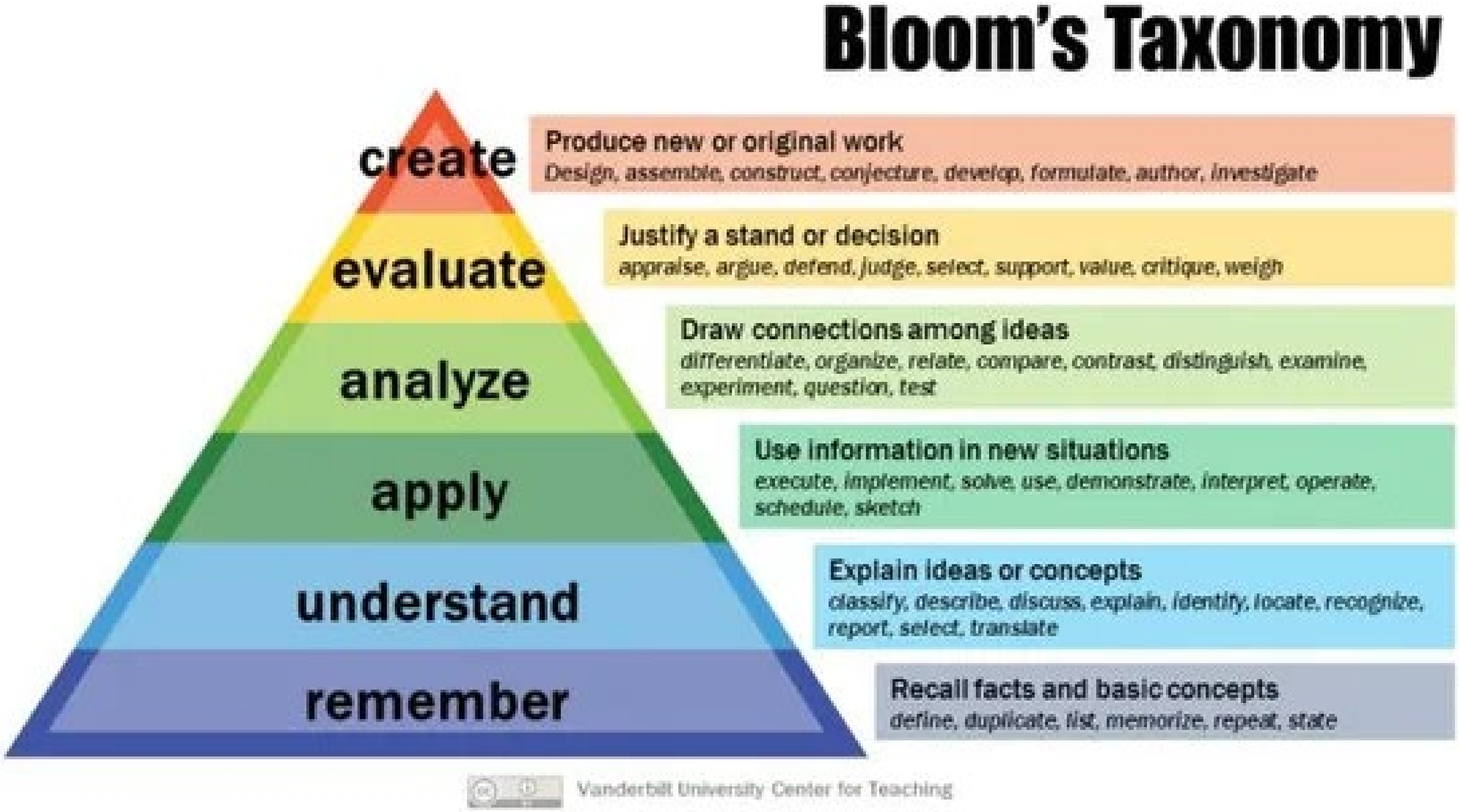
Is he a wizard or a prophet?

Or is it something else?

Obviously his many years of observing global health patterns, talking to experts in the field, and his analysis of global structures and trends, allowed him to put forward an informed hypothesis or prediction.

Either that, or he just watched the movie 'Contagion' in 2011, which pretty much outlined the real world progression

How the skill of prediction fits in to Bloom's



Development of prediction strengthens critical thinking ability, and is one of the key actions within Bloom's 'analyse & evaluate' domains

CRITICAL THINKING SKILLS

1 Knowledge Identification and recall of information	define fill in the blank list identify	label locate match memorize	name recall spell	state tell underline
	Who ____? What ____? Where ____? When ____?		How ____? Describe ____. What is ____?	
2 Comprehension Organization and selection of facts and ideas	convert describe explain	interpret paraphrase put in order	restate retell in your own words rewrite	summarize trace translate
	Re-tell ____ in your own words. What is the main idea of ____?		What differences exist between ____? Can you write a brief outline?	
3 Application Use of facts, rules, and principles	apply compute conclude construct	demonstrate determine draw find out	give an example illustrate make operate	show solve state a rule or principle use
	How is ____ an example of ____? How is ____ related to ____? Why is ____ significant?		Do you know of another instance where ____? Could this have happened in ____?	
4 Analysis Separating a whole into component parts	analyze categorize classify compare	contrast debate deduct determine the factors	diagram differentiate dissect distinguish	examine infer specify
	What are the parts or features of ____? Classify ____ according to ____. Outline/diagram/web/map ____.		How does ____ compare/contrast with ____? What evidence can you present for ____?	
5 Synthesis Combining ideas to form a new whole	change combine compose construct create design	find an unusual way formulate generate invent originate plan	predict pretend produce rearrange reconstruct reorganize	revise suggest suppose visualize write
	What would you predict/infer from ____? What ideas can you add to ____? How would you create/design a new ____?		What solutions would you suggest for ____? What might happen if you combined ____ with ____?	
6 Evaluation Developing opinions, judgements, or decisions	appraise choose compare conclude	decide defend evaluate give your opinion	judge justify prioritize rank	rate select support value
	Do you agree that ____? Explain. What do you think about ____? What is most important?		Prioritize ____ according to ____? How would you decide about ____? What criteria would you use to assess ____?	

Prediction is key critical thinking skill, and plays a major role in the scientific inquiry process

All Thinking Is Defined by the Eight Elements That Make It Up

Thinking, then:

- generates purposes
- raises questions
- uses information
- utilizes concepts
- makes inferences
- makes assumptions
- generates implications
- embodies a point of view

- https://www.criticalthinking.org/pages/critical-thinking-learning-models/704

Anderson and Sosniak (1994), updated the taxonomy reflecting relevance to the 21st century

Improving Hypothesis Testing Skills: Evaluating a General Purpose Classroom Exercise with Biology Students in Grade 9.

Michael Gregg Wilder
Portland State University

https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1426&context=open_access_etds

Lawson et al. (2000) **argue that hypothetico-deductive reasoning is of paramount importance in scientific investigation**. The authors clearly delineate the six considerations that are required to engage in hypothetico-deductive reasoning.

logical reasoning abilities in children and adolescents - ***Inhelder and Piaget*** (1958).
The authors distinguished between concrete and formal mental operations. A child exhibiting concrete operations will **have explicit (but limited) awareness of the abstract logical "actions" when solving a problem**.
In contrast, **the formal operational thinker can produce and evaluate explanatory hypotheses**, because they recognition that observations can be explained "in terms of the formal operations - hypothetico-deductive thought."
In other words, hypotheticodeductive thought requires an awareness that deductive reasoning can justify general conclusions about observations.

Critical development in the later primary / early secondary years (11 – adult)
https://www.theclassroom.com/formal-operational-vs-concrete-operational-12056773.html

The more you are exposed to activities that follow a formal process of investigating, analysing, and evaluating a problem; the more you come to an understanding that this formal thinking process can be used to help solve problems.

The ability to make predictions, inferences, form hypothesis, is an important part of the development of critical thinking.

The skill of prediction is a critical component of critical thinking, scientific reasoning, the scientific process.

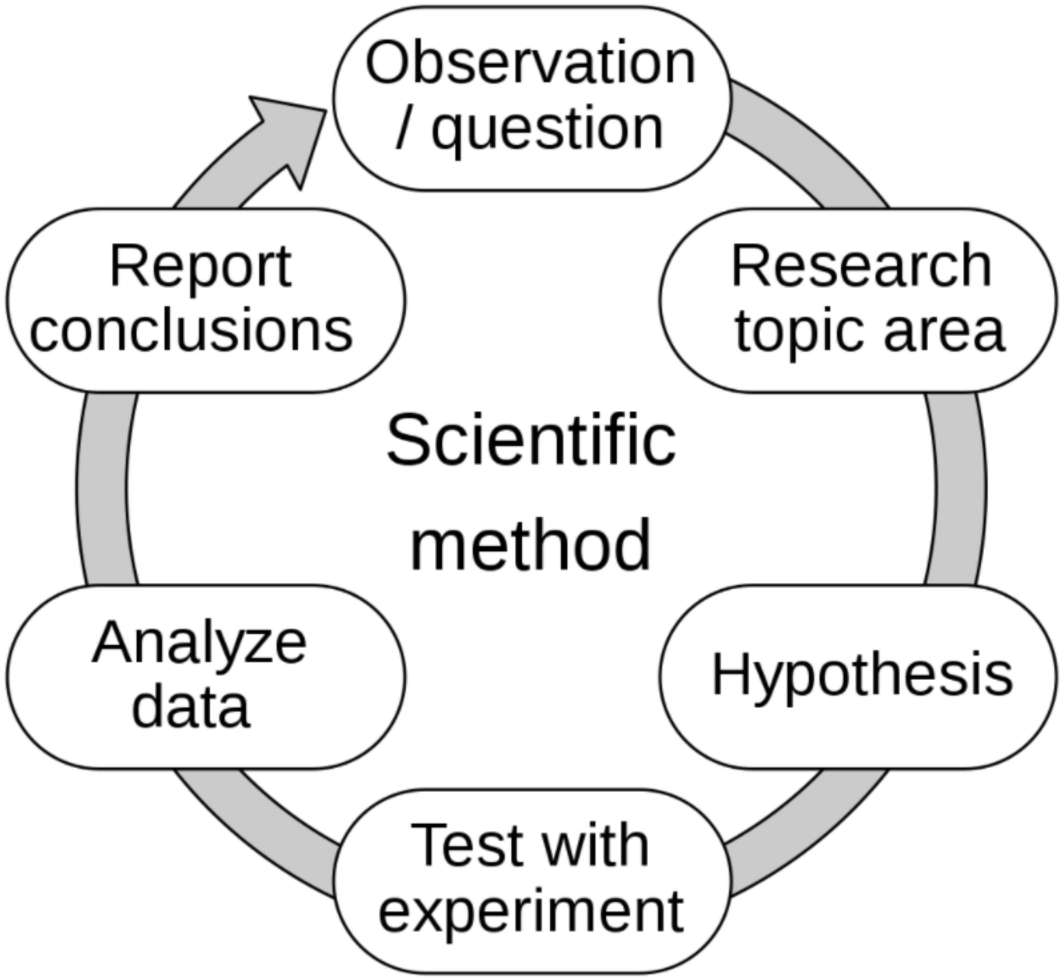
The more accurately you are able to predict, the more closer you come to understanding the thing you are making predictions for.

The **hypothetico-deductive model** or **method** is a proposed description of the scientific method. According to it, scientific inquiry proceeds by formulating a hypothesis in a form that can be falsifiable, using a test on observable data where the outcome is not yet known.

Victorian Curriculum

Scientific investigations

Scientific investigations are activities in which ideas, predictions or hypotheses are tested and conclusions are drawn in response to a question or problem. Investigations can involve a range of activities, including experimental testing, field work, locating and using information sources, conducting surveys, and using modelling and simulations.



Which part is the most difficult to organise, and takes up the most time?

It is also the part the students love the most

Table 1: Oregon's 2009 High School Science Standards and Lawson *et al.*'s (2000) analysis of hypothetico-deductive reasoning.

2009 Oregon High School Science Standards:	Lawson *et al.*'s analysis of hypothetico-deductive reasoning:
H.3S.1 Based on observations and science principles formulate a question or hypothesis that can be investigated through the collection and analysis of relevant information.	1. What is the central causal question? 2. What hypotheses can be advanced to answer this question?
H.3S.2 Design and conduct a controlled experiment, field study, or other investigation to make systematic observations about the natural world, including the collection of sufficient and appropriate data.	3. How can each hypothesis be tested? 4. What are the consequences or predictions of each hypothesis and/or test?
H.3S.3 Analyze data and identify uncertainties. Draw a valid conclusion, explain how it is supported by the evidence, and communicate the findings of a scientific investigation.	5. How do the results of the tests match the predictions? 6. What conclusion can be drawn based on these results?

What designs / shapes make stronger bridges?

Triangular shapes with rounded edges help evenly distribute loads on bridges.

Test this hypothesis using 3D design software and simulation tests – predict outcomes and compare these to test results.

Analyse simulation test results against predictions to evaluate and/or adjust assumptions. Compare simulated tests with real-world tests to compare results.

Science Inquiry Skills	
Questioning and predicting	
Identify questions, problems and claims that can be investigated scientifically and make predictions based on scientific knowledge	Formulate questions or hypotheses that can be investigated scientifically, including identification of independent, dependent and controlled variables
Planning and conducting	
Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed	Independently plan, select and use appropriate investigation types, including fieldwork and laboratory experimentation, to collect reliable data, assess risk and address ethical issues associated with these investigation types
In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task	Select and use appropriate equipment and technologies to systematically collect and record accurate and reliable data, and use repeat trials to improve accuracy, precision and reliability
Recording and processing	
Construct and use a range of representations including graphs, keys and models to record and summarise data from students' own investigations and secondary sources, and to represent and analyse patterns and relationships	Construct and use a range of representations, including graphs, keys, models and formulas, to record and summarise data from students' own investigations and secondary sources, to represent qualitative and quantitative patterns or relationships, and distinguish between discrete and continuous data
Analysing and evaluating	
Use scientific knowledge and findings from investigations to identify relationships, evaluate claims and draw conclusions	Analyse patterns and trends in data, including describing relationships between variables, identifying inconsistencies in data and sources of uncertainty, and drawing conclusions that are consistent with evidence
Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method	Use knowledge of scientific concepts to evaluate investigation conclusions, including assessing the approaches used to solve problems, critically analysing the validity of information obtained from primary and secondary sources, suggesting possible alternative explanations and describing specific ways to improve the quality of data
Communicating	
Communicate ideas, findings and solutions to problems including identifying impacts and limitations of conclusions and using appropriate scientific language and representations	Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

Technologies Contexts	
Engineering principles and systems	
Analyse how motion, force and energy are used to manipulate and control electromechanical systems when creating simple, engineered solutions	Investigate and make judgements on how the characteristics and properties of materials are combined with force, motion and energy to create engineered solutions

Stage 1: Pre-Testing & backfilling knowledge

Learning Intention
Introduction to bridge design techniques. Understanding of basic structures & stress distribution techniques

Task design
Deign, construction, testing, and evaluation of a spaghetti bridge with a 40cm span
Task aims (Learning Intention)

Bridge testing method
Span bridge between two surfaces and hang weights from the centre point

Constraints
Materials constraints – Limited supply of pasta, glue, tape
students are not always able to stick within constraints guidelines – especially the boys

Evaluation of results
A fair & scientific method of analysis and evaluation was needed (We used Covid pandemic data as a backdrop for evaluating results)

Main aim or overarching learning intention for the unit:

Help students to make better informed designs

Pre task learning – knowledge backfilling

Introduction to bridge design, Stress, strain, tension, compression, torsion, shearing, bending, load distribution techniques.

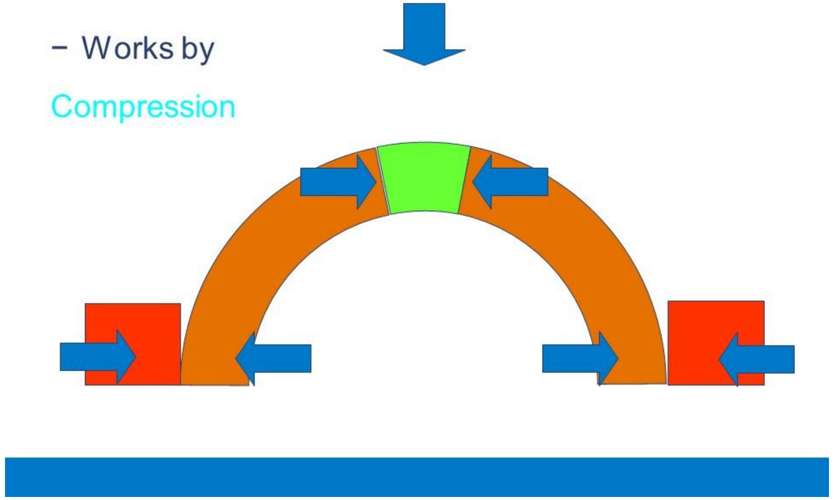
The history of bridge design, common shapes, bridge spans, contemporary bridge design, bridge failures, safety factors.

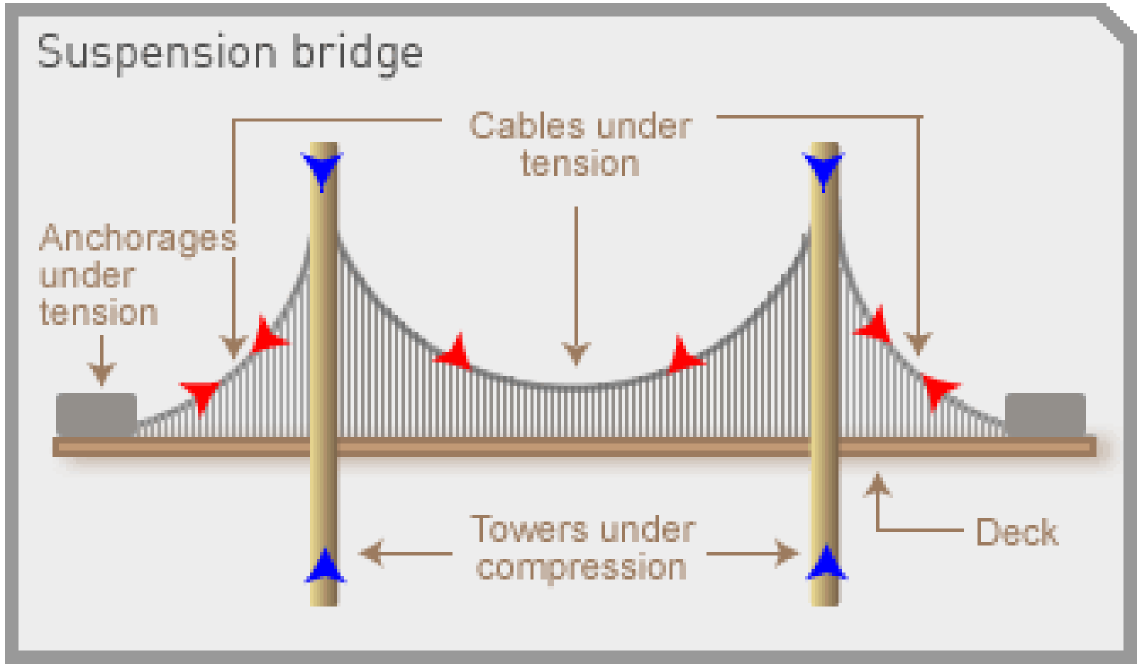
Equipment	Factor of Safety *- FOS -*
Aircraft components	1.5 - 2.5
Boilers	3.5 - 6
Bolts	8.5
Cast-iron wheels	20
Engine components	6 - 8
Heavy duty shafting	10 - 12
Lifting equipment - hooks ..	8 - 9
Pressure vessels	3.5 - 6
Turbine components - static	6 - 8
Turbine components - rotating	2 - 3
Spring, large heavy-duty	4.5
Structural steel work in buildings	4 - 6
Structural steel work in bridges	5 - 7
Wire ropes	8 - 9

Arch Bridges

– Works by

Compression





What is the safety factor of the Westgate Bridge?

What is its load capacity?

Designed to carry 40,000 vehicles per day with a maximum load of 25 tonnes per vehicle
Average weight of a car = 1.5 tonnes
25/1.5 = 16.67
A safety factor of roughly 17 (just count the trucks before you drive onto it)

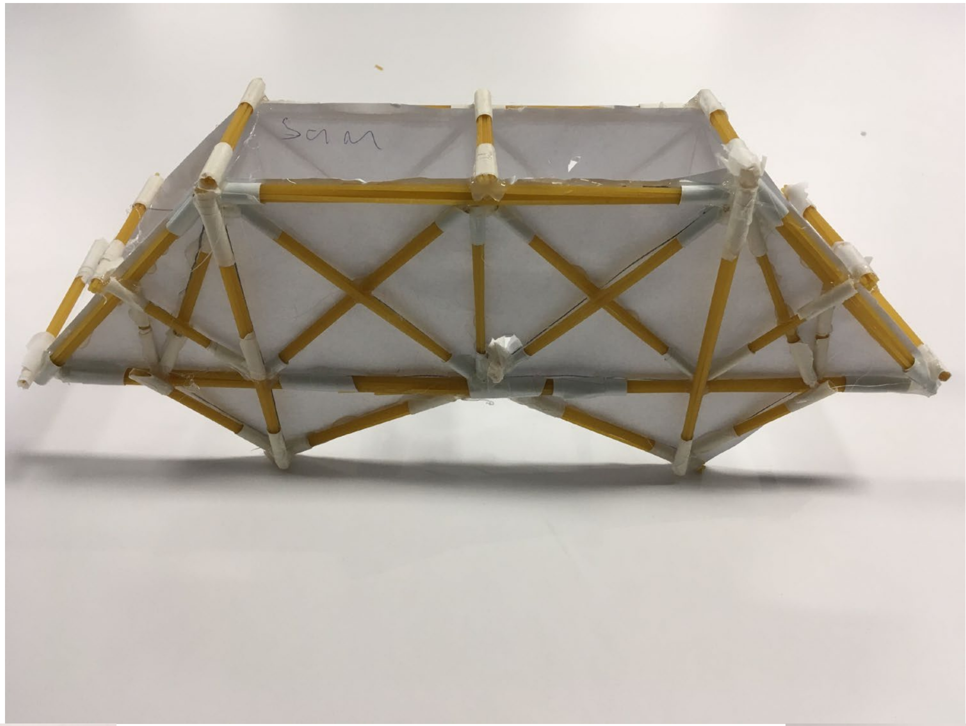
Misconceptions

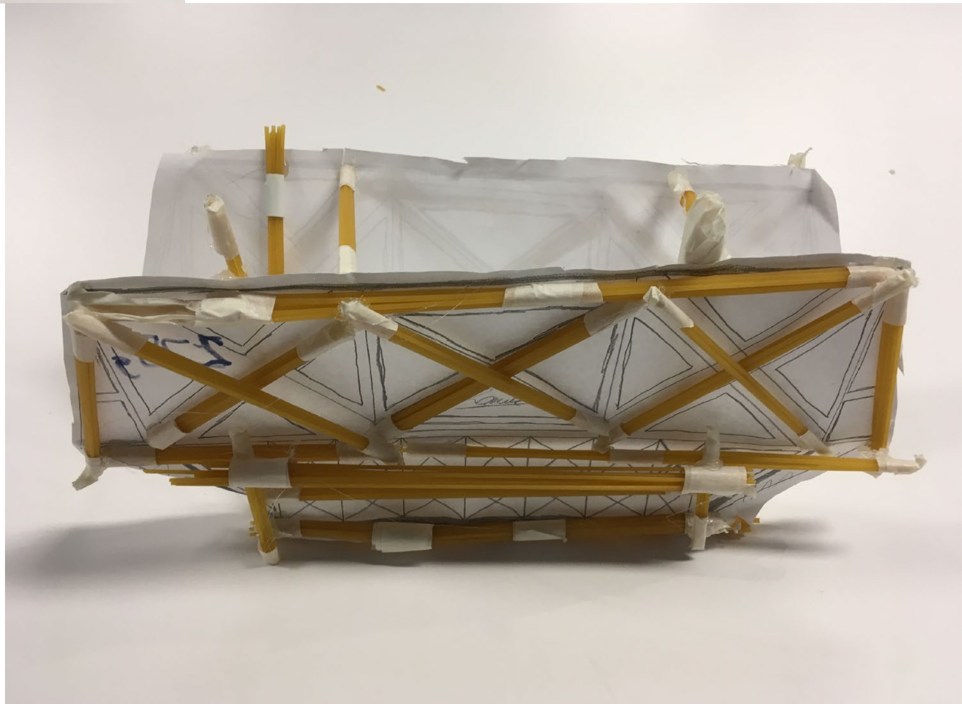
Initial student predictions about forces on a bridge, distribution of load

Initially many students predict the point of greatest stress to be at the point where the load is applied.

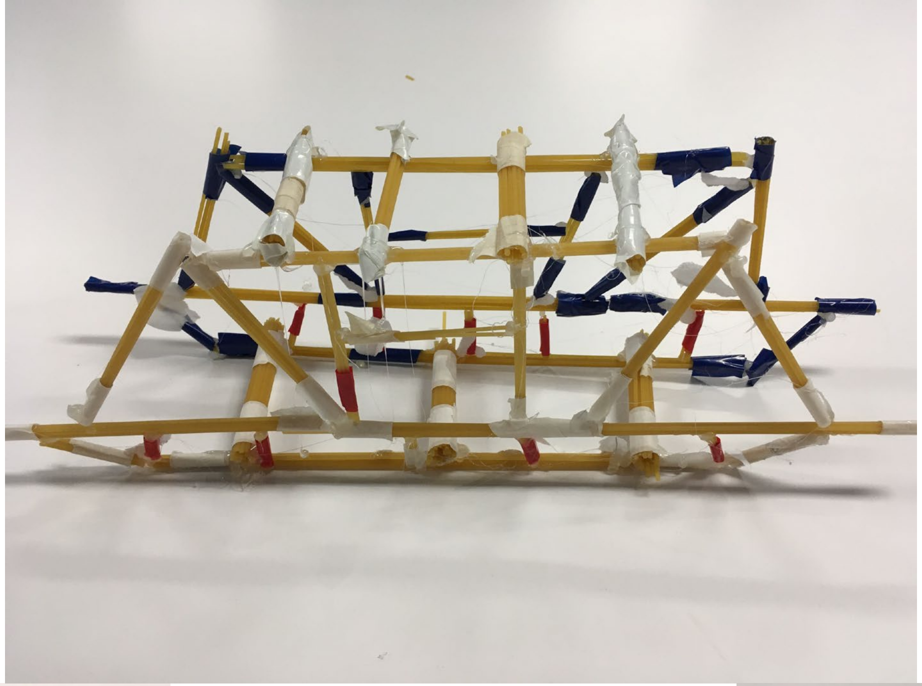
This because they do not yet understand the mechanics of load distribution.

Spaghetti bridge designs



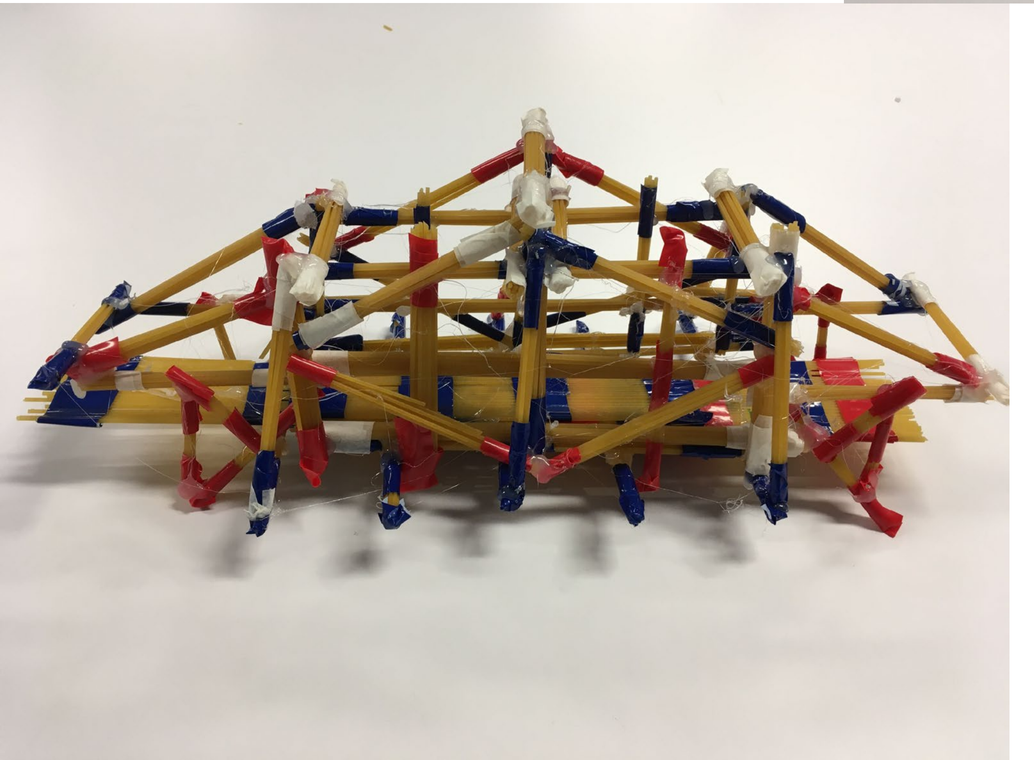


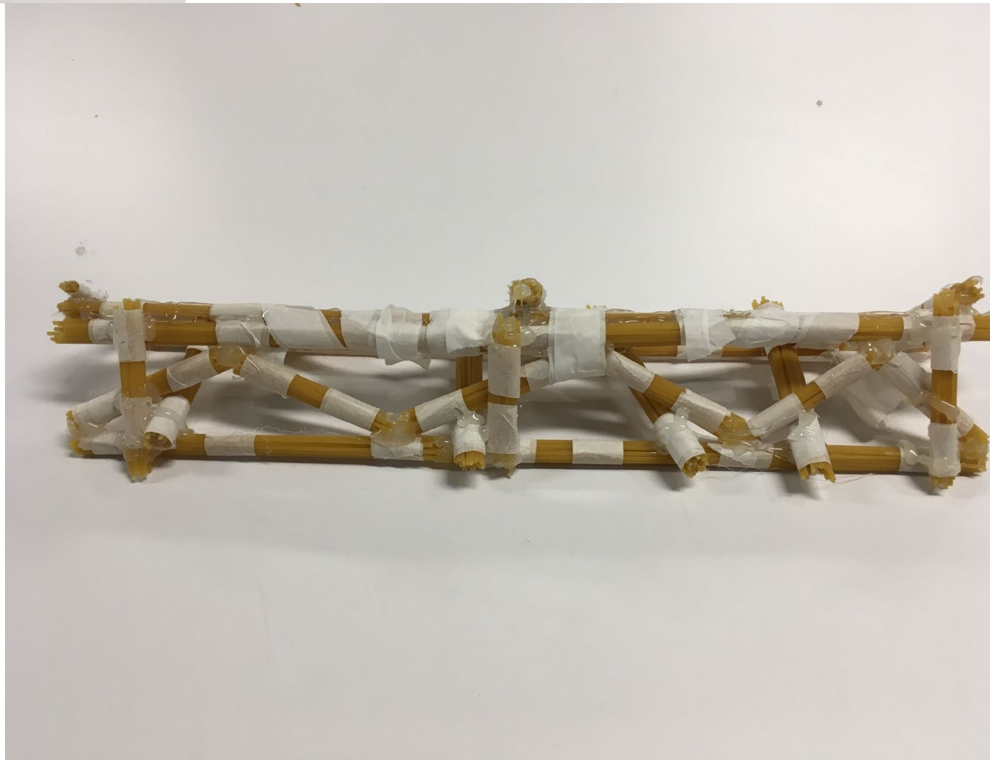
Prior to testing, students recorded their predictions as marks on the surface of their bridges



Limitations

The real-world test of these bridges allowed for only one single test, because the test destroyed the bridge.

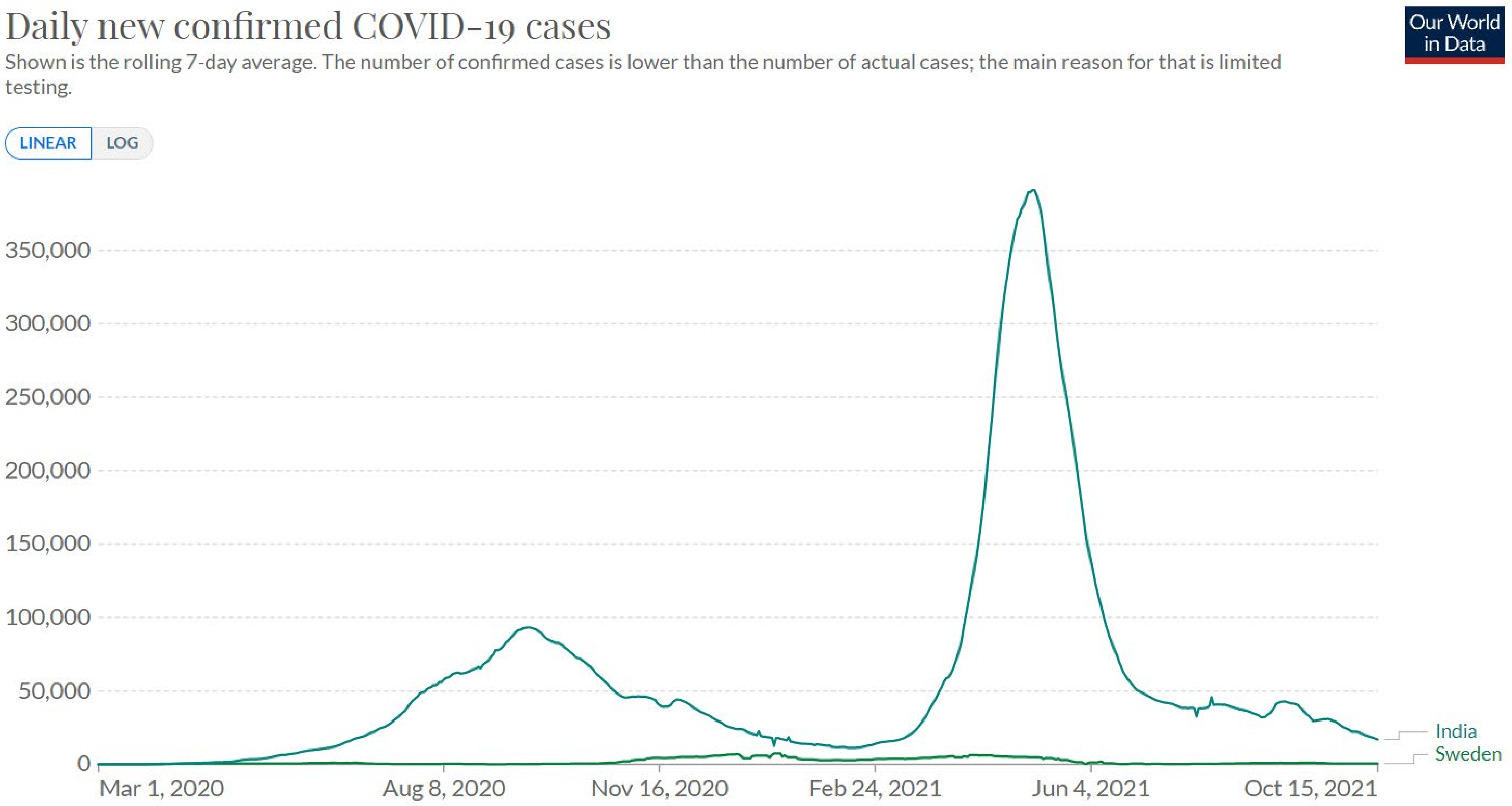




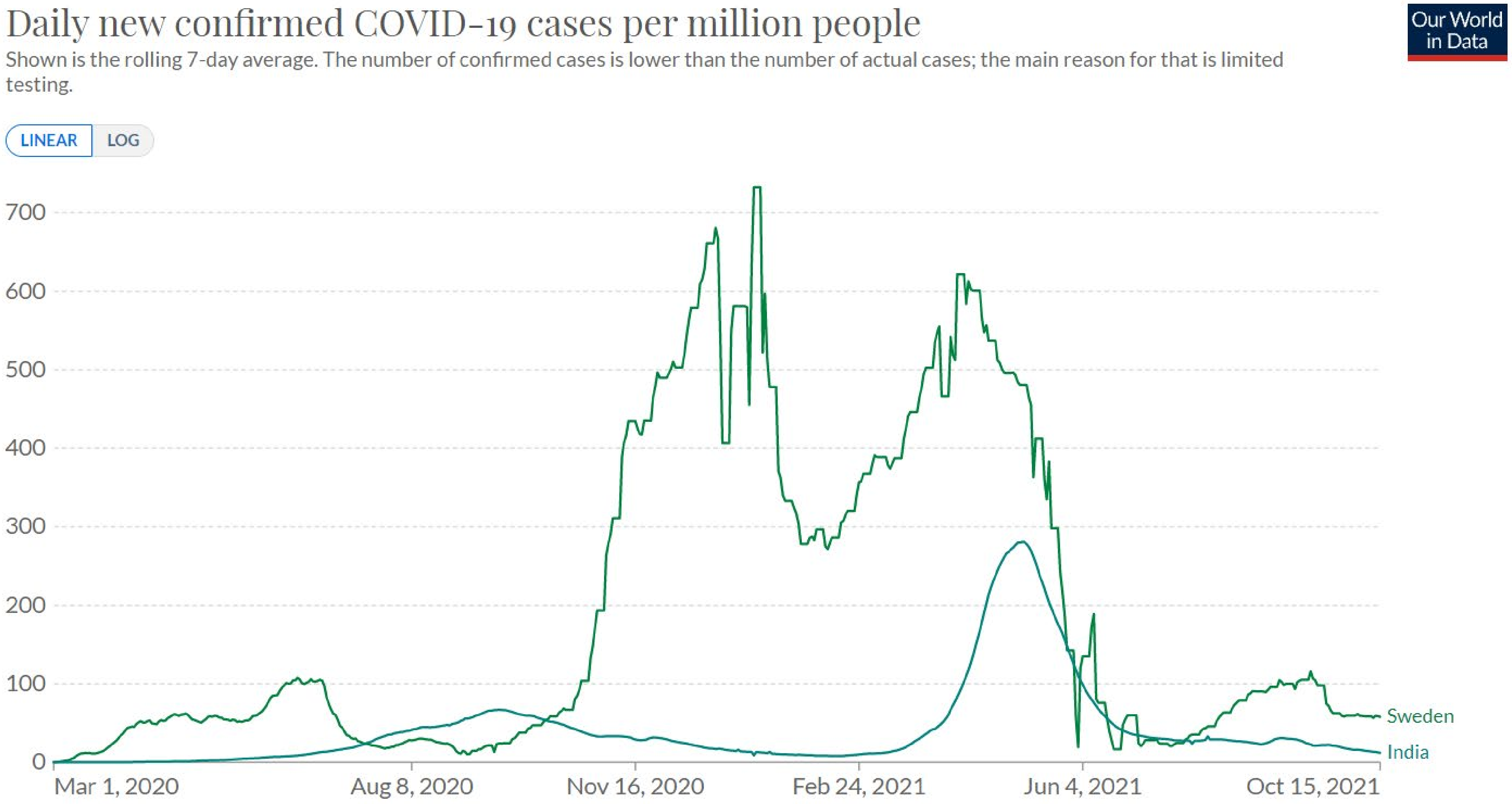
Group	Weight of Bridge	Weight held by Bridge
Harmony's Team	180.5	1150
Josh's Team	275	2000
Chaise's Team	254.5	4500
Riley's Team	398	4000
Curtis	97.5	1200
Cody	163	1000
Ash	358	6000
Sam	185	3000
Tyson D's Team	395	6000

Because some teams ignored the materials constraints, a fair method of assessment was needed.

Covid cases by number



Covid cases relative to population



Group	Weight of Bridge	Weight held by Bridge	Weight held per gram of bridge
Harmony's Team	180.5	1150	6.371191136
Josh's Team	275	2000	7.272727273
Chaise's Team	254.5	4500	17.68172888
Riley's Team	398	4000	10.05025126
Curtis	97.5	1200	12.30769231
Cody	163	1000	6.134969325
Ash	358	6000	16.75977654
Sam	185	3000	16.21621622
Tyson D's Team	395	6000	15.18987342

Stage Two: Informed design, Hypothesis (predictions), and rigorous testing

Learning Intention
Introduction to CAD Design. Introduction to CAD simulated testing to help inform design.

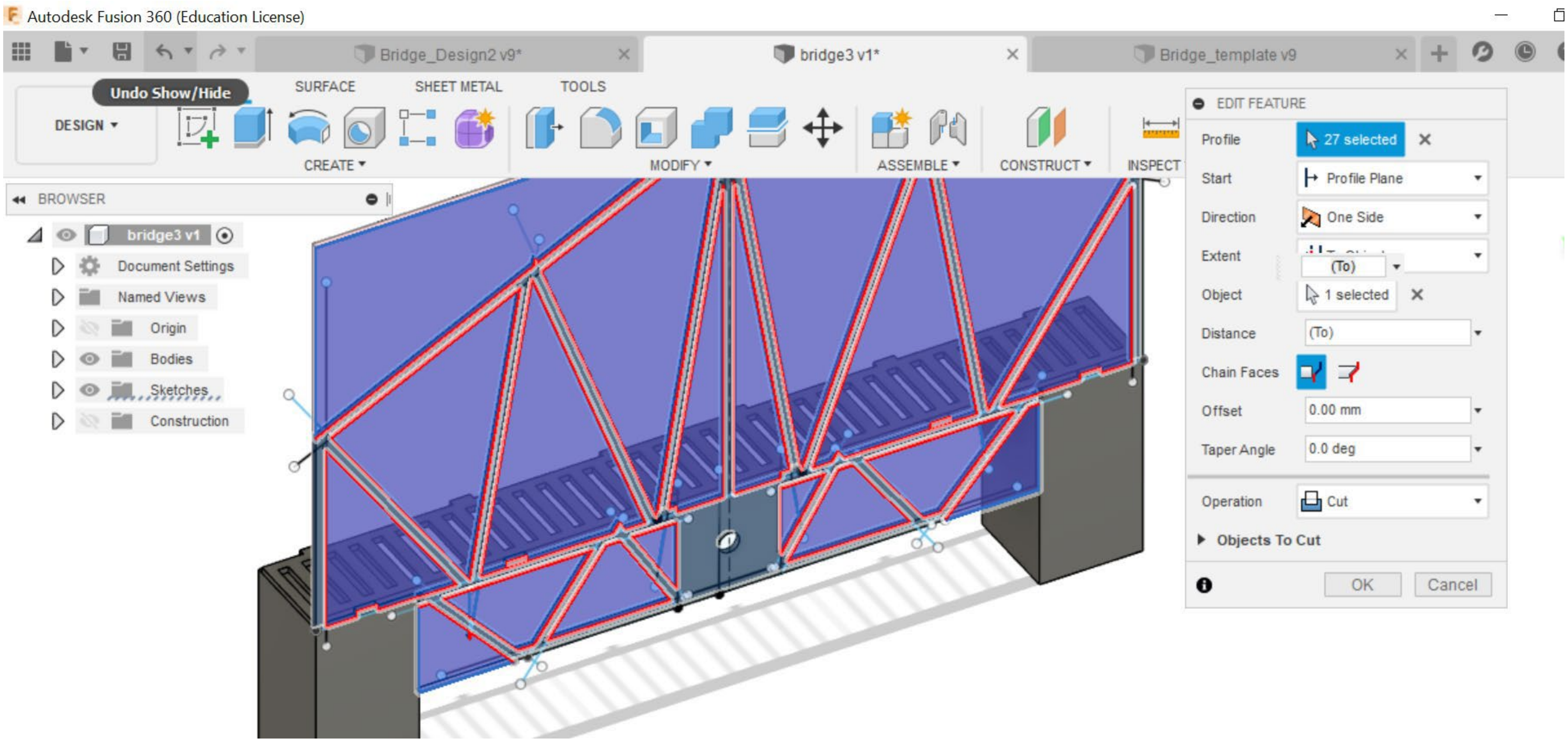
Task Two design:
Design, construction, testing and evaluation of a bridge using 3D CAD software and lasercut MDF wood

Bridge testing method
Simulated: Use CAD simulation software to conduct multiple tests
Real world: Span bridge between two surfaces and hang weights from the centre point

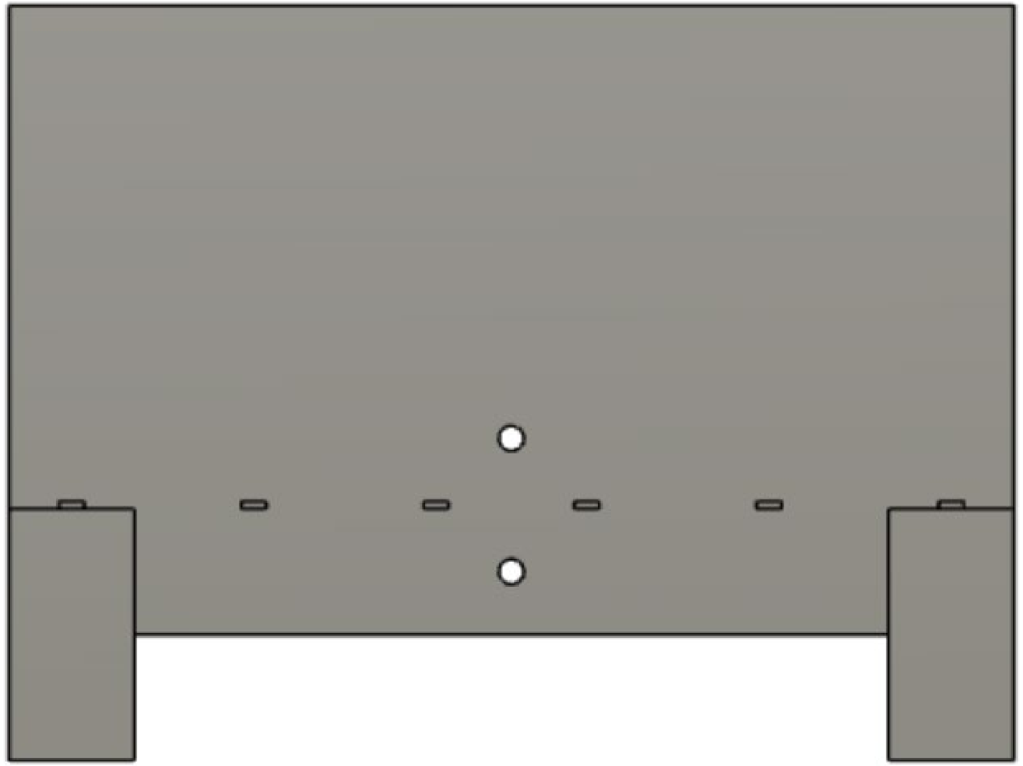
Constraints
Materials & parameter constraints – The bridge design must fit within the template footprint. No structural member (other than those specified) can be wider than 5mm.
Once again, students are not always able to stick within constraints guidelines – especially the boys

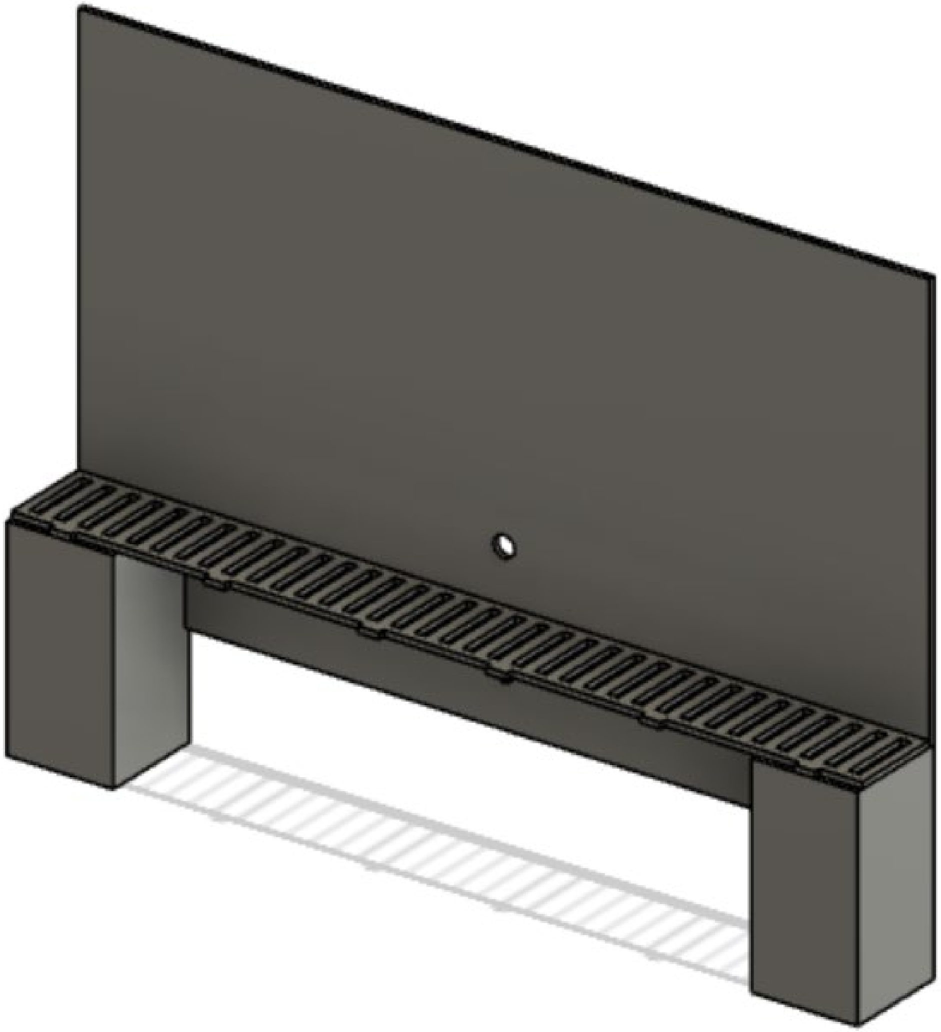
Evaluation of results
A fair & scientific method of analysis and evaluation was needed (We used Covid pandemic data as a backdrop for evaluating results)

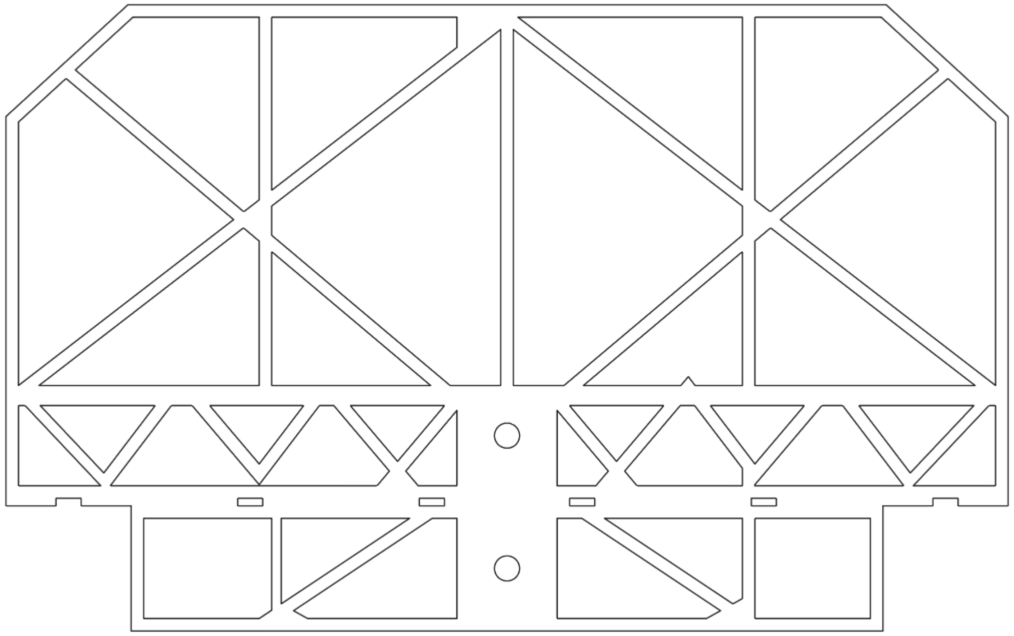
Students were trained in how to use Fusion 360 CAD software to design and test their bridge designs

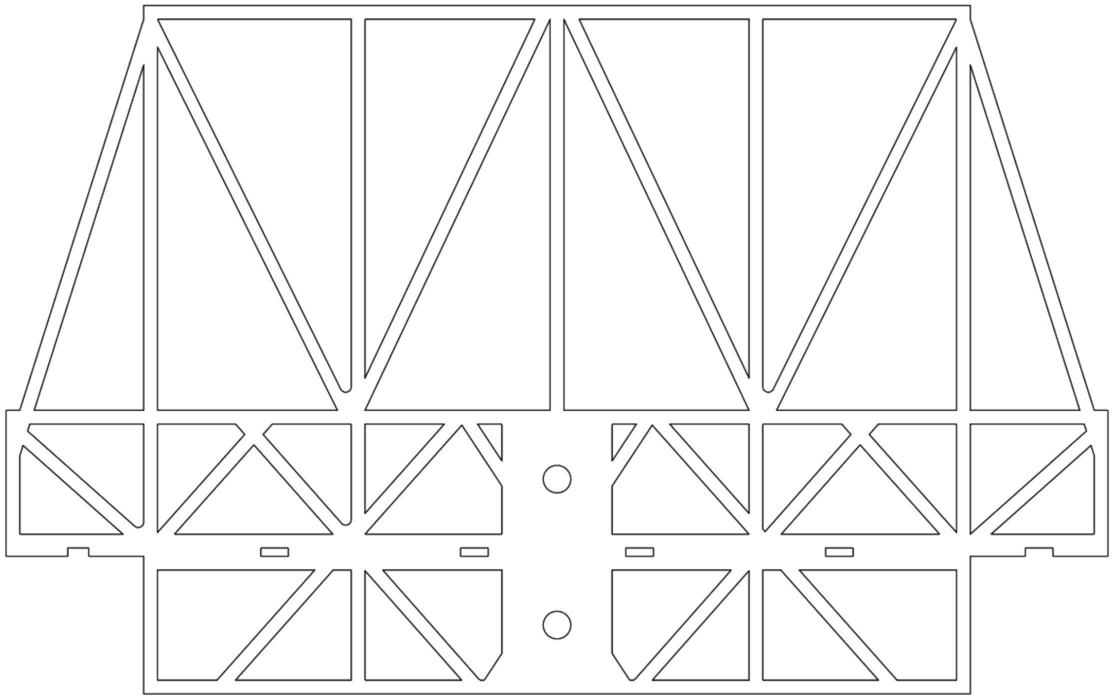


Design of the bridges was scaffolded via use of a template, which also helped the students work within the design constraints.

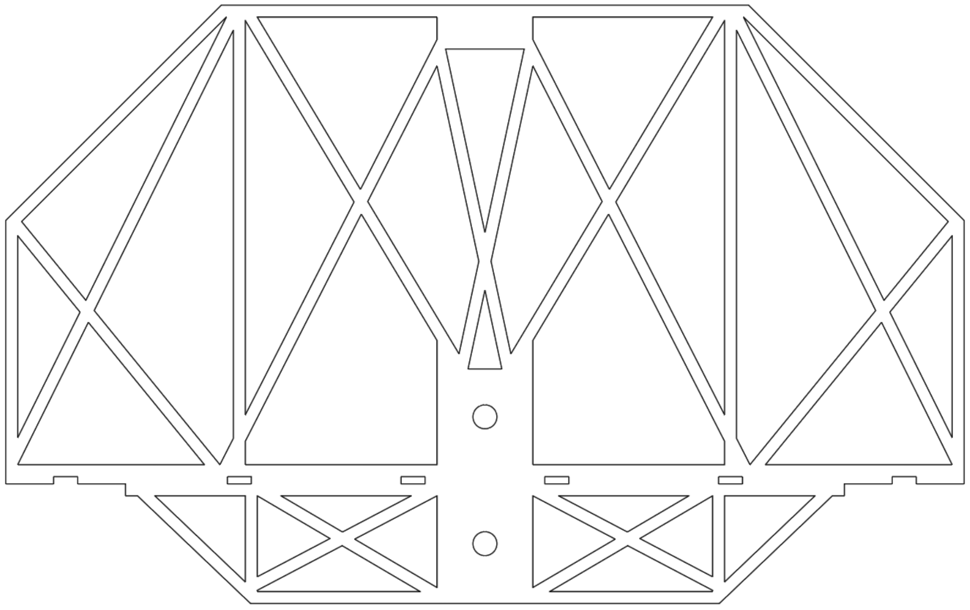


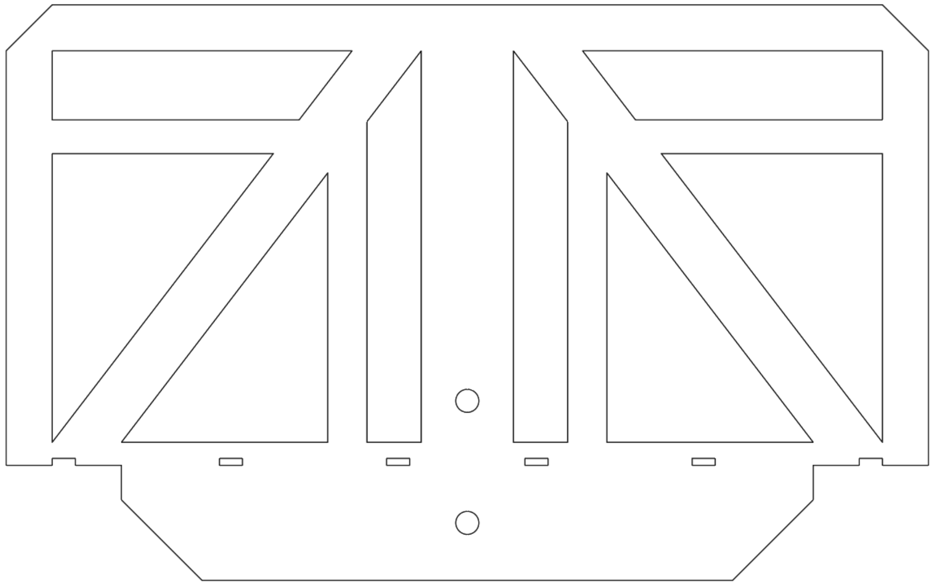






CAD Bridge Designs





The Systems Engineering Process

Priority	Engineering Stage	Order of thinking	Time Taken
1	Designing and modelling	High - Creative	
2	Evaluating / Reviewing	High - Evaluate	
3	Test / Diagnose	High – Analyse	
4	Plan / Produce	Low - Apply	
5	Identify / Research	Low - Understand	

Where the priority areas end up with outdated technology

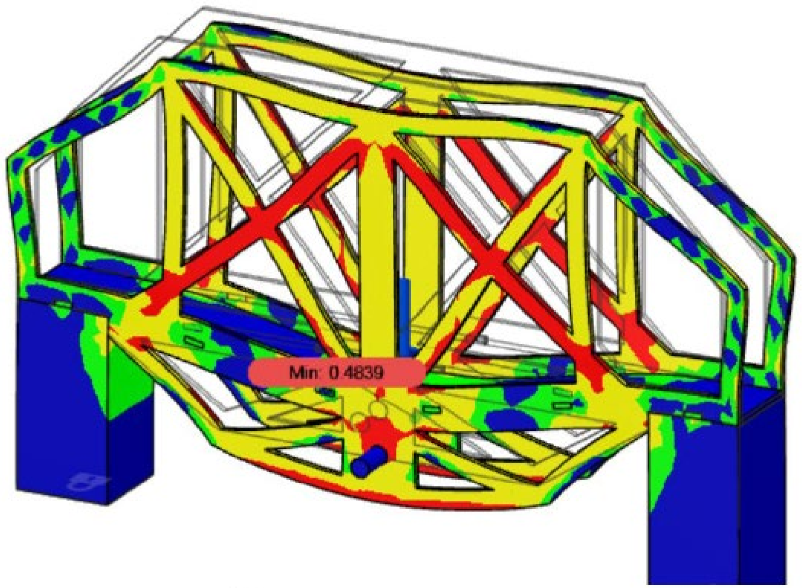
Time Taken	Engineering Stage	Order of thinking	Priority
4 Weeks	Plan / Produce	Low - Apply	4
3 Weeks	Designing and modelling	High - Creative	1
1 Week	Test / Diagnose	High – Analyse	3
1 Week	Evaluating / Reviewing	High - Evaluate	2
1 Week	Identify / Research	Low - Understand	5

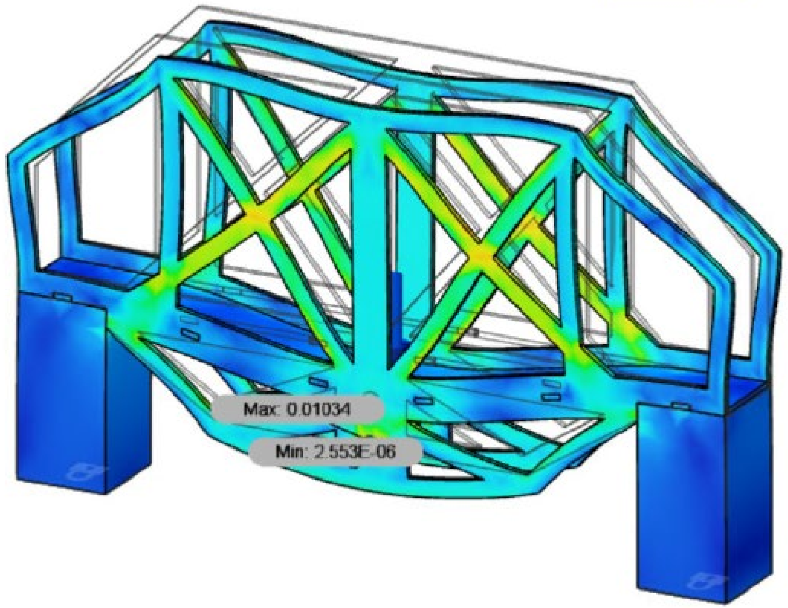
Cognitive Upsizers

Having access to a laser cutting machine meant that the time saved from the **‘production’** stage could be put into the **‘testing & evaluating’** stages.

A very important trade off.

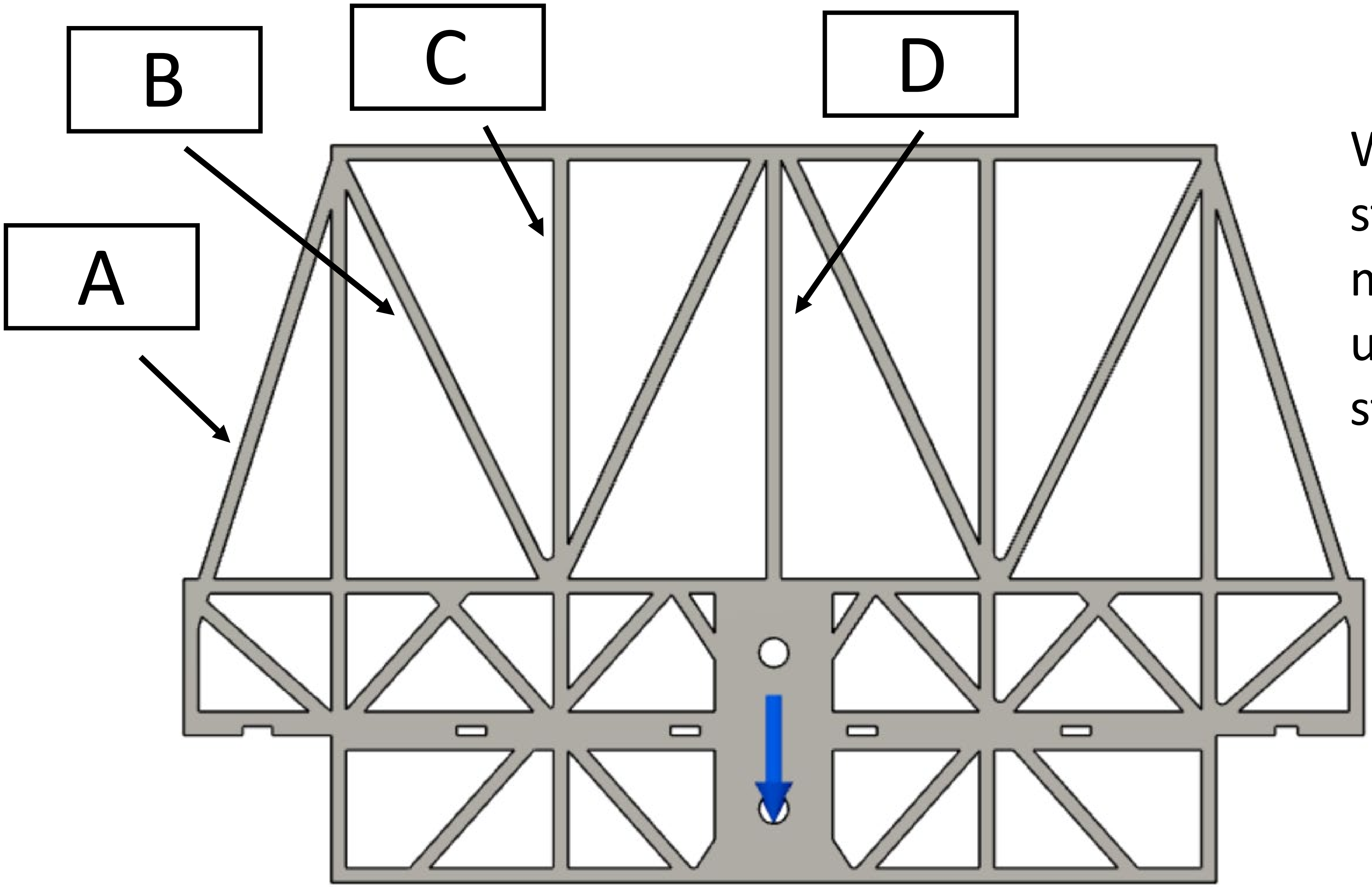
Simulation test



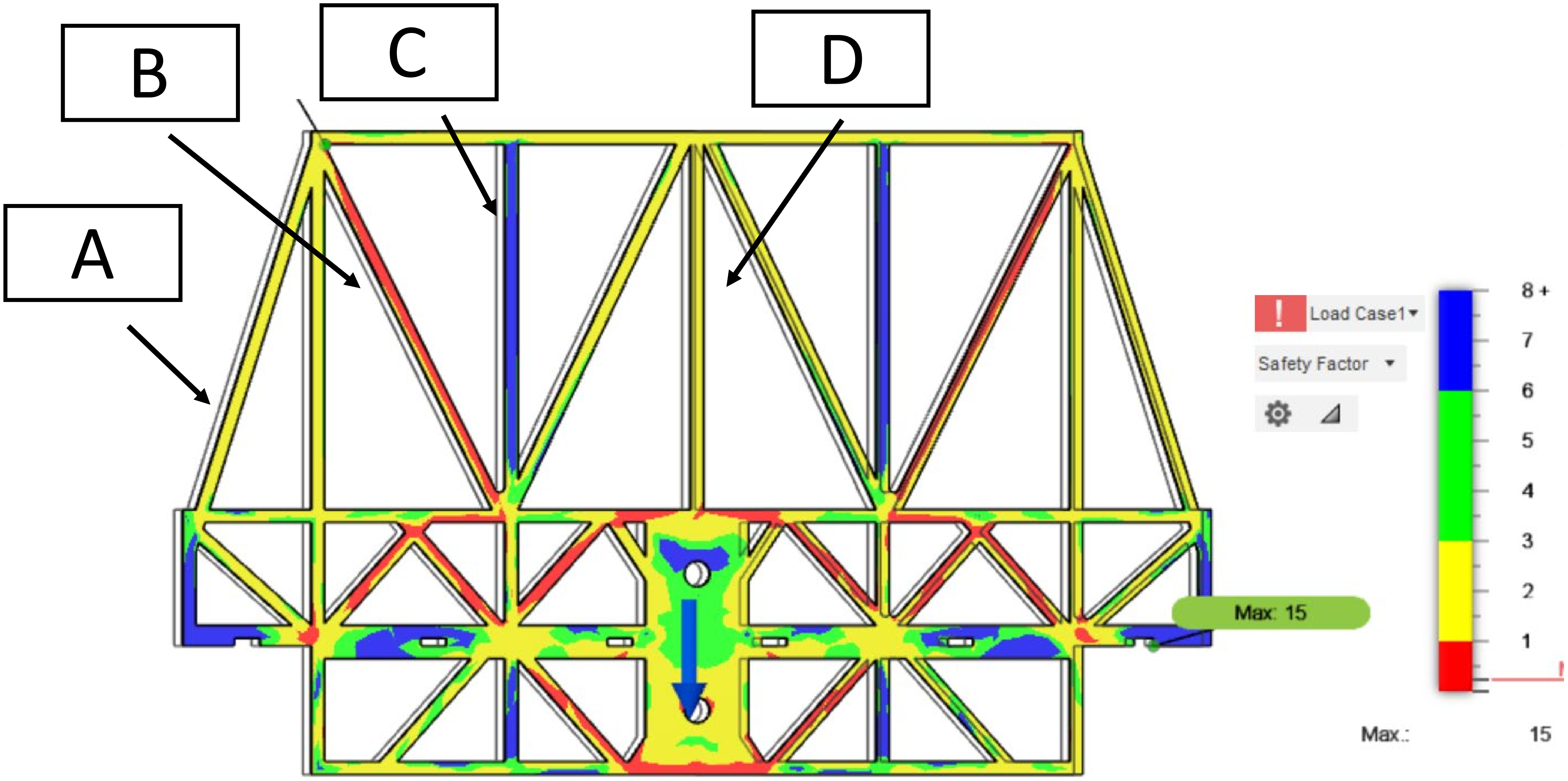


Students use the simulated stress test to make predictions of how their bridge will perform in a real-world stress test.

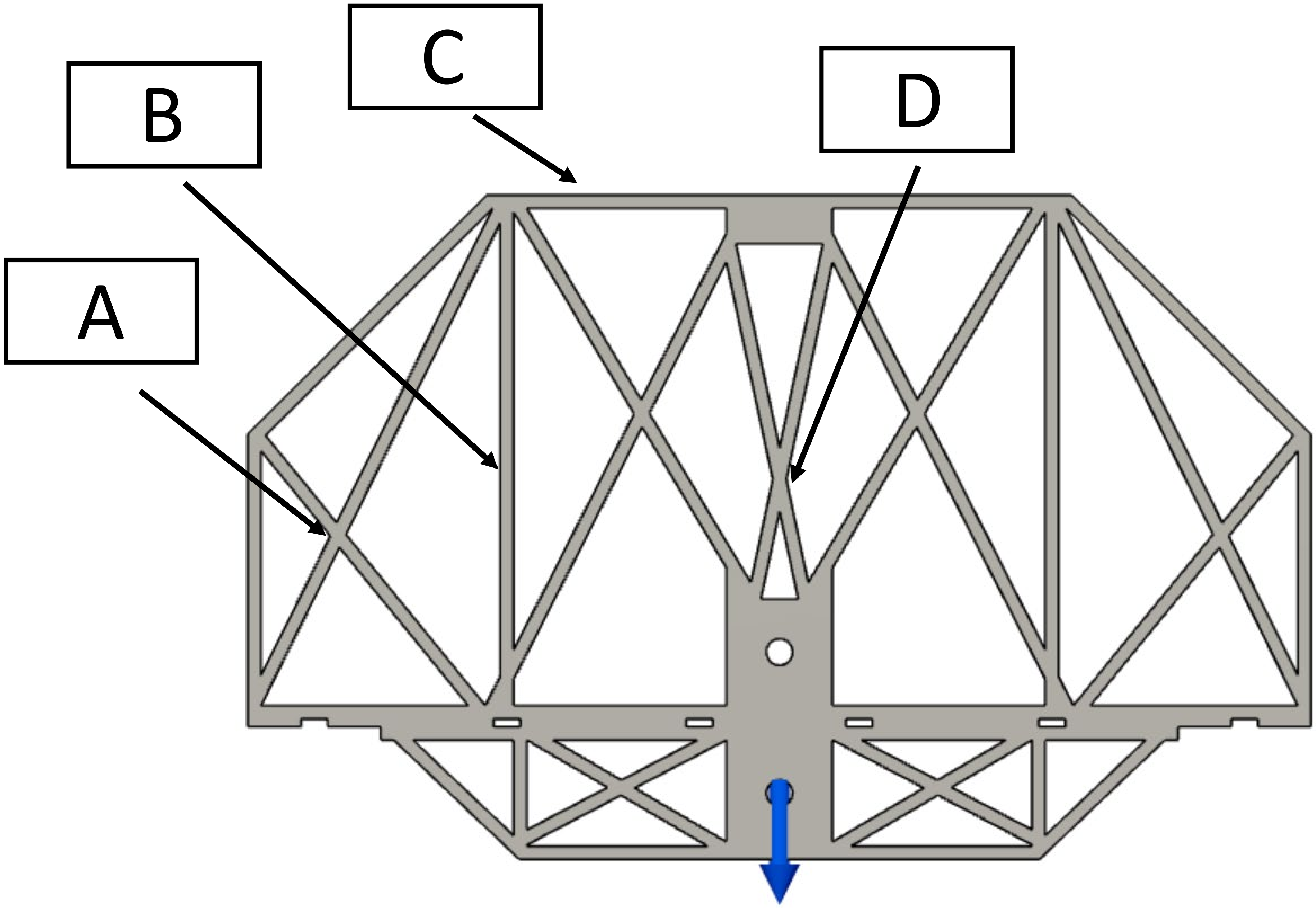
Test Environment Strengths
A major strength of the simulation test environment, is that the test can be performed multiple times, which allowed the students to make slight modifications and then re-test to evaluate their modified designs.



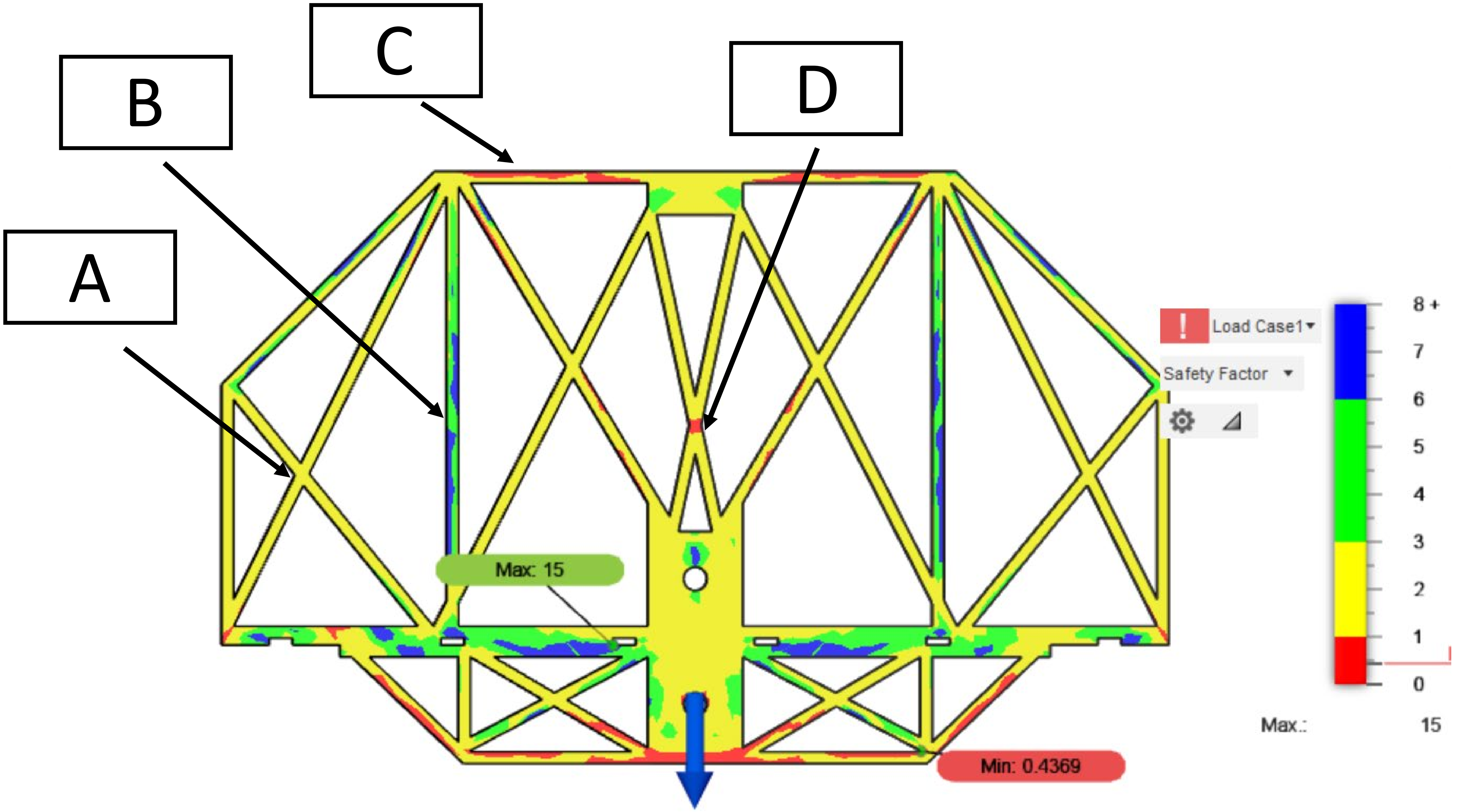
Which structural member will be under the most stress?



A
B
C
D
Load Case1
Safety Factor
Max: 15
8 +
7
6
5
4
3
2
1
Max.:
15

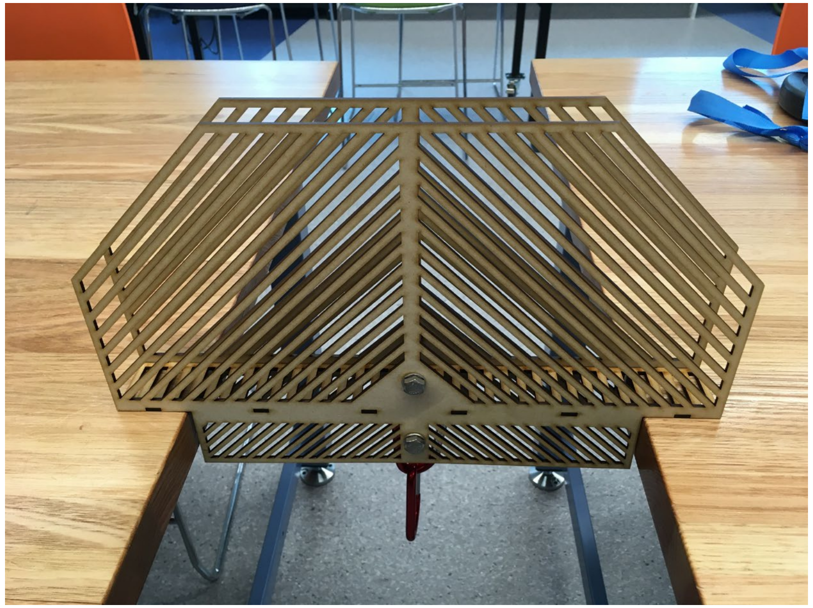


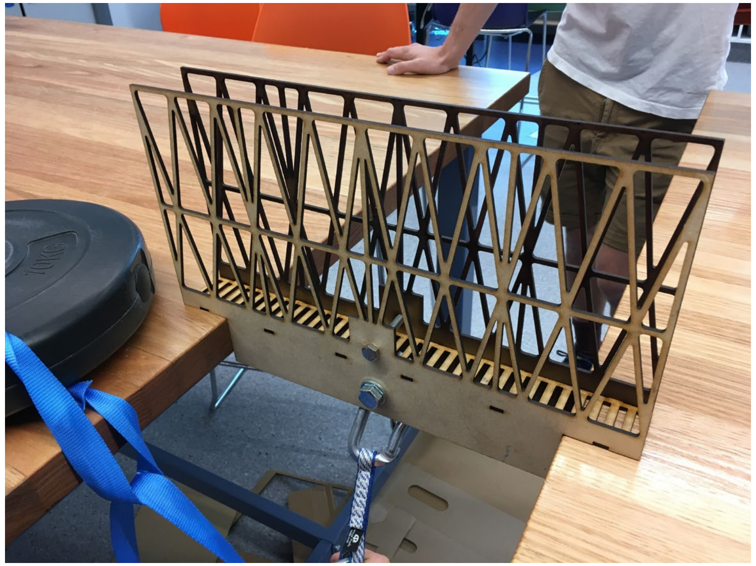
Which structural member will be under the most stress?

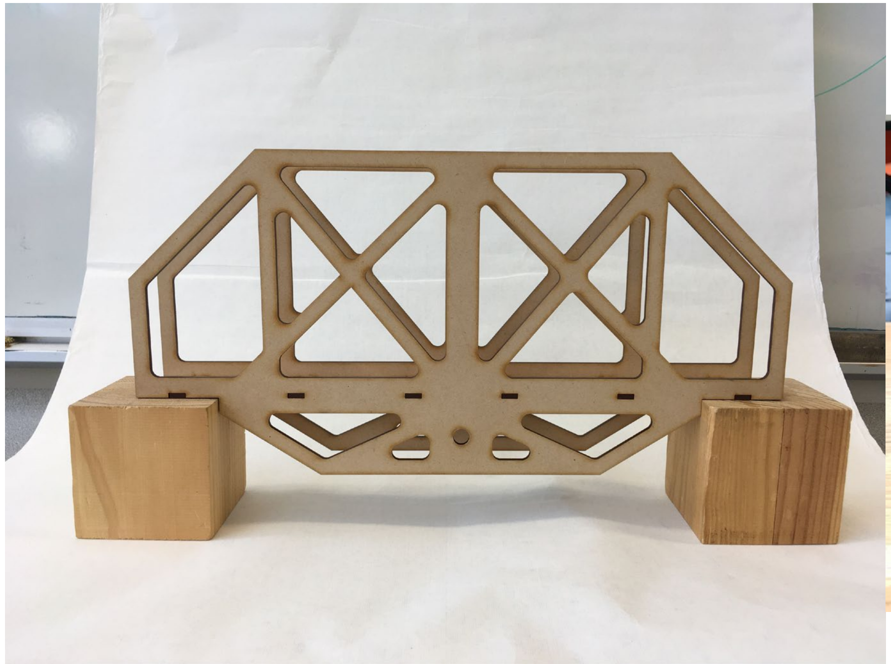


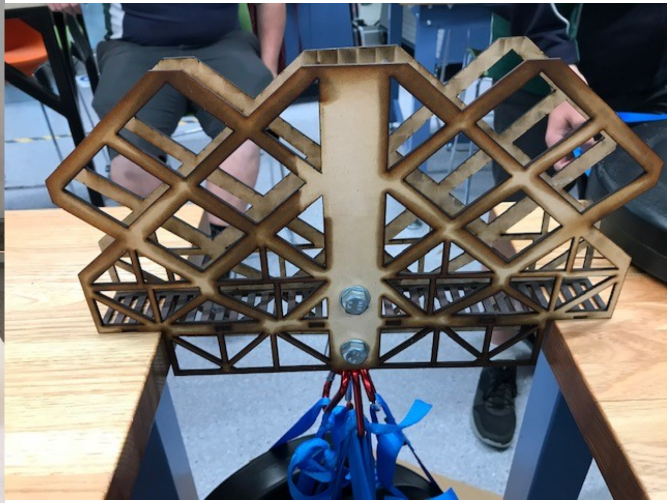
A
B
C
D
Max: 15
Min: 0.4369
Load Case1
Safety Factor
8 +
7
6
5
4
3
2
1
0
Max.:
15

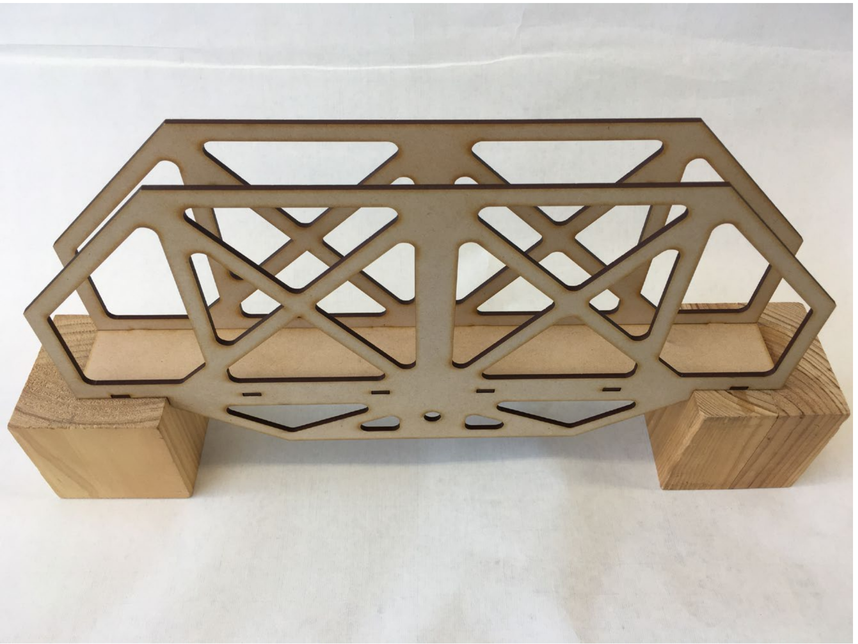
Laser-cut Bridges



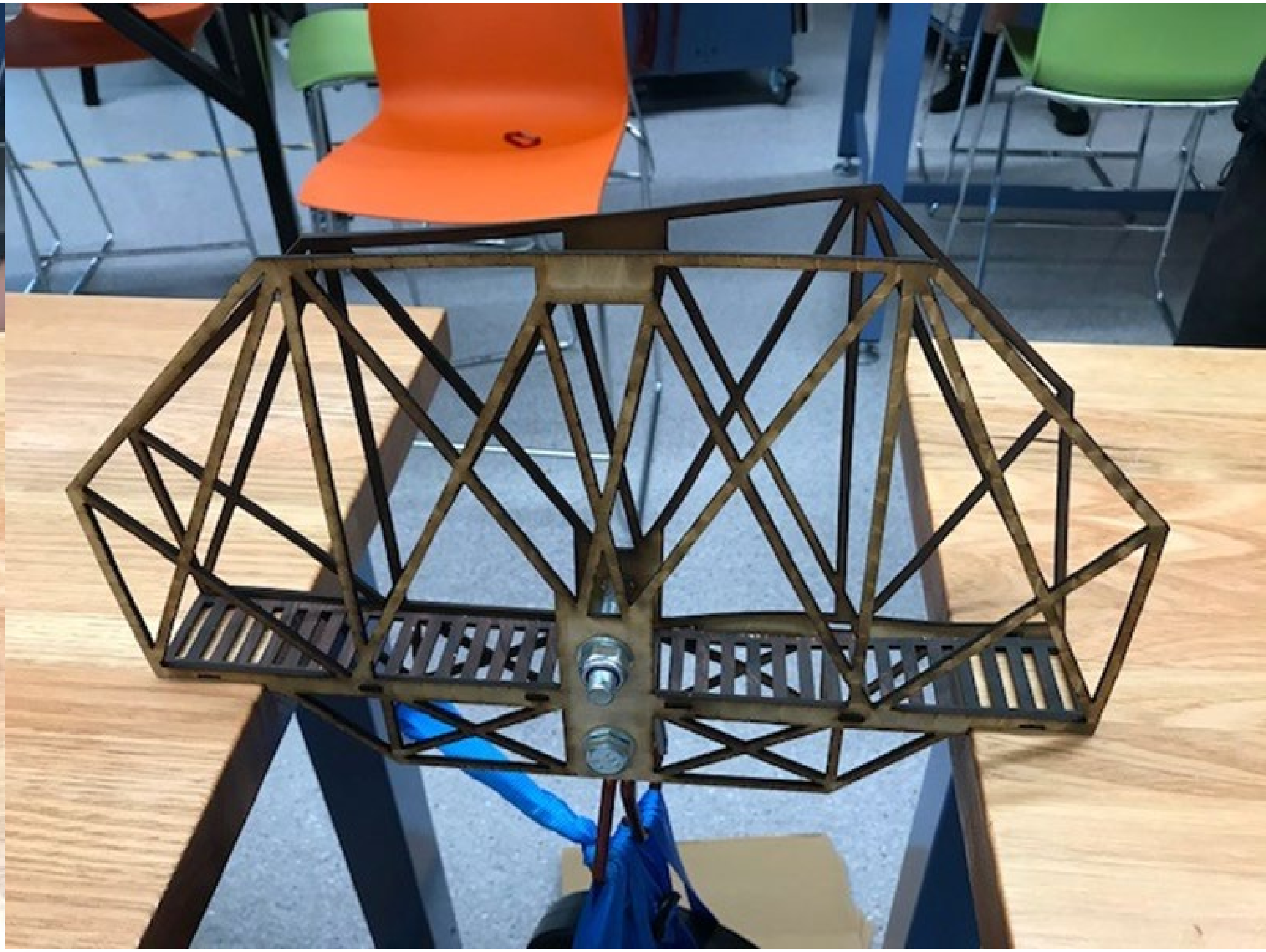








Real-world physical tests – bridges under load



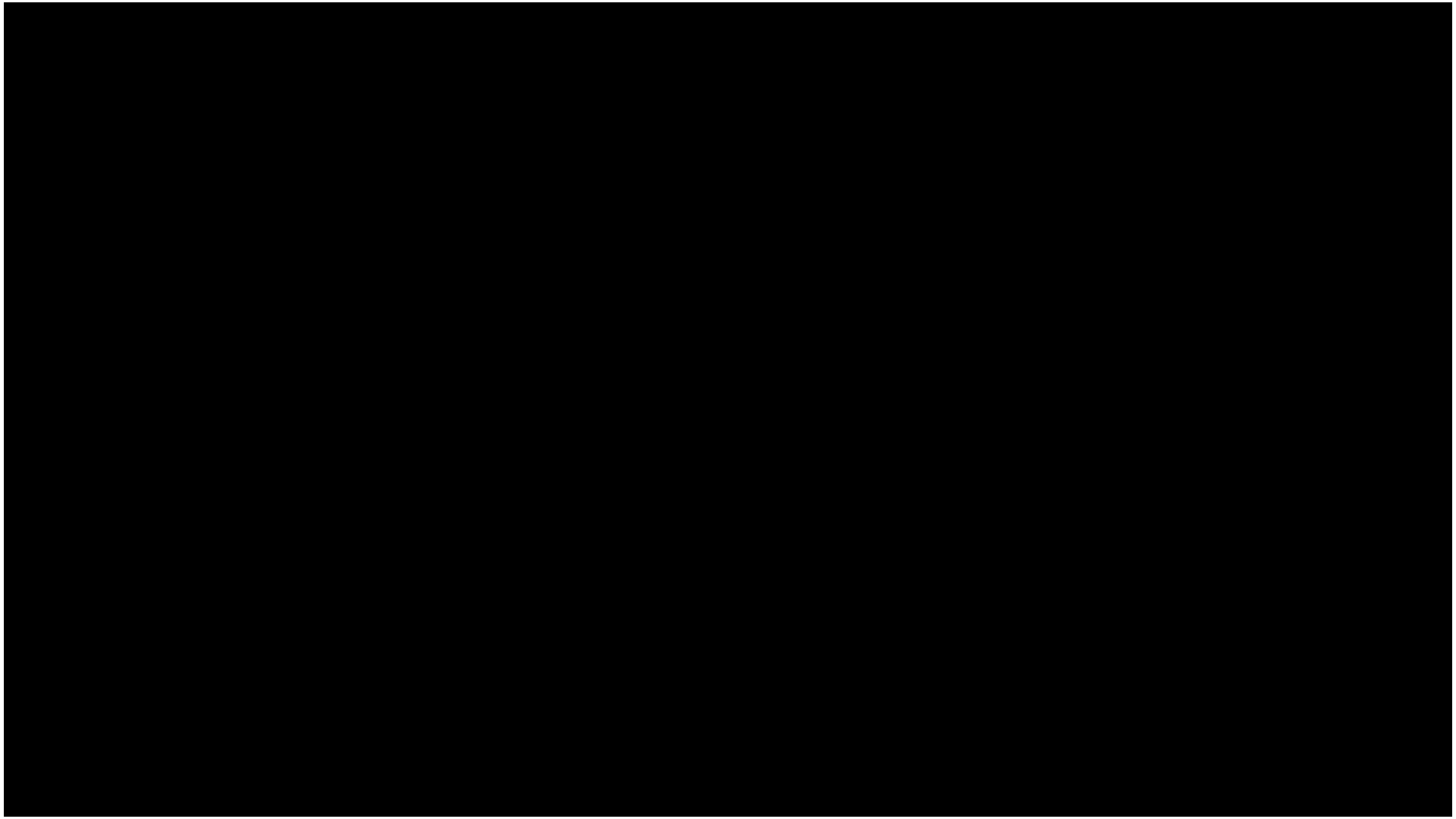
Physical Tests

Students used the data gathered from the simulated tests to inform their predictions about where the stress concentrations and breaking points would be on their bridges during the physical tests.

The students placed physical texter marking on their bridges to indicate these points.

Test Limitations

One major limitation in the physical test environment was the inability to record the bridge failure with a high speed camera. This piece of equipment would have allowed more accurate and detailed analysis.



https://youtu.be/sXkg6tBYyxU

Stage 3: Consolidation of understanding, synthesis & transposition of understanding to a new application

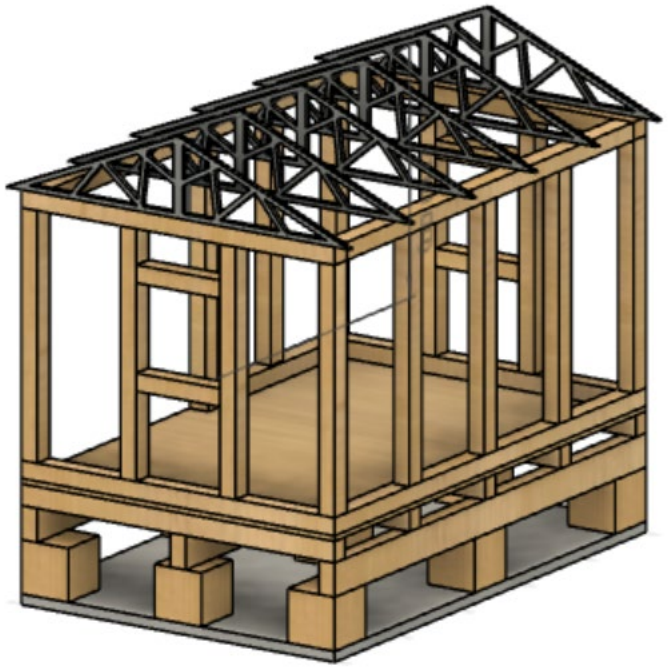
Learning Intention
Consolidation of CAD Design skills. Introduction electronics & embedded systems

Task Three design:
Design, construction, testing and evaluation of a model house

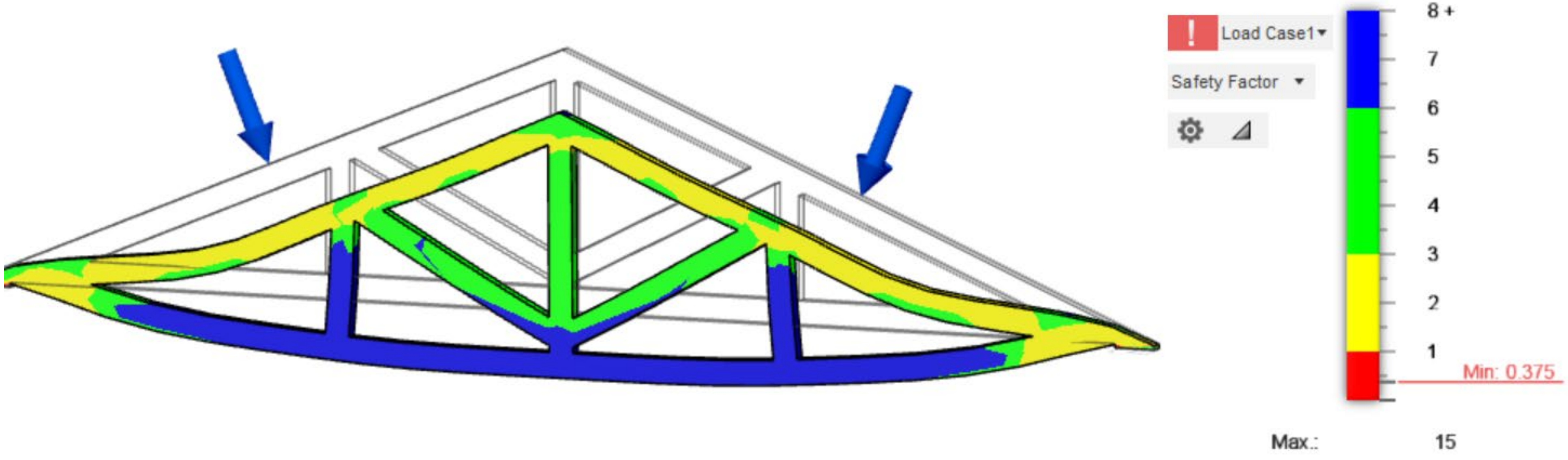
Testing method
Simulated: Use CAD simulation software to conduct multiple tests (Fusion360 & Tinkercad)
Real world: Test circuits and code using physical Arduino devices and electrical components.

Constraints
Materials & parameter constraints – All sizing must comply with standard construction material sizes scaled to the model.

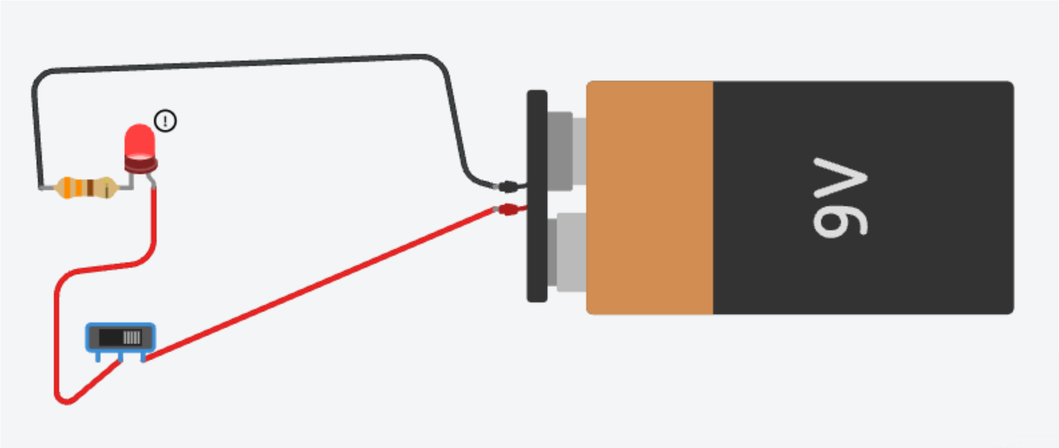
Evaluation of results
Electronics was evaluated using observations of functions compared with the predicted / expected functions.
Aesthetics also became an important evaluation criteria as the building progressed

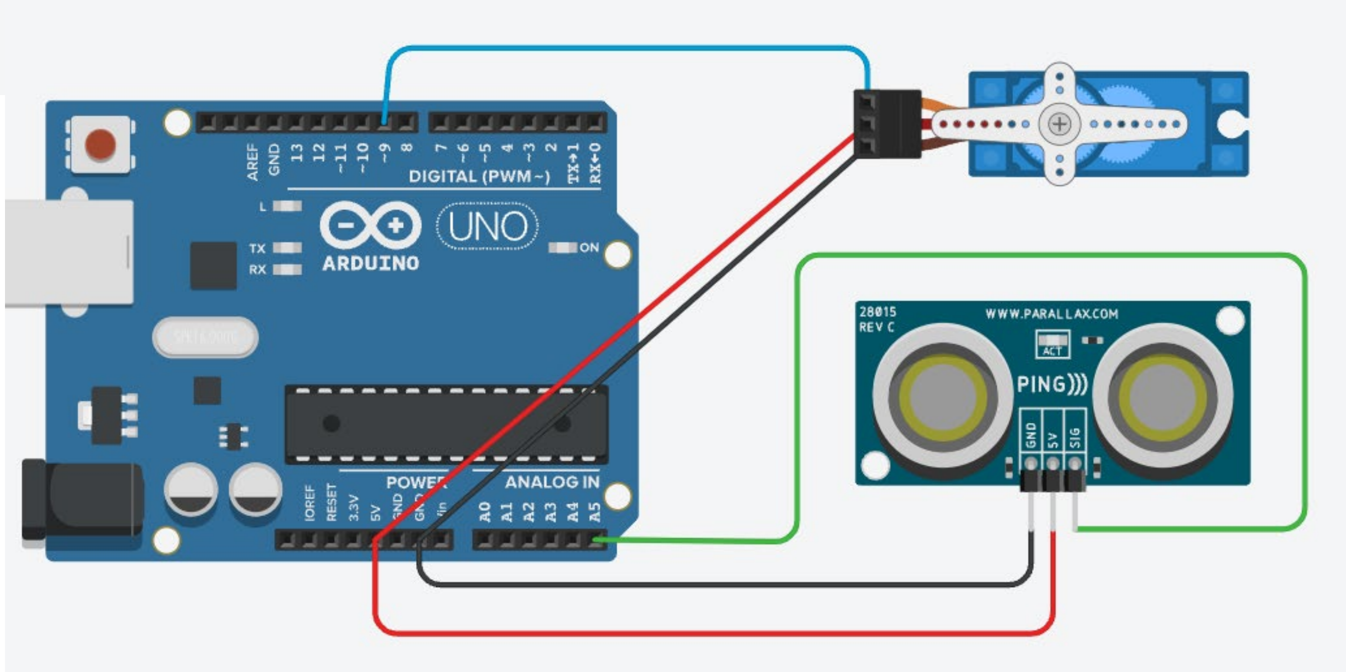


Students applied their newly acquired engineering skills and knowledge to help them solve problems in the new task and to help them design relevant tests.



Electronics Simulation Software





Students used the Tinkercad platform to test their circuits and code prior to conducting physical real-world tests.

Links to resources:

My YouTube Channel https://www.youtube.com/channel/UCjxo7WuMO-4xMRY_hqqeWaQ
More videos on this unit of work will be available soon

Fusion 360 Free Education link: https://www.autodesk.com/education/edu-software/overview?sorting=featured&filters=individual

TinkerCad - electronics simulation tool: https://www.tinkercad.com/

Online resources folder for this unit of work:
https://1drv.ms/u/s!AnMei_NOVnKXgrAaRAL3UEe64A5nKw?e=x12WLJ