

2020 Delaware Bridge Design Competition
11th – 12th Grade Guidelines



Refer to Bridge Design Competition for Important Dates

1. **Objective:** The objective of the Delaware Bridge Design Competition is to design and build a model cable-stayed bridge that will be tested for a strength-to-weight ratio using balsa wood. Student teams from across the state of Delaware will compete against one another, with grade levels ranging from 11th to 12th. Interested teams should fill out the application form provided on the DelDOT Bridge Design Competition website and submit it prior to the deadline. Teams are required to submit a proposal explaining their design process and experiences during the project. Drawings detailing each team's design should also be submitted with the proposal. On the day of the competition, teams will present a 10 minute PowerPoint presentation and structurally test their bridges against teams throughout the state to determine the winning bridge. A Challenge Entry Kit will be provided to each team to begin their project. Only materials included in the kit supplied can be used in the construction of the bridge. The material kit will be shipped by the specified date on the bridge design competition web page. The competition objectives are for students to:

- a) Design a **Balsa Wood Cable-Stayed Bridge** (Specifications in section 5 of this guideline) using the least amount of materials to support the desired load.
- b) Effectively communicate their analysis and design processes through a report portfolio. Report should include design drawings using Bentley PowerDraft CAD software.
- c) Give an oral presentation on the final design.

Each bridge will be checked for design according to the rules. The bridges will be weighed and strength tested during the competition to calculate strength-to-weight ratio.

2. **Eligibility:** Students eligible range from 11th – 12th grade and should attend a school located in Delaware. The Delaware Bridge Design Competition is designed for teams of three (3) students to participate. While schools should strive to create teams of 3 students, the Delaware Bridge Design Competition is an inclusive event and will accommodate teams of 2 or 4 as well. Teams can be no larger than 4 students.
3. **The Challenge:** An engineer's job is to not only design a safe bridge to carry required loads, but also to make sure that it is cost effective (least amount of materials used to achieve the desired load). To simulate this process, teams will use the following strength-to-weight ratio calculation to develop a bridge that carries a high load capacity relative to the bridge weight. Strength to weight ratio is determined by dividing the maximum load carried by the weight of bridge.

Example: Assume a team constructs a bridge with the following characteristics

- Maximum load = 120 pounds (lb.)

- Unit conversion: 1 pound = 454 grams (g)
(120lb. × 454g/lb.) = 54,480g
- Bridge weight = 20g

4. **Materials:** Provided in kit

- Balsa Wood
- String
- Ruler
- Long Pins
- Drafting Paper
- S-Hook
- U-Bolt Bracket
- Wax Paper
- Model Smart 3D Software
- Wood Glue
- Painter's Bucket
- Measuring Cup
- Safety Cutters
- Safety Manual
- Bridge Builder CD
- Teacher's Guide CD
- MicroStation V8i Software

5. **Bridge Specifications:** Students will design and build a model cable-stayed bridge based on the following specifications.

- The materials provided in the kit are the **ONLY** materials to be used when building the bridge structure. Any modifications to the structural properties of the balsa wood or using different glue than provided will result in judges recording zero (0) weight held.
- The instrument used for testing will be the Pitsco Structures Testing Instrument as seen in figure 2.
- Lamination shall be permitted one layer thick, in either direction, as shown in the picture below. Lamination is gluing two members along their length. **ONLY** the vertical elements of the piers are permitted to be laminated in a 2x2 configuration. Bridge decks will **NOT** be permitted and will result in judges recording a zero (0) for weight held.
- Connections can be butt joints, miter joints, or notched joints. Lap splices are permitted, but no greater than 1/4 of an inch.
- The distance between the centers of the piers shall be 14 inches. The back spans should be at least 8 inches from the center of the piers to accommodate the loading of the back span. The minimum length of the bridge will need to be 30 inches. See below for details.
- The bridge deck shall be no taller than 2 inches.
- No part of the pier shall overhang the tester supports lengthwise nor touch the bridge deck outside of the support. The bridge deck can freely sit on the pier within the 1.75 inches of the tester support, but not touch the tester support. **The bridge deck must not**

be glued to the bridge pier. The piers must be no wider than 4.5 inches at the bottom, but can be wider as the towers rise vertically

- h) A block of wood that is 30 inches long by 2 inches wide by 1 inch high must be able to be laid across the bridge deck as shown in figure 3. Therefore, the deck must be wider than 2 inches to accommodate the block.
- i) Tester supports will be placed at 14 inches on center (see figure 3).
- j) During testing, the bridge cables (strings) must be utilized in load transfer to the piers. The bridge shall be designed to work as a whole (deck, piers, and cables).
- k) There will be three points of simultaneous loading spaced at 14 inches on center. The middle of the center span must have a 3/4 inch hole to allow a 5/8 inch testing rod/bolt to pass through and attach to the 30 inch block of wood for strength testing as seen in the picture and the diagram below. The rod/bolt must be able to pass through the full height of the bridge. Diagrams do not represent the required design and shall only be used for dimension reference.

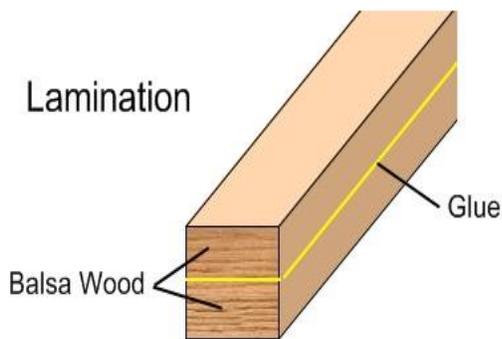


Figure 1. Lamination



Figure 2. PitSCO Tester

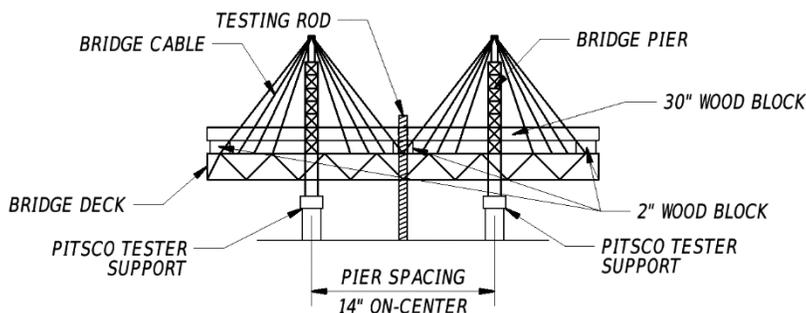


Figure 3. Tester Configuration Detail

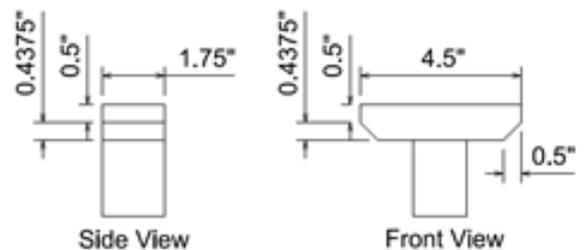
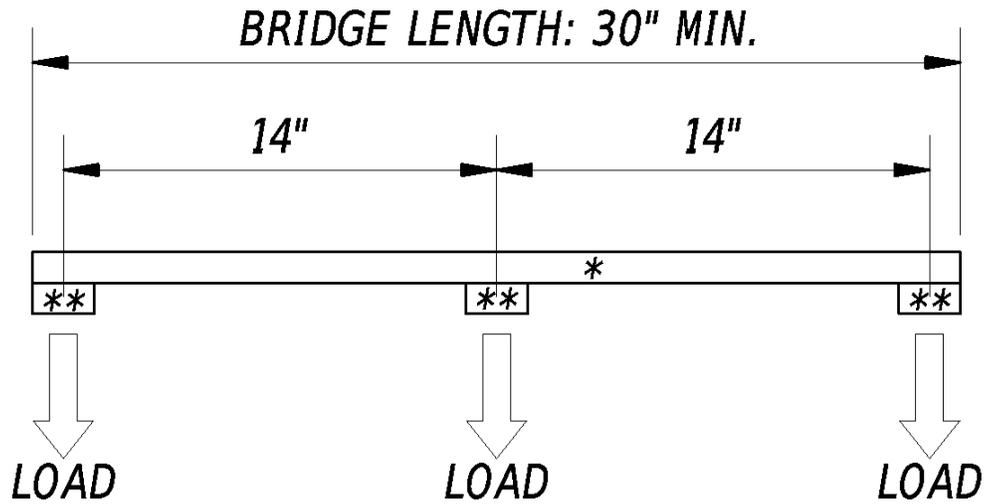


Figure 4. Support Detail



***30" LONG x 2" WIDE x 1" THICK BLOCK**

**** (3) 2" LONG x 2" WIDE x 1" THICK BLOCKS**

Figure 5. Loading Block

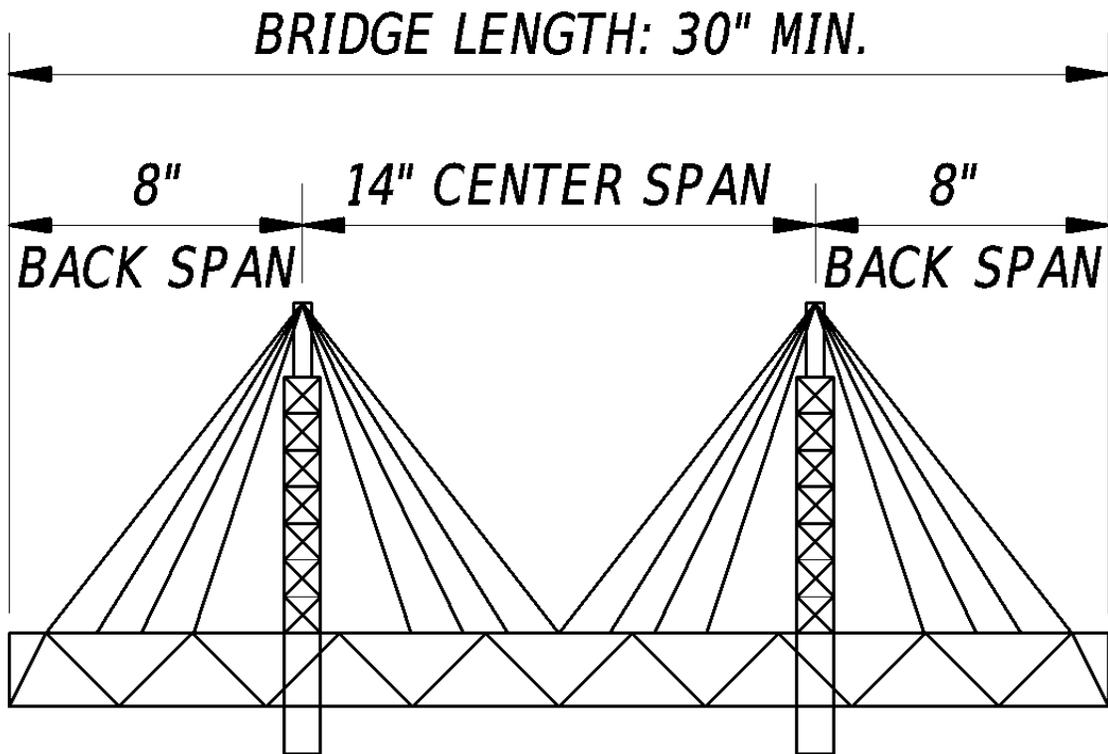


Figure 6. Bridge Span Configuration

PERFORMANCE (40% of the total score) – Achievement of performance goals and stability of construction. Bridges will be weighed and then tested on the structural tester. Results will be used to calculate strength-to-weight ratio. Any bridge not meeting the specifications in section 5 will result in a disqualification in the performance section and a score of zero (0) points. Bridge performance will be given a maximum of 100 points:

Scores on the strength-to-weight ratio will be based on the following equation: $(\text{Ratio}_i / \text{Ratio}_{\text{Highest}}) * (100 \text{ points})$

- Ratio_i = The strength-to-weight ratio of the team being judged
- $\text{Ratio}_{\text{Highest}}$ = The highest strength-to-weight ratio recorded amongst all teams

Example:

Team 1 – Strength-to-Weight Ratio = 3000; $(3000 / 3000) * (100) = 100$ Points

Team 2 – Strength-to-Weight Ratio = 2000; $(2000 / 3000) * (100) = 66.67$ Points

Team 3 – Strength-to-Weight Ratio = 1000; $(1000 / 3000) * (100) = 33.33$ Points

6. **Proposal Specifications:** The information below gives an indication of what the judges are looking for in each section.

a) **Proposal Format:** The written proposal should be typed, double-spaced using size 12 Times New Roman font on 8.5 x 11 paper with all pages numbered, and 1 inch margins all around. Sections **must** be in order of the outline below.

- I. **Title Page** – Include name of competition, type of bridge, team name, team logo (each team must have a unique logo), name of the school or organization, names of students, name of teacher or advisor.
- II. **Table of Contents.**
- III. **Summary of Proposal** – Clearly and concisely stated. (At least ½ page, no more than one page).
- IV. **Introduction to Team** – Indicate the team name, team members as well as the background of each member
- V. **Body** – The main part of the report.
 - i. Explain the scientific principles behind your design.
 - ii. Describe the design and engineering challenges you encountered.
 - iii. Include Graphs and/or charts representing bridge testing and any supporting Calculations.
 - iv. Include at least five (5) screen-shots of modeling software used.
 - v. Include at least five (5) pictures. Picture will include at least one of each of the following:
 - a. Team working during bridge design.
 - b. Team working during construction.
 - c. Constructed bridge.
 - vi. Explain how you tested your design, and the improvements this led you to make.

- vii. Describe the construction challenges that you encountered in building your bridge and how you solved these problems.
- VI. **Conclusions** – Include recommendations about construction and design changes you would consider for future bridges. Summarize the overall success of the project through design and construction. Discuss what the team learned throughout the project.
- VII. **Acknowledgments** – List the names of the adults who assisted you in the project with a brief description of what they did. Include a certification, signed by all student team members and adults assisting, stating that: “We hereby certify that the majority of the ideas, design, and work was originated and performed by the students, with limited assistance by adults, as described above.”
- VIII. **Bibliography** – List all references used, using MLA formatting.
- IX. **Appendices**
 - i. **Daily Journal and Schedule:** Include progress reports of day-to-day work on project, including date, performance, and comments from each team member. Show on a time line, or similar method, how you scheduled your project. Include brief records of meetings, telling how you managed the schedule.
 - b) **Timeliness:** Proposals received after the deadline will not be accepted.

PROPOSAL (30% of the total score) – Proposal reports will be evaluated on formatting, presentation, and design and construction. Reports should be well thought out and provide substantial information on the design process. See included **Proposal Scoring Rubric** for scoring assessment. This is a helpful guide to follow while formulating the proposal.

Each team is required to submit either an electronic copy of their proposal or two (2) hard copies of their proposal to Nicholas Dean, a Supervising Engineer for the Delaware Department of Transportation. **Electronic copies of the proposal are preferred.** Do not send the bridge itself. All entries become the property of Delaware Department of Transportation and will not be returned.

7. **Design Drawing Specifications:** Computer Aided Drafting (CAD) is used to convey an engineer’s plan to stakeholders in order to produce safe, efficient, and cost effective projects. Bentley PowerDraft CAD is provided at no cost to all participants. Refer to the website for download instructions and how to use video tutorials. All design drawings required for the competition must be created using applicable CAD software and be presented on one of the following sheet sizes:
 - 8 ½” x 11”
 - 11” x 17”
 - 22” x 34”

It is the responsibility of the competitors to ensure the design drawings are easily read and understood. Judges will examine each entry to make sure it fits the specifications given in the rules. Each team’s drawings must resemble their balsa wood bridge model entered in the competition.

Specifications

- a) Three (3) views must be provided:
 - I. Plan (top view looking down on bridge)
 - II. Section (vertical slice through center of the bridge)
 - III. Elevation (side view of bridge)

DESIGN DRAWINGS (15% of the total score) –CAD drawings of the bridge showcases the team’s use of the software. Drawings will be given a maximum of 100 points. See included Design Drawings rubric for scoring assessment. This is a helpful guide to follow while formulating the drawings.

8. **Oral Presentation:** Teams attending the DelDOT Bridge Design Competition will present to a panel of judges comprised of various engineers. Each team will be expected to make a PowerPoint presentation and be able to answer questions from the panel of judges about their entry. Supporting materials may be presented to the judges.

ORAL PRESENTATION (15% of the total score) – Teams will present a 10 minute PowerPoint presentation (a deduction is assessed if over or under 10 minutes). A 5 minute questionnaire session will follow the presentation, where judges will ask questions pertaining to each team’s project. See included Oral PowerPoint Presentation rubric for scoring assessment. This is a helpful guide to follow while formulating the presentation.

PREPARING FOR COMPETITION

Form a team of interested students or friends. Discuss the challenges and design specifications. The Delaware Bridge Design Competition is designed for teams of three (3) students to participate. While schools should strive to create teams of 3 students, the Delaware Bridge Design Competition is an inclusive event and will accommodate teams of 2 or 4 as well. Teams can be no larger than 4 students. Each team must have at least one teacher or other adult to help and advise, though a single adult may be advisor to more than one team.

Study the rules. The individual challenge documents and the grading criteria will give important information, which must be followed if your team is to achieve the best results. Failure to adhere to the rules could lead to penalties, or even disqualification. If any of the information is not clear, please contact for additional help.

Plan the timing of the project. Ensure that everyone in the team knows the important dates and recognizes that this means that all major development work should be finished before these dates.

Keep records of meetings and working drawings carefully, and give members of the team responsibility for different sections of the final report.

Notes to Adults: It is extremely important that **the work on all phases of the project is to be done by the students.** Adult assistance is to be limited to:

- Mentoring
- Basic guidance of the students
- Teaching engineering, mathematical and scientific principles applicable to the project
- Guiding students in research
- Assisting in the production of the report and preparation of the drawings
- Overseeing the manufacturing stages of the project

Guidance should be in the form of asking questions, (leading questions if necessary) to promote creative thinking by the students to identify the scientific and engineering principles involved. *Encourage students to consult credible web sites and other resources to help with the project. Encourage students to test and improve their designs.* A good way to begin is for each student to design and/or construct a rough prototype, test it, and make improvements.

Proposal Scoring
Delaware Bridge Design Competition

Proposal Format

- | | | |
|---|------------|-----------------------|
| <input type="checkbox"/> Typed | (1 point) | |
| <input type="checkbox"/> Double Spaced | (1 point) | |
| <input type="checkbox"/> 12 Point Font (Times New Roman) | (1 point) | |
| <input type="checkbox"/> All pages on 8.5 x 11 paper | (1 point) | |
| <input type="checkbox"/> Information is in the proper order | (1 point) | |
| <input type="checkbox"/> All pages are numbered | (1 point) | |
| <input type="checkbox"/> Style and presentation | (3 points) | |
| <input type="checkbox"/> Mechanics | (3 points) | |
| <input type="checkbox"/> Visuals | (3 points) | Score_____/ 15 points |

Proposal Presentation

- | | | |
|---|-------------|-----------------------|
| <input type="checkbox"/> Title page | (1 point) | |
| <input type="checkbox"/> Table of Contents | (1 point) | |
| <input type="checkbox"/> Summary (no more than 2 pages) | (5 points) | |
| <input type="checkbox"/> Introduction | (1 points) | |
| <input type="checkbox"/> Body | | |
| <input type="checkbox"/> Sections identified | (1 points) | |
| <input type="checkbox"/> Scientific principles of the design | (10 points) | |
| <input type="checkbox"/> Design and engineering challenges | (10 points) | |
| <input type="checkbox"/> Modeling software screenshots | (5 points) | |
| <input type="checkbox"/> Graphs and Calculations | (5 points) | |
| <input type="checkbox"/> Photographs | (5 points) | |
| <input type="checkbox"/> Testing and improvements | (5 points) | |
| <input type="checkbox"/> Solving challenges | (5 points) | |
| <input type="checkbox"/> Conclusion | | |
| <input type="checkbox"/> Recommendations | (2 points) | |
| <input type="checkbox"/> Success of the project | (2 points) | |
| <input type="checkbox"/> Lessons learned | (2 points) | |
| <input type="checkbox"/> Acknowledgements | | |
| <input type="checkbox"/> Adults involved | (1 points) | |
| <input type="checkbox"/> Description of what the adults did | (1 points) | |
| <input type="checkbox"/> Certification and signatures | (2 points) | |
| <input type="checkbox"/> Bibliography | (1 points) | |
| <input type="checkbox"/> Appendices | | |
| <input type="checkbox"/> Daily Journals and scheduling
(must be legible) | (20 points) | Score_____/ 85 points |

TOTAL SCORE: __/100 Points

Design Drawings Scoring
Delaware Bridge Design Competition

Required Detail Views

- | | | |
|---|-------------|----------------------|
| <input type="checkbox"/> Plan View | (10 points) | |
| <input type="checkbox"/> Section View | (10 points) | |
| <input type="checkbox"/> Elevation View | (10 points) | Score____/ 30 Points |

Technical Content for each Detail View

- | | | |
|--|-------------|----------------------|
| <input type="checkbox"/> Title of View | (6 points) | |
| <input type="checkbox"/> Dimensions/Text | (12 points) | |
| <input type="checkbox"/> Units | (6 points) | Score____/ 24 Points |

Detail Drawing Formatting for all Sheets*

- | | | |
|---|-------------|----------------------|
| <input type="checkbox"/> Proper Page Sized Used | (6 points) | |
| <input type="checkbox"/> Sheet Border | (6 points) | |
| <input type="checkbox"/> Team Name | (6 points) | |
| <input type="checkbox"/> Team Members | (6 points) | |
| <input type="checkbox"/> Date Drawing was Completed | (6 points) | |
| <input type="checkbox"/> Scale | (6 points) | Score____/ 36 Points |
|
 | | |
| <input type="checkbox"/> Overall Quality | (10 points) | Score____/ 10 points |

TOTAL SCORE:___/100 Points

***All three views (Plan, Section, and Elevation) may be placed on one Sheet**

Oral PowerPoint Presentation

Team will present to a panel of judges comprised of engineers. Each team is expected to make a PowerPoint presentation and be able to answer questions. Questions will be asked by the judges at the conclusion of their presentation. Each presentation should be 10 minutes with an additional 5 minutes allotted for questions at the end. A deduction will be assessed for presentations not meeting the 10-minute requirement. A scoring rubric has been provided for the presentation as a guide to assist in preparation.

Scoring:

Each category will be judged on a scale from 0 to 20 points.

CATEGORY	20	15	10	5	0	Sub-Score
Content	Covers topic in-depth with details and examples. Subject knowledge is excellent	Includes essential knowledge about the topic. Subject knowledge appears to be good.	Includes essential information about the topic but there are 1-2 factual errors	Content is minimal or there are several factual errors	Did not fulfill requirements	_____/20
Mechanics	No misspellings or grammatical errors	Three or fewer misspellings and/or mechanical errors	Four misspellings and/or grammatical errors	More than 4 errors in spelling or grammar	Did not fulfill requirements	_____/20
Organization	Content is well organized with related material grouped together	Content is logically organized for the most part	Overall organization is flawed	There was little clear or logical organizational structure	Did not fulfill requirements	_____/20
Presentation	Interesting, well-rehearsed with smooth delivery that holds audience attention	Relatively interesting, rehearsed with a fairly smooth delivery that usually holds audience attention	Delivery not smooth, but able to hold audience attention most of the time	Delivery not smooth and audience attention lost	Did not fulfill requirements	_____/20
Attractiveness	Makes excellent use of font, color, graphics, effects, etc. to enhance the presentation	Makes good use of font, color, graphics, effects, etc. to enhance to presentation	Makes use of font, color, graphics, effects, etc. but occasionally these detract from the presentation content	Use of font, color, graphics, effects etc. but these often distract from the presentation content	Did not fulfill requirements	_____/20
Total Sub-Score						_____/100
Over 10 Minutes: (-2 pts per minute)						_____
TOTAL SCORE						_____

Delaware Bridge Design Competition Suggestions and Helpful Hints

1. Students should be prepared for questions at the end of the presentation. These questions may be concentrated in the following topics. However, note that the judges are free to ask any question about any topic. Therefore, each team should be prepared.
 - a) Choice of design
 - b) Civil engineering careers related to bridges
 - c) Safety
 - d) Impacts of bridges
 - e) Lessons learned
2. Stay organized and keep track of time limits.
3. If you have a question, don't be afraid to ask. Please contact:
 - a) Nicholas Dean at Nicholas.Dean@delaware.gov
 - b) [Please CC following individuals:](#)
 - Paul Huhn at Paul.Huhn@delaware.gov
 - Marc "Gus" Toussaint at Marc.Toussaint@delaware.gov
 - Sean Weaver at Sean.Weaver@delaware.gov
4. Contact your mentors. They will answer many of your questions.
5. Check out other bridges in your area or around the world.
6. Make sure to research topics and concepts.