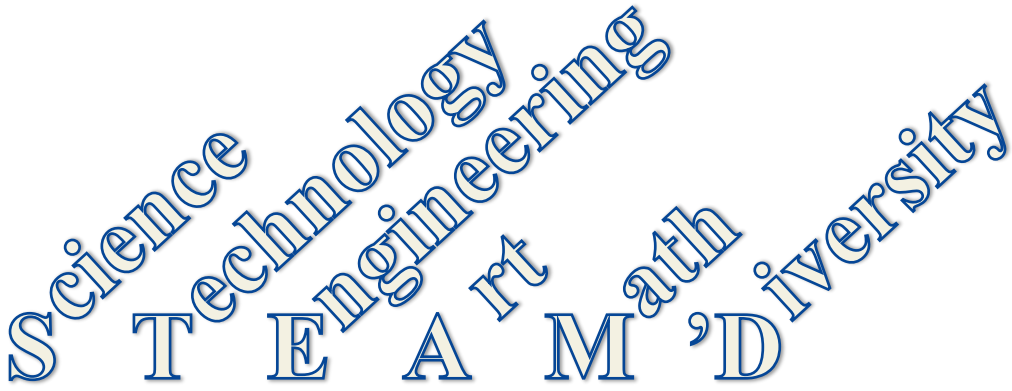
Thomas Telford Engineering Challenge

Supplement #2 to:

The Scots of Scarborough -- Volume 1, #1

A Contribution to the Scottish Diaspora Tapestry Tour
From the James McCowan Memorial Social History Initiative

- The Scottish Diaspora Tapestry: The Scots of Scarborough Exhibition, Celebrating the Relationship between Scots and the Forest
- The Tree (Anonymous)
- The Tree as a Learning Metaphor
- I Remember By John Rae ("Jack") McCowan
- Tools for Working with Trees… and Wood
- The Rae Family of Lesmahagow & Scarborough
- Thomas Telford, Eskdale Stonemason and Engineer
- James McCowan, Collier and Coalmaster



The theme of the Scarborough Panels of the Scottish Diaspora Tapestry is the relationship between the Scottish settlers and the forest.

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https://www.teacherspayteachers.com/Store/Mccowans-Basics-Of-Engineering

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Introduction from the Scottish Engineering Hall of Fame

(In *The Scots of Scarborough*, V1 #1) it was a pleasure to read of the early, determined struggles of Scots families in Scarborough (Ontario) to create a prosperous and thriving community. Mankind has a natural urge to build and improve, in the spirit of one of the greatest creative civil engineers of all time, Thomas Telford, who features as a possible, I like to think probable, connection to the emigrants from Eskdale.

The Scots are also inveterate wanderers and, in the words of Robert Louis Stevenson, *"and I see like a vision the youth of my father, and of his father, and the whole stream of lives flowing down there far in the north, with the sound of laughter and tears ...*"

However far one travels, invisible threads reach back to our roots and origins, and these deserve to be given substance, as in this narrative and the Scottish Diaspora Tapestry. I am pleased to see the reference to the Scottish Engineering Hall of Fame, doing exactly what it was intended - informing a wider world, and inspiring young people to see engineering as the creative art that it surely is.

I hope this good work in Scarborough can build too, and form the basis of educational projects so that the next generations can see those threads to the past and thereby give it substance and meaning, from which they too can build.

Professor Gordon Masterton, OBE
Chairman and Founder, Scottish Engineering Hall of Fame

Background… and the Challenge in Brief

For over three centuries, ordinary Scottish folk including coalminers, trades-people, farmers and farm servants have carried their strong work ethic, social institutions and values to the four corners of the globe. In their adopted communities they made new friends, learned together, and shared ideas, perspectives and dreams. In 2014, the Year of the Scottish Homecoming, the Scottish Diaspora Tapestry project (www.scottishdiasporatapestry.org) was front-and-centre in the celebration of Scottish achievement around the world. Hundreds of volunteers in over thirty countries where Scots made homes outside Scotland were all dedicated to finishing their panels for the Scottish Diaspora Tapestry. And the celebration continues with exhibitions of the Tapestry around the world! The Scottish Diaspora Tapestry will be on a North American tour May through December 2016.

Canada's multicultural diversity will be celebrated in Scarborough, Ontario, from September 17 to October 1, 2016, in a very special way.

The theme of the Scarborough panels of the Scottish Diaspora Tapestry is the relationship between the Scottish settlers and the Ontario forest. Some information about the Scarborough panels of the Tapestry is at:

- http://www.scottishdiasporatapestry.org/ca12-from-croft-to-clearing
- http://www.scottishdiasporatapestry.org/ca13-scarborough-logging-bee

2016 is ***Scotland's Year of Innovation, Architecture and Design***. The Scarborough exhibition of the 304-panel tapestry will be unique. Senior high school student teams -- wherever they may be -- are invited to design a 36-foot long model of the central unsupported span of the Menai Suspension Bridge by which to hang the entire Tapestry at the exhibition. The Menai bridge -- arguably the world's first modern suspension bridge and having a central unsupported span of about 175 m -- was designed by Thomas Telford (ca 1820) who had apprenticed as a stone mason in Dumfriesshire alongside the Thomson brothers who later settled in Scarborough.

The design work behind this new kind of bridge certainly involved innovation and both critical and creative thinking. The *Thomas Telford Engineering Challenge* will get students to practise the kinds of thinking that Telford probably used in order to "*come up with this new kind*" of longer-span bridge.

The student teams will also build a four-foot long model of their design which they will equip with strain gauges by which to monitor stresses in the members of their bridge.

Thomas Telford's Menai Bridge, Wales
(http://www.engineeringhalloffame.org/profile-telford.html)
Arguably the world's first modern suspension bridge

Please also refer to *The Scots of Scarborough*, V1#1, Supplement #1. This is an outline of some suggested initial learning activities for secondary school students. More learning activities in this regard are forthcoming – Science, Technology, Engineering, Art, Mathematics, Diversity.

Some Administrative Issues

The *Thomas Telford Engineering Challenge* is intended for senior high school students who have some interest in engineering as a career option.

Every member of a team (four to six students per team) must register for the challenge. Every team must be guided by a qualified teacher(s) in all aspects of the challenge. There is no "entry fee" for a student team to register for this challenge. However, teachers will purchase the learning activities and resource materials at:

https://www.teacherspayteachers.com/Store/Mccowans-Basics-Of-Engineering

There are costs associated with implementing the Scarborough Exhibition of the Scottish Diaspora Tapestry. A significant portion of the proceeds from the sale of the learning resources and activities will be used to offset the costs of the Scarborough Exhibition. Teachers may distribute the resource materials and learning activities only to members of their registered student team. Relevant learning activities and various supporting resources will be available starting Feb. 1/16. Starting Feb. 15/16, students on the registered teams will have free access to further relevant learning activities on http://thinkproblemsolving.org – quizzes, discussion forums etc.

The deadline for team registration is February 15, 2016. The deadline for submission of the design, technical report and all other evidence of learning is April 15, 2016. All submitted materials must be electronic – doc, pdf, ppt, jpg, mov, mpeg formats. Important design data / information from a CAD application must be exported or otherwise copied into one of the previously listed file formats and submitted as part of the Technical Report.

For further information, please contact: D. B. McCowan, P.Eng., Past Chair, Professional Engineers Ontario Education Committee, bmccowan@netrover.com or go to

https://www.teacherspayteachers.com/Store/Mccowans-Basics-Of-Engineering

Requirements, Constraints and System Considerations

In total, the Scottish Diaspora Tapestry is over 500 feet long, being comprised of 304 fabric panels of 540 mm by 540 mm each. The total mass of all panels is 100 kg. Every panel has Velcro along the rear of its top edge, by which it may be mounted.

To exhibit the tapestry in Scarborough, a creative solution is required. To hang the tapestry, groups of students will design a model of the central unsupported centre span of the world's first modern suspension bridge -- the Menai Bridge in Wales.

Some requirements / constraints include:

- The available space in the auditorium of St. Andrew's Presbyterian Church, Scarborough, is 44 feet long by 40 feet wide
- No holes may be drilled in walls, floor, ceilings
- Tables are available upon which supplementary Tapestry text will be displayed and above which the Tapestry must be hung:
    - The tables are each 48 inches long and 30 inches wide and 30.5 inches high
    - The tables link together end-to-end as shown below

- The teams will each produce detailed design drawings of their solution as well as a technical report dealing with elements of science, technology, engineering, art, math, and diversity (STEAM'D). Technical Report topics include (but are not limited to):
    - Analysis of the actual Menai Bridge: in essence, how does a suspension bridge "work?"
    - The thinking process that Thomas Telford might have used in order to "come up with" the idea for a new "kind" of bridge
    - Analysis of stresses in their model design
    - All document types that are necessary in the design / build / evaluate process (design brief, task list etc. as listed at ** below)
    - Design drawings and related documents must be sufficiently detailed for a reasonably skilled person(s) to build, assemble and install the bridge with little to no questions or uncertainty
    - In general, the team must show that their design is a superior solution and that it closely "models" the unsupported central span of the Menai Suspension Bridge in Britain.
    - **Note**: Questions posed in various Supplements to "*The Scots of Scarborough*" are intended to be helpful.
- The bridge must span more than 32 feet, but not greater than 36 feet (ie between the towers)
- The bridge must accommodate the prominent display of at least 240 panels, each of size 540 mm by 540 mm.
    - Note: Other arrangements are being made to display any remaining panels.
    - The Technical Report must justify the number of panels that are placed on prominent display on the bridge.
- Other than the cables (rope), the entire bridge must be made of wood
- Metal fasteners may be used.
    - Note: Every panel has Velcro along the rear of its top edge, by which the panel may be mounted
- Teams will then build a 1:10 scale model of their design – which, henceforth we will call the "4-foot model":
    - Teams must record / document the construction process
    - Teams may enhance their model bridge with electronic features

- Teams must design-in strain gauges and use a suitable hardware / software platform by which to monitor stresses in important members of their model bridge
- Teams must devise and justify test methods for the application of a 10 kg (total) load distributed uniformly on the deck of the bridge.
- Teams must record / document the testing process, results and analysis
- NOTE: The entire "system" must be tested. Of course this load must not cause breakage or permanent deformation of any part of the system.

Evaluation of Submitted Designs / Achievement Categories

An independent panel of Professional Engineers will judge entries in the following general categories:

Weight	Design Process Element	Achievement Category
15%	Analysis of Suspension Bridges such as the Menai Bridge	Thinking -- Critical
20%	Technical Reporting (Design Process documents)	Communication
20%	Design (including strength, stability, efficient use of materials and other essential concepts of technology in this context) (clearly stating assumptions)	Thinking -- Creative
15%	Build / Construct the 1:10 scale model of their design	Application
15%	Test / Monitor Stresses / Evaluate	Thinking
15%	Knowledge and Understanding of relevant fundamental concepts and processes: (Reports from the Moodle quizzes at thinkproblemsolving.org)	Knowledge

Teams must ensure that their evidence in each of the above categories is very easy for the judges to find – a "communication" issue.

Achievement Categories… During the Challenge… the Student Will…

Come to Know and Understand (Knowledge of Concepts and Processes)

- 3-Dimensional Parametric Computer Aided Design
- Safety in a shop using wood working tools
- Principles of working on an engineering design team
- Other concepts, procedures and work habits important in engineering problem-solving
- The thinking processes used by innovators like Thomas Telford, civil engineer
- Aspects of the agricultural and industrial revolutions in relation to improvements in socio-economic infrastructure
- The migration of peoples around the world, enhancing regional diversity, and their positive impacts on community-building

Reason-Out for Themselves (Thinking / Inquiry)

- Plan
    - Identify the problem, select strategies and resources
    - Assign tasks and due dates to team members and use sound principles of design team project management
    - Pose questions that need answers

- Solve Problems Using Critical & Creative Thinking, Tools of Math and Concepts of Science
    - Use the design process to find and thoroughly document a solution – how to creatively exhibit almost 300 tapestry panels, each of which is 540 mm square
    - Practice the kinds of thinking that the innovator Thomas Telford probably used in his development of the modern suspension bridge
- Process Information
    - Recall relevant information from memory regarding concepts and procedures from other course work or grade work, including science, math, technology
    - Translate given statements into their own words or into another format (graph, equation etc.) for example, to make a problem easier to understand
    - Interpret multiple statements (pages, paragraphs, sentences) within a particular context – sort, group, prioritize, classify, summarize, "read between the lines", state simplifying assumptions, reveal relationships, make simple connections between ideas, filter out "noise" (and use the 80/20 principle)
    - Apply recently acquired knowledge (including tools of math and concepts from science) in a new situation, reinforcing connections
    - Analyze a more complex situation: take apart; break down into sub-systems; make valid assumptions; reverse-engineer; form conclusions; know when to obtain more data; use formal logic; to Analyze is an essential ingredient for "critical thinking"
    - Synthesize alternative solutions: Put together; goal-setting; combine seemingly disconnected concepts into a workable value-added product or process; to Synthesize is an essential ingredient for "creative thinking"
    - Evaluate – Make judgments against criteria; weigh pros and cons; decision-making; monitor the success of a solution; self-examination; reflect on learning

Communicate to / with Others (Communication)

- ** Produce design process documents: Design Brief, Research Report, Requirements, Specifications, Task List, Design Drawings, Parts List, Fabrication Plan, User / Assembly / Installation Guide, Warning Labels, Promotional materials, Test Report.
- Collaborate with other team members verbally, visually and in writing (four to six students per team)

Do and Practice (Application of Skills)

- Use a parametrically-driven 3D Computer Aided Design package to design a 36 foot long model of the unsupported central span of the Menai Suspension Bridge
- Use wood-working tools to build a four foot long model suspension bridge – a 1:10 scale of their design
- Instrument the four foot bridge using strain gauges and a relevant hardware / software platform
- Trigonometry, algebra, free-body diagrams, law of the lever, cancelling units of measure – and other tools of math and concepts of science
- Improve sound work habits
- Improve essential skills