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Fabrication And Educational Application of a Hydraulic Bridge Model for Integrating Road and Water Transport

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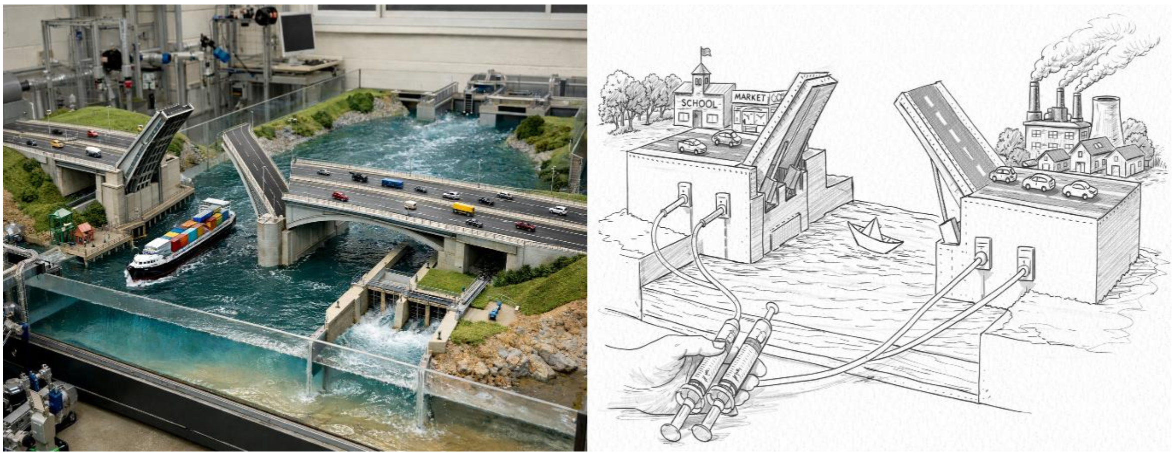
ABSTRACT

This project report describes the design, fabrication, and educational application of a hydraulic bridge model intended to demonstrate the principles of fluid pressure, mechanical advantage, and applied physics in secondary school learning environments. The hydraulic bridge model was developed as a practical exhibition project to support competency-based learning and to illustrate how physics concepts can be used to solve real community transport problems (Pereira et al., 2025). The model represents a situation where an industrial area and a market center are separated by a river, requiring both road transport across the river and water transport beneath the bridge. The model operates on Pascal's principle, utilizing a syringe-based hydraulic system to actuate a bascule-style lifting mechanism, thereby allowing simulated waterborne traffic to pass while maintaining road connectivity when closed (Spencer Group, 2018). The fabrication process employs low-cost, accessible materials including syringes, tubing, and craft components to create a working prototype that visually represents the engineering principles underlying real-world movable bridges, such as the Maryport Articulated Bridge which employs hydraulic operation with counterweight assistance for pedestrian and cycle access (Kashmir Monitor, 2022). The hydraulic bridge model, constructed from simple materials such as syringes, plastic tubing, and craft sticks, serves as a tangible demonstration of Pascal's Law and the transmission of pressure through confined fluids. By integrating principles of road and water transport infrastructure, this model bridges theoretical physics concepts with real-world engineering applications.

Studies have demonstrated that engaging students in hands-on prototyping activities enables the modelling of complex systems through iterative design cycles, making abstract scientific principles tangible and accessible (Curtin University Dubai, 2025). Furthermore, the integration of road and water transport within a single model provides a concrete platform for discussing multimodal transport systems and infrastructure planning. By enabling students to manipulate hydraulic pressure to control bridge movement, the model bridges theoretical knowledge with practical application, fostering an understanding of how engineering solutions address real-world transportation challenges (The Kashmir Monitor, 2022). This project thus serves as a versatile pedagogical tool, promoting active learning, collaborative inquiry, and the application of scientific and engineering design processes in secondary and tertiary education settings (Teach Engineering, 2026).

Keywords: Hydraulic bridge model, Pascal's Law, pressure education, STEM learning, transport integration, physics instruction



Realistic Diagram of The Local Community Problem.

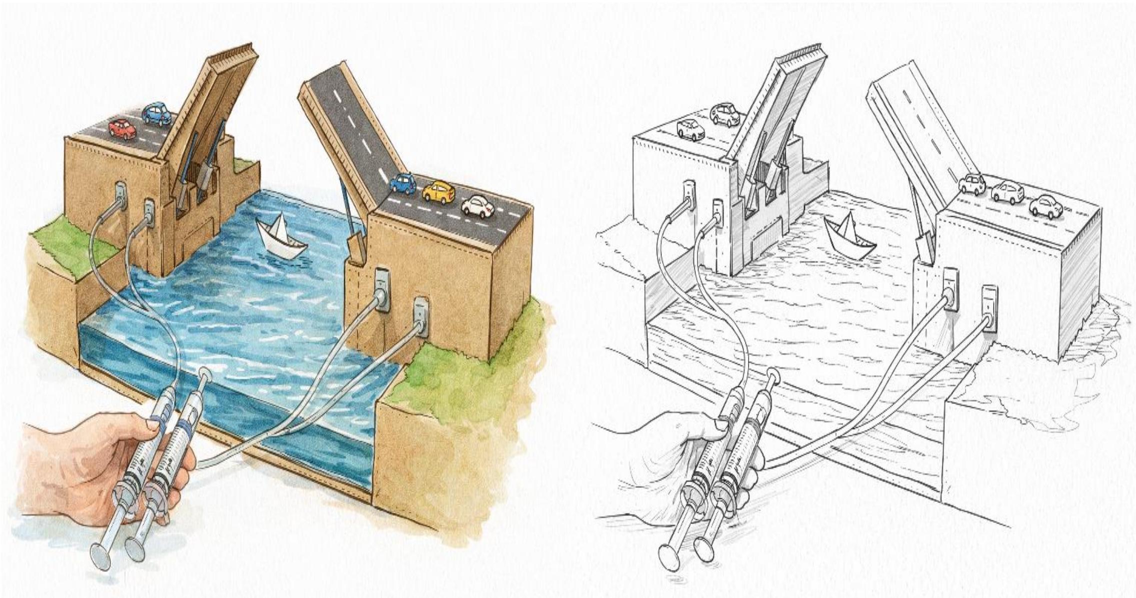


Diagram of the Model Solution to The Problem.

INTRODUCTION

Physics plays a fundamental role in explaining natural phenomena and enabling technological development in modern society (Remperas & Calzada, 2025). In secondary school education, practical demonstrations and project-based learning greatly enhance student understanding of abstract scientific concepts. However, many schools struggle with limited laboratory equipment, which makes it difficult for teachers to demonstrate complex principles such as pressure transmission and mechanical systems. This project therefore proposes the fabrication of a hydraulic bridge model as an innovative teaching aid that demonstrates fluid mechanics and engineering applications (Msimango, 2026).

Background

In many communities, rivers and wetlands create barriers that limit efficient transport between production areas and commercial centers. In such situations, bridges are constructed to allow vehicles and people to cross from one side to the other while still allowing boats to pass along the river. A hydraulic bridge is a special type of bridge that can be raised using hydraulic systems so that water vessels can move underneath without obstruction (Thakare et al., 2026). This type of infrastructure demonstrates important physics concepts such as Pascal's principle, pressure transmission in liquids, and mechanical force multiplication.

Problem Statement

In many physics classrooms, learners find it difficult to understand the practical meaning of fluid pressure and hydraulic systems because they rarely see these systems in operation. The lack of practical models and demonstrations results in learners memorizing formulas without appreciating their applications in engineering and technology (Corral Abad et al., 2021). There is therefore a need for a simple and affordable demonstration model that teachers can use to illustrate hydraulic principles in an engaging and visual way. This project addresses that need by constructing a working hydraulic bridge model that can be used during classroom demonstrations and exhibitions.

The pressing need for innovative, practical STEM pedagogy in Uganda is starkly illuminated by the nation's parallel crises in infrastructure and education, a gap that the "Fabrication and Educational Application of a Hydraulic Bridge Model for Integrating Road and Water Transport" project directly confronts. Uganda’s transport sector exemplifies this challenge, with the country's failure to develop a robust multi-modal system placing an overwhelming burden on its road networks while its vast inland water transport potential on Lake Victoria remains critically underutilised; cargo movement on the lake has drastically collapsed from handling roughly 30% of national trade in the early 2000s to a mere 1% today, driven by policy neglect and the deterioration of vital port infrastructure at Jinja and Port Bell (Daily Express, 2022). This logistical failure has profound consequences, as farmers in areas like Mbale or Mbarara can lose up to half their produce before it reaches Kampala due to poor feeder roads and a lack of cold-chain facilities, directly impacting household incomes and national food security. Simultaneously, Uganda's education system, particularly under its new Competence-Based Curriculum, struggles to cultivate the critical thinking and practical skills required to solve such complex, real-world problems, a challenge exacerbated by a significant lack of access to STEM resources and exposure to hands-on engineering concepts in many schools (Nile Post. "Special Report, 2026). Furthermore, the logistical challenges extend beyond infrastructure and into the classroom, as transport poverty, exemplified by the WeLearn-WeTeach bicycle initiative that aims to address learners walking up to 15 kilometres to school, remains a fundamental barrier to consistent attendance and participation in practical learning, especially for girls and those in remote areas like Kyegegwa, Adjumani, and Kamuli. This project directly addresses these interconnected issues by leveraging the development of a tangible, functional hydraulic bridge model which operates on Pascal's Law and demonstrates principles of fluid mechanics and structural engineering not merely as a physics teaching aid, but as a powerful pedagogical tool to make abstract concepts of force and pressure accessible, while simultaneously providing a tangible platform for students to explore the principles behind the country's urgent need for modern, integrated transport infrastructure (AllAfrica. "Uganda” 2026). As such, the project is positioned to foster a generation of Ugandan engineers and innovators equipped with the practical skills and conceptual understanding to ultimately revitalise the nation's underperforming transport sector and build a seamless, multi-modal system that connects road, rail, and water networks, thereby strengthening supply chains, bolstering regional trade, and driving sustainable economic development (New Vision. "Broken links, 2025).

Objectives

(i) The main objective of the project is to design and fabricate a working hydraulic bridge model that demonstrates the application of fluid pressure in engineering systems.

(ii) Another objective is to provide a practical teaching aid that improves the teaching and learning of physics concepts related to pressure, force, and simple machines.

(iii) The project also aims to demonstrate how physics knowledge can be used to solve real community problems such as transportation barriers caused by rivers.

(iv) Finally, the project seeks to promote creativity, innovation, and hands-on learning among students through the construction and operation of scientific models.

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Description of the Hydraulic Bridge

The hydraulic bridge constructed in this project is a model structure designed to lift its central section using hydraulic pressure generated through a syringe-based system.

The model consists of a base platform representing the river banks, a movable bridge deck, support pillars, and a hydraulic lifting mechanism.

When pressure is applied through the hydraulic system, the bridge deck rises to allow boats or water vessels to pass beneath the structure.

After the vessel passes, the hydraulic pressure can be released so that the bridge returns to its original horizontal position for road transport.

Materials Used

Several locally available materials were used in constructing the hydraulic bridge model to ensure that the project remains affordable and replicable in school environments.

Paper boards were used to construct the base and bridge deck because they provide adequate strength while remaining lightweight and easy to shape.

Plastic syringes and flexible tubing were used to form the hydraulic system that transmits pressure and produces the lifting motion.

Additional materials such as straws, glue, cello tape, and water were used to assemble and improve the appearance of the final model.

Construction Procedure

Step 1: Identification of the Community Problem

The first step involved identifying a real community problem that could be addressed using physics principles. In this case, the problem considered was a situation where an industrial site and a market center are separated by a river, making transportation of goods and people difficult. The project required a solution that could allow both road transport across the river and water transport along the river. After analyzing the situation, the idea of designing a hydraulic bridge was selected as a practical solution.

Step 2: Designing the Bridge Model

After identifying the problem, a simple design of the hydraulic bridge model was prepared. The design included the main parts of the bridge such as the base platform representing the river banks, the bridge deck that vehicles would pass over, the supporting pillars, and the hydraulic lifting system. The design also showed where the hydraulic cylinders or syringes would be placed in order to raise and lower the bridge deck. This planning stage ensured that the construction process would be organized and efficient.

Step 3: Selection and Collection of Materials

The next step involved selecting suitable materials that could be used to fabricate the bridge model. Preference was given to materials that are affordable, locally available, and easy to manipulate. Materials such as paper boards, cardboard, plastic syringes, flexible plastic tubes, glue, hinges, and markers were collected. These materials were chosen because they are strong enough to support the model structure while also allowing easy demonstration of the hydraulic mechanism.

Step 4: Construction of the Base Platform

The base platform of the bridge model was then constructed using paper boards or hard cardboard. The base was designed to represent the two river banks with a gap in the middle symbolizing the river channel. Care was taken to ensure that the base structure was stable and strong enough to support the bridge deck and other components. The base also served as the foundation on which the entire bridge structure would be mounted.

Step 5: Fabrication of the Bridge Deck

After the base platform was prepared, the bridge deck was constructed. The deck represents the road surface that vehicles and pedestrians would use to cross the river. It was designed using a flat paper board or cardboard surface that was long enough to span the gap between the two river banks. The bridge deck was also made light enough so that it could easily be lifted by the hydraulic system.

Step 6: Installation of the Bridge Supports and Hinges

The next step involved installing support structures and hinges that would allow the bridge deck to move. Support pillars were attached on both sides of the river banks to hold the bridge in position. Hinges were then fixed between the bridge deck and the support structure so that the bridge could rotate or lift upward when hydraulic pressure was applied. These hinges act as pivot points that allow the bridge to move smoothly.

Step 7: Installation of the Hydraulic System

Once the bridge structure was in place, the hydraulic lifting system was installed. Plastic syringes were connected using flexible plastic tubing and filled with water or another suitable liquid. One syringe acted as the input piston while the other acted as the output piston connected to the bridge deck. When force is applied to the input syringe, the liquid transmits pressure through the tubing and causes the output syringe to push upward, lifting the bridge deck.

Step 8: Testing the Hydraulic Mechanism

After installing the hydraulic system, the model was carefully tested to ensure that it worked properly. Pressure was applied to the input syringe to check whether the bridge deck could lift smoothly. Adjustments were made to improve the movement of the bridge and to eliminate any leakage in the tubing connections. This testing stage helped ensure that the model was functioning correctly before it was presented for demonstration.

Step 9: Finishing and Decoration of the Model

Once the mechanical operation was confirmed to be working properly, the bridge model was improved for exhibition purposes. The structure was painted to make it visually appealing and to clearly distinguish the road surface, river channel, and supporting pillars. Additional features such as small model vehicles and boats were added to help illustrate how the bridge supports both road and water transportation.

The Hydraulic Bridge as a Pedagogical Tool

The hydraulic bridge model fabricated from simple materials syringes serving as hydraulic cylinders, plastic tubing as fluid conduits, and craft sticks as structural elements provides an accessible yet powerful platform for physics education. When students construct and operate these models, they directly observe the relationship between applied force, fluid pressure and mechanical output. This hands-on engagement transforms abstract principles into concrete experiences, supporting deeper conceptual understanding. Recent research has validated the effectiveness of hydraulic bridge models in educational settings. A study published in the Journal of Physics demonstrated that implementing hydraulic bridges as learning media improved students' laboratory skills, with pre-test scores averaging 68.17 increasing to 81.79 in post-tests. Theoretical validation by media experts yielded scores of 84.17%, confirming the feasibility and quality of hydraulic bridges as instructional resources.

Bridging Theory and Practice

Beyond teaching pressure concepts, the hydraulic bridge model introduces students to the integration of road and water transport systems an increasingly relevant consideration in infrastructure planning. Movable bridges, including bascule bridges and lift bridges, use hydraulic systems to balance the competing demands of land-based and water-based transportation. The Slauerhoffbrug in the Netherlands, for example, employs double-acting hydraulic cylinders to lift its deck, allowing boats to pass while maintaining road connectivity. By constructing and operating hydraulic bridge models, students gain insight into how scientific principles enable the coexistence of diverse transport modes.

Theoretical Framework

Pascal's Law and Hydraulic Systems

The operational principle of the hydraulic bridge model is grounded in Pascal's Law, which forms the conceptual foundation for understanding pressure transmission in fluids. Pascal's Law states that when pressure is applied to a confined fluid at rest, the pressure change is transmitted undiminished throughout the fluid in all directions. In practical terms, this means that force applied to a small piston creates pressure that is transmitted through the fluid to a larger piston, resulting in a multiplied output force. The mathematical relationship governing hydraulic systems is expressed as:

$$\mathbf{P = F/A}$$

Where P represents pressure, F represents force, and A represents area. This equation demonstrates that for a given pressure, increasing the area of the output piston proportionally increases the output force. This principle enables hydraulic systems to function as force multipliers, allowing relatively small input forces to lift substantial loads.

Constructivist Learning Theory

The educational application of hydraulic bridge models aligns with constructivist learning theory, which posits that learners actively construct knowledge through experience and reflection. According to this framework, hands-on activities that allow students to manipulate variables and observe outcomes facilitate deeper understanding than passive reception of information. The hydraulic bridge project embodies constructivist principles by engaging students in the design, construction, testing, and refinement of working models. Through this process, learners develop not only content knowledge but also critical thinking skills, problem-solving abilities, and engineering design competencies.

STEM Integration and Sustainable Development

The fabrication of hydraulic bridge models also advances broader educational goals related to STEM education and sustainable development. By integrating science, technology, engineering, and mathematics in a single project, students develop interdisciplinary competencies essential for addressing complex real-world challenges. Furthermore, the hydraulic bridge project connects to Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). By demonstrating how scientific principles enable sustainable infrastructure solutions, the project helps students understand the relevance of physics to global development challenges.

Fabrication of the Hydraulic Bridge Model

Materials and Design Considerations

The hydraulic bridge model can be fabricated using readily available, low-cost materials, making it accessible for classroom implementation. The primary components include;

- **Structural elements:** Popsicle sticks, cardboard, or laser-cut MDF pieces forming the bridge deck, towers, and base

- **Hydraulic components:** Syringes (typically 5-10 mL), plastic tubing, and water as the working fluid
- **Assembly materials:** Adhesive (glue or hot glue), rubber bands, and small clamps

The design should accommodate a lifting mechanism that raises and lowers the bridge deck, with the hydraulic system providing the actuating force. Syringes serve dual functions as both the operator (input) and actuator (output) cylinders, with tubing connecting them to form a closed hydraulic circuit.

Construction Process

The construction process typically follows these steps;

Step 1: Base and Deck Construction

The bridge deck is formed by gluing popsicle sticks side by side, with a second layer added perpendicularly for reinforcement. Support beams are constructed along the sides of the deck to provide structural integrity.

Step 2: Tower Construction

Two rectangular towers are assembled from popsicle sticks, dimensioned to accommodate the lifting mechanism. The towers are securely attached to the base, ensuring proper alignment and stability.

Step 3: Hydraulic System Integration

The hydraulic system is prepared by filling two syringes with water and connecting them with plastic tubing, ensuring all air bubbles are expelled to maintain incompressibility. The syringes are secured to opposite sides of the bridge towers using adhesive or rubber bands.

Step 4: Lifting Mechanism Assembly

One syringe (the actuator) is attached to the bridge deck, while the other (the operator) is fixed to the base. This configuration allows the deck to lift when the operator syringe is depressed, as water is forced into the actuator syringe, extending its plunger.

Step 5: Testing and Refinement

The completed model is tested by operating the syringe system, with adjustments made to ensure smooth lifting and lowering. The structure may be reinforced with additional popsicle sticks as needed.

Design Variations and Adaptations

The basic hydraulic bridge design can be adapted to accommodate different educational contexts and objectives. Some variations include;

- **Bascule bridge configuration:** A single leaf that rotates upward on a hinge
- **Vertical lift bridge:** A deck that rises vertically on guide tracks
- **Multi-cylinder systems:** Incorporating multiple hydraulic actuators for more complex movements

These variations allow teachers to differentiate instruction and challenge advanced students with more complex engineering problems.

Educational Application in Physics Instruction

Lesson Structure and Time Allocation

The hydraulic bridge project can be implemented within a single class period (approximately 45-60 minutes) or extended across multiple sessions depending on learning objectives. A recommended structure includes:

Introduction (10 minutes): Brief presentation of Pascal's Law and hydraulic principles, introducing real-world applications such as drawbridges and construction equipment

Construction (20-25 minutes): Students work in pairs or small groups to fabricate hydraulic bridges using provided materials

Experimentation and Observation (10-15 minutes): Students test their bridges, varying input force and observing the resulting movement, recording observations

Discussion and Reflection (10 minutes): Class discussion connecting observations to theoretical principles, addressing challenges encountered and solutions developed

Connecting to Curriculum Objectives

The hydraulic bridge project addresses multiple curriculum objectives related to pressure and fluid mechanics:

- Understanding pressure as force per unit area
- Explaining the transmission of pressure through fluids
- Applying Pascal's Law to real-world systems
- Describing the operation of hydraulic systems as force multipliers
- Connecting scientific principles to engineering applications

The integration of road and water transport provides additional opportunities for cross-curricular connections with geography, environmental science, and civil engineering.

Assessment Strategies

Assessment can take multiple forms within the hydraulic bridge project;

- **Formative assessment:** Observation of construction process, questioning during experimentation
- **Summative assessment:** Written explanations of hydraulic principles, design sketches, or presentations
- **Performance assessment:** Evaluation of functional bridge operation and ability to articulate scientific principles

Research indicates that such project-based assessment approaches are effective in developing students' laboratory skills and conceptual understanding.

Integration of Road and Water Transport Concepts

The Role of Movable Bridges in Transport Infrastructure

Hydraulic bridges represent a critical intersection of road and water transport systems. Movable bridges allow waterways to remain navigable while providing continuous road connectivity, addressing the competing demands of land-based and maritime transport. This integration is particularly important in regions with extensive canal networks or where rivers bisect urban areas.

Examples of hydraulic bridges in operation worldwide demonstrate the practical significance of this technology:

- **Slauerhoffbrug, Netherlands:** A fully automated bascule bridge using double-acting hydraulic cylinders, opening approximately 10 times daily to accommodate water traffic

- **Various drawbridges:** Using hydraulic systems to lift or swing bridge sections, enabling ship passage while maintaining road connections

Environmental and Sustainability Considerations

The integration of road and water transport through hydraulic bridges also raises important environmental considerations. Research has shown that bridge structures can affect flood dynamics, with potential impacts on peak discharge and water levels in rivers. Understanding these hydrological interactions is essential for sustainable infrastructure planning, connecting physics concepts to environmental science and sustainability. The hydraulic bridge project provides a foundation for discussing these broader implications, helping students recognize the relevance of physics to environmental challenges and sustainable development.

Promoting Systems Thinking

By examining the hydraulic bridge as an integrated system combining mechanical, fluid, and structural elements, students develop systems thinking competencies. They learn to consider how changes in one component affect the entire system, how multiple forces interact, and how engineering solutions must balance competing constraints skills that transfer beyond physics to other domains.

CONCLUSION

The fabrication and educational application of hydraulic bridge models represents a powerful approach to teaching pressure concepts in secondary school physics. By constructing and operating these models, students directly experience Pascal's Law in action, transforming abstract principles into concrete understanding (Hartini et al., 2026). The hands-on nature of the project engages multiple learning modalities, supports conceptual development, and fosters positive attitudes toward science. Furthermore, the hydraulic bridge project effectively integrates principles of road and water transport, demonstrating how physics concepts underpin critical infrastructure systems. This connection enhances the relevance of physics instruction, helping students recognize the value of scientific understanding in addressing real-world challenges.

Research evidence supports the effectiveness of this approach, with studies demonstrating significant improvements in laboratory skills and conceptual understanding among students who engage in hydraulic bridge projects. The model's validation by educational experts (84.17% theoretical validation score) confirms its quality and feasibility as an instructional resource. For educators, the hydraulic bridge project offers a flexible, accessible, and engaging approach to physics instruction that can be implemented with minimal resources (Ilma et al., 2026). By connecting scientific principles to engineering practice and sustainability considerations, it provides a rich learning experience that extends beyond the physics classroom.

The hydraulic bridge project demonstrates the powerful relationship between physics principles, engineering innovation, and community problem solving. Through the fabrication of this model, the project clearly illustrates how scientific knowledge can be translated into practical solutions that address real transportation challenges (Erpicum et al., 2021). The model represents a situation where an industrial site and a market center are separated by a river, creating the need for a transportation system that accommodates both road vehicles and water vessels. By applying hydraulic principles, the bridge can be raised to allow boats to pass underneath and lowered again to enable vehicles and pedestrians to cross the river safely (Daniel, 2023).

From an educational perspective, the project serves as an effective teaching aid that strengthens the teaching and learning of physics in secondary schools. The hydraulic bridge model provides a concrete demonstration of important concepts such as fluid pressure, Pascal's principle, force transmission, and mechanical motion (Chen, 2019). When learners observe and interact with the model, they are able to visualize how theoretical formulas and scientific laws are applied in real engineering systems. This practical exposure enhances conceptual understanding, promotes curiosity, and encourages learners to develop interest in science, technology, engineering, and innovation.

The project also aligns well with the objectives of modern competency-based education, which emphasizes creativity, problem solving, and the application of knowledge to real- life situations. By designing and constructing the hydraulic bridge model, students engage in hands-on learning experiences that strengthen critical thinking and technical skills. Such project-based learning activities help learners appreciate the relevance of physics beyond the classroom and demonstrate how scientific knowledge contributes to infrastructure development and community improvement.

Furthermore, the hydraulic bridge project highlights the importance of integrating different modes of transportation within a single infrastructure system (Gkoumas et al., 2024). By allowing both road transport and water transport to operate efficiently, the bridge supports economic activities such as trade, fishing, and movement of goods between industrial and commercial areas. This integration contributes to improved accessibility, reduced travel time and enhanced economic interactions within the community (Iqbal & Riaz, 2024).

In conclusion, the hydraulic bridge model successfully demonstrates how physics education can be connected to real-world technological solutions (Yang et al., 2020). The project not only enhances the teaching and learning of physics concepts but also provides a meaningful example of how scientific principles can be used to address community needs. Therefore, incorporating such innovative practical projects in secondary school physics education can significantly improve student engagement, deepen conceptual understanding, and inspire future generations to apply scientific knowledge in solving societal challenges (Al-Kamzari & Alias, 2025).

REFERENCES

1. Al-Kamzari, F., & Alias, N. (2025). A systematic literature review of project-based learning in secondary school physics: theoretical foundations, design principles, and implementation strategies. Humanities and Social Sciences Communications, 12(1), 286.
2. AllAfrica. "Uganda: Can Uganda Revive a Collapsed Cargo Lifeline?" allAfrica.com, 2026.
3. BMAU. "BMAU Briefing Paper 20/22: Developing a seamless multi-modal transport system-Is Uganda on track?" Ministry of Finance, Planning and Economic Development, Uganda, 2022.
4. Busitema University. "Busitema University pioneers Uganda's inaugural Railway Institute." Busitema University News, 2024.
5. Çengel Y.A. & Cimbala J.M. (2018). Fluid Mechanics: Fundamentals and Applications (4th Edition). McGraw-Hill Education.
6. Chen S.H. (2019). Computational geomechanics and hydraulic structures (p. 7). Singapore: Springer.
7. Corral Abad E., Gómez García M.J., Diez-Jimenez E., Moreno-Marcos P.M. & Castejón Sisamon, C. (2021). Improving the learning of engineering students with interactive teaching applications. Computer Applications in Engineering Education, 29(6), 1665-1674.
8. Curtin University Dubai. (2025). Curtin Dubai engineering students deliver hands-on workshop at GEMS Modern Academy. Curtin University Dubai.
9. Daily Express. "Equity Bank gives Busoga High School new bus under asset financing." Daily Express Uganda, 2026.
10. Daily Express. "WeLearn-WeTeach Initiative targets school dropout with 728 bicycles." Daily Express Uganda, 2026.
11. Daniel, R. A. (2023). Modern solutions for vertical lift gates as closures in locks, river dams and flood barriers. Inżynieria Morska i Geotechnika, Gdańsk, (4).
12. Erpicum S., Crookston B.M., Bombardelli F., Bung D.B., Felder S., Mulligan S. & Palermo M. (2021). Hydraulic structures engineering: An evolving science in a changing world. Wiley Interdisciplinary

Reviews: Water, 8(2), e1505.

13. Gkoumas K., Stepniak M., Cheimariotis I. & Marques dos Santos F. (2024). New technologies for bridge inspection and monitoring: A perspective from European Union research and innovation projects. Structure and Infrastructure Engineering, 20(7-8), 1120-1132.
14. Halliday D., Resnick R. & Walker J. (2018). Fundamentals of Physics (11th Edition). Wiley.
15. Hartini, S., Dewantara, D., & Meilani, A. (2026). Project-based learning on pascal's law: A quasi-experimental study on problem-solving skills in environmental contexts. Journal of Environment and Sustainability Education, 4(1), 182-191.
16. Hibbeler R.C. (2017). Engineering Mechanics: Statics and Dynamics (14th Edition). Pearson Education.
17. Ilma, N.M., Nabila, S., Musyarofah A.H., & Syahrama A.R. (2026, January). Bio-Hydro Pressure Simulator: An Integrative Physicsâ€“Biology Tool for Visualizing the Concept of Fluid Pressure and the Circulatory System. In PISCES: Proceeding of Integrative Science Education Seminar (Vol. 5, No. 1, pp. 329-338).
18. Inspirely. "Hydraulic Bridge Ultimate Wooden Kits." Inspirely Education, 2025.
19. Iqbal U., & Riaz, M.Z.B. (2024). Blockage at cross-drainage hydraulic structures–Advances, challenges and opportunities. Heliyon, 10(16).
20. Ministry of Education and Sports. (2020). Lower Secondary School Curriculum Framework. Kampala, Uganda.
21. Msimango, E. Z. (2026). The pedagogical practices of grade 8 technology educators in teaching mechanical systems and control at Madibeng Sub-District.
22. National Curriculum Development Centre (NCDC). (2020). Physics Teaching Syllabus for Lower Secondary Schools. Kampala, Uganda.
23. New Vision. "Broken links: Why Uganda's supply chains struggle to deliver value." NewVision.co.ug, 2025
24. Nile Post. "Special Report: Can Uganda revive a collapsed cargo lifeline?" Nilepost News, 2026.
25. Pereira R.B., da Costa F.R., da Costa L.R., Moraes L.E.F., Janzen B., Feitosa V.M. & Janzen J.G. (2025). Enhancing engineering education in transport phenomena through project-based learning with a nature-based solution approach. Education Sciences, 15(8), 1050.
26. Remperas R.N. & Calzada M.P.T. (2025). Teachers' challenges and best practices on laboratory approaches in science teaching. International Journal of Science, 2(5).
27. Serway R.A. & Jewett J.W. (2019). Physics for Scientists and Engineers (10th Edition). Cengage Learning.
28. Spencer Group. (2018). Maryport Articulated Bridge. Spencer Group Projects.
29. Teach Engineering. (2026). Fluid Forces: Powering Bridges with Hydraulic Systems - Activity. Teach Engineering.
30. Thakare S.B., Chavan A.A., Shinde S.B. & Abhichandani H.J. (2026). Dams and Hydraulic Structures. BR Publications.
31. The Kashmir Monitor. (2022). Tech-savvy trio develops 'hydraulic bridge' to solve energy crisis in Kashmir. The Kashmir Monitor.
32. Tipler P.A. & Mosca G. (2016). Physics for Scientists and Engineers (6th Edition). W.H. Freeman.
33. Yang Y., Ng S.T., Zhou S., Xu F.J. & Li H. (2020). Physics-based resilience assessment of interdependent civil infrastructure systems with condition-varying components: A case with stormwater drainage system and road transport system. Sustainable Cities and Society, 54, 101886.
34. Young H.D. & Freedman R.A. (2020). University Physics with Modern Physics (15th Edition). Pearson.