JOSE
The Journal of Open Source Education

Static Equilibrium in Remote Alaska

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DOI: 10.xxxxxx/draft

Software

- Review
- Repository
- Archive

Submitted: 14 February 2024
Published: unpublished

Summary

This course module intertwines physics education with the unique challenges faced by Alaska's remote communities. It begins with fundamental statics concepts, emphasizing forces in equilibrium and vector problem-solving. Progressing through equilibrium in structures and torque, it culminates in practical applications like bridge construction in Alaska. The course, aimed at first-year high school students, introduces Python programming for physics applications. It's structured for in-person and self-guided learning on CoLab. The Alaska context adds depth, exploring social, ecological, and engineering challenges in these communities, emphasizing the necessity of interdisciplinary collaboration for sustainable solutions.

This course module, designed for first-year high school students with no prior knowledge of static equilibrium and programmatic data analysis, serves as an introductory bridge to programming through high school physics. It is structured as a multi-week course that introduces Python programming and its application in physics. The module comprises five units tailored for an in-person learning environment, featuring live coding sessions and explanations, followed by independent or pair coding activities. Hosted on CoLab, it supports both self-guided and classroom-based learning, extending educational opportunities beyond the traditional classroom setting.

Statement of Need

Contextualized STEM Content

The benefits of contextualized science, technology, engineering, and mathematics (STEM) teaching are well known. "Contextualized Modules in Physics for Junior High School Students" by Marzan indicated that contextualized modules in physics enabled students to outperform the traditional lecture group in post-test evaluations (Marzan, 2018). Similar results were seen by Cid in "Contextualized magnetism in secondary school: learning from the LHC (CERN)" (Cid, 2005). That article discussed the introduction of simple physical calculations related to magnetic phenomena in old accelerators and the Large Hadron Collider. They discussed how these calculations can be used in classrooms to spark students' curiosity, aid their understanding of physical concepts, and illustrate the connection between theoretical physics ("cold equations") and the dynamic world of scientific research. Furthering the discussion about contextualized education, Cech's article in Nature, titled "Education: Embed social awareness in science curricula," emphasizes the need for a more integrated approach to teaching socially responsible students science, technology, engineering, and mathematics (STEM) in general (Cech, 2014). The study conducted by Cech showed that engineering students often leave university less interested in public welfare than when they started, which is contrary to what should be happening. The article suggests that STEM education should incorporate social issues throughout its curricula, not just in separate ethics courses. This is based on the premise that STEM practitioners who understand the role of their profession in society are better equipped to solve real-world problems. The article concludes that addressing public-welfare concerns should be a fundamental part of STEM education, suggesting that even a small proportion of homework and exam questions focusing on the social implications of scientific work could help reverse the trend of disengagement from these crucial issues. This approach is vital for producing well-rounded professionals capable of addressing the complex challenges of our time.

Cech was not alone in this sentiment and the idea has been echoed in works such as "The people part of engineering: Engineering for, with, and as people" by Fila et al (Fila et al., 2014). This was also seen in "History of Science in Physics Teaching Possibilities for Contextualized Teaching?" by Jardim et al which discusses the use of a historical approach in science education, particularly in physics, to provide a more contextualized understanding of the development of scientific knowledge (Jardim et al., 2021). The primary aim is to explore how lessons incorporating a Cultural History of Science approach can enable activities that encourage students to consider their socio-cultural context, with a specific reference to Brazilian scientific production. It also investigates how students can develop a deeper understanding of scientific practices through classroom discussions inspired by this approach, focusing on both historical contexts and students' own social environments. The approach allows students to recognize that science is developed by various social actors, in different settings beyond the laboratory and involves diverse actions. The findings suggest that this method of teaching science is effective in historically contextualizing science development while also enabling students to reflect on scientific production within their social context. Furthermore, this was discussed in the context of high school education in Upegui et al's , "Integration of the Topic of Social Justice into High School Biology Curricula" (Upegui et al., 2022). That study found that this more contextualized approach not only enhances students' understanding of STEM concepts but also prepares them for comprehensive participation in society by making them aware of and sensitive to social inequities.

Examining our case study

In rural Alaska, the importance of contextualizing STEM decisions with social considerations is a clear need. Pathways are vital between remote communities to essential services, traditional hunting grounds, and educational facilities. These pathways, often dependent on frozen rivers and lakes during the colder months, have been the lifeblood of subsistence farming, hunting, and gathering traditions for generations. However, as the impacts of climate change intensify, the once reliable pathways face a series of unprecedented challenges that threaten to unravel the fabric of community life. Rising temperatures lead to delayed freezing and early thawing of rivers and lakes, resulting in thinner, less predictable ice. What was once a reliable and sturdy path across frozen rivers and lakes has become increasingly treacherous, posing significant dangers to those relying on these natural highways. Remote communities now grapple with the uncertainty of if and when their vital connections will be safe to traverse. As climate change disrupts the delicate balance of Alaska's ecosystem, storms have also grown in frequency and intensity. The once-familiar natural rhythm of seasonal changes has been upended, leaving communities vulnerable to unpredictable weather patterns. Fierce winds, heavy precipitation, and intense storms wreak havoc on the pathways, jeopardizing mobility and making travel arduous and dangerous.

In response to these challenges, building bridges has emerged as a promising solution to ensure reliable connections between remote communities. Bridges can offer year-round access, providing a lifeline during the warming months when traditional pathways are impassable in winter. The benefits of bridges are apparent, enabling greater access to essential services, healthcare facilities, and educational opportunities. They can foster economic growth by facilitating trade and commerce, uplifting these communities through improved connectivity. While building bridges can bring numerous benefits to remote communities, some drawbacks can significantly impact local culture and subsistence farming lifestyles. These drawbacks stem from changes in access, mobility, and cultural dynamics that can alter the traditional way of life in these communities. In this perspective piece, we shed light on the intricate relationship between social science and engineering challenges faced in building and maintaining bridges in remote Alaska. The course highlights the social, cultural, and ecological challenges of Alaska, fostering critical thinking and problem-solving skills. This comprehensive approach ensures students are not only academically prepared but also socially and environmentally aware, addressing the urgent need for interdisciplinary education in today's rapidly changing world.

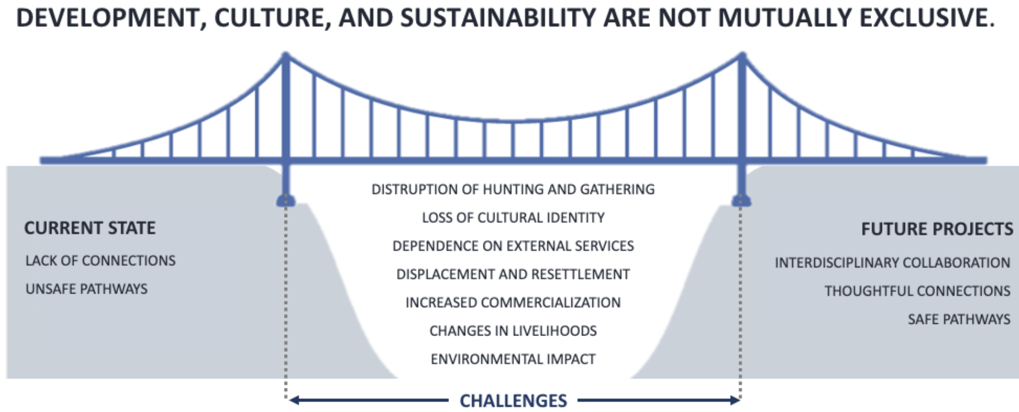

Figure 1: Description of Image

The community of Aleknagik (pop. 197) is located on both the north and south shores at the outlet of Aleknagik Lake where it flows into the Wood River (*Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data*, 2010). Residents of Aleknagik are predominantly Alaska Native (91%) and are Yup'ik-speaking peoples called the Kiatagmiut, whose traditional territory included the Nushagak River drainage to the east into the Wood River lakes, including Aleknagik Lake (Veltre, 1996). A school was established in 1933 that brought together several communities to the present location. In 1959, a road was constructed to connect the south shore with the regional hub of Dillingham. The road was upgraded in the 1980s and paved in the mid-2000s.The Wood River Bridge was constructed in 2015, connecting the two sides of the community. Until then, the north shore, where the school as well as city and tribal government offices are located, was accessible only via boat in the summer or snow machine in the winter, or via small aircraft that can land on the state-maintained runway (Holen et al., 2012). The bridge now allows frequent travel to Dillingham (pop. 2,226), a regional hub and one of two main harbors for the Bristol Bay fishery, the largest sockeye salmon fishery in the world (*Dept of Labor Research & Analysis - State of Alaska*, 2021). Dillingham has a paved runway that can handle large jet aircraft, and it has two grocery stores, a bulk food store, a bank, a middle and high school, the University of Alaska Fairbanks (UAF) Bristol Bay campus, a hospital, and other services provided by a small city (*Harvests and Uses of Wild Resources in Dillingham, Alaska, 2010*, 2010).

The Wood River Bridge was a long-sought infrastructure project. Studies for the bridge began in the early 2000s after an earmark from Senator Ted Stevens. Two longtime state legislators from the region, Rep. Bryce Edgmon of Dillingham and Sen. Lyman Hoffman of Bethel, pushed the project forward with local support that led to an appropriation from the Alaska Legislature of $20 million in 2008. A long line of mayors from Aleknagik kept the bridge momentum going with legislative support as well as support from AKDOT (Dischner & Bendinger, 2021). The Wood River Bridge was a successful project with broad support. In order to understand the impacts of the Wood River Bridge on the wellbeing of Aleknagik residents, we conducted both questionnaire surveys and in-depth interviews from 2022 to 2024. The results suggest that the bridge has reduced travel fatalities across the river substantially; has improved accessibility to shopping, healthcare, education, and hunting on the south side of the lake; and has increased social interactions between the two sides of Aleknagik. The residents, however, are also concerned with the growing number of tourists and with people from outside of the village more easily accessing their natural resources (e.g., berry picking and salmon fishing).

Overview, Content, and Structure

Target audience

The target audience is primarily high school students who are new to the concepts of static equilibrium and programmatic data analysis. This course is designed to introduce these students to the fundamentals of physics through a practical and interactive approach, incorporating Python programming as a tool for learning and problem-solving. The content is tailored to engage young learners who have an interest in physics and computational analysis, and who are keen on understanding real-world applications, particularly in the unique environmental and social context of Alaska's remote communities. By the end of the module, students should be able to:

- Understand and apply basic principles of statics and forces in equilibrium.
- Analyze structural equilibrium in various scenarios, particularly in bridge construction.
- Utilize Python programming for data analysis and problem-solving in physics.
- Integrate social, ecological, and engineering perspectives to address challenges in Alaska's remote communities.
- Develop critical thinking and interdisciplinary problem-solving skills relevant to real-world issues.

Content

The content of this course focuses on introducing high school students to statics in physics, emphasizing real-world applications in the context of Alaska's remote communities. It covers fundamental concepts like forces in equilibrium, structural equilibrium, and the principles of torque, while intertwining these lessons with Python programming for data analysis. The course also addresses the social, ecological, and engineering challenges specific to Alaska, aiming to foster a deeper understanding of interdisciplinary approaches in problem-solving and the importance of sustainable, community-focused solutions. A summary of each unit can be found in Table 1 below:

Table 1: Summary of course material. ## Course Content:

Lesson	Content Summary	Google CoLab
1	This lesson introduces the fundamental concepts of statics, focusing on the principles of forces in equilibrium. It provides an understanding of how to solve problems involving force vectors, both through graphical and analytical methods. The lesson emphasizes the importance of understanding the conditions for equilibrium in various physical scenarios, and it guides students in applying these principles to practical, real-world problems.	Open in Colab
2	The lesson covers concepts like support forces and net force, and teaches students how to apply the principles of vertical and horizontal equilibrium. It emphasizes visualizing parametric relationships and includes practical examples like evaluating the stability of a person standing on ice.	Open in Colab
3	This lesson introduces the concepts of torque and rotational equilibrium. This lesson teaches students how to calculate torque and understand its role in physical systems, particularly focusing on its application in various equilibrium scenarios	Open in Colab
4	This lesson reinforces understanding of forces and equilibrium in physics and engineering, with a focus on practical problem-solving.	Open in Colab
5	This lesson focuses on understanding conditions for static equilibrium in bridges, including balancing forces and torques. Students learn about internal forces like shear forces and moments that contribute to equilibrium.	Open in Colab

Experience of Use

The high school physics teacher who implemented this curriculum expressed a positive and engaging experience with the course material. According to her comments, students were actively engaged as they worked through the background information on the challenges faced by Alaska's remote communities and followed along with the Python code. They particularly appreciated the practical application of the curriculum, where they explored how the thickness of ice impacts its load-bearing capacity. The students also weighed in on their experience with the curriculum. They found the walkthrough on writing and running the code to be very detailed, however they believed the information could be condensed for members with some prior background in Python. In conversations with the high school teacher, it was discussed to leave the curriculum in its current form but to encourage those who might use it to critically evaluate the level of coding experience in their students and potentially provide two versions, one with all the python explanation and one without for those who already have a coding background. Overall the students were enthusiastic about the curriculum's ability to bridge the gap between coding skills and real-life applications; the high school teacher found that this curriculum successfully fostered a meaningful connection between programming, physics, and real-world challenges.

Conclusion

This course module serves as an example of the transformative potential of contextualized STEM education. By intertwining physics education with the unique challenges faced by Alaska's remote communities, this curriculum not only equips high school students with a solid foundation in statics and Python programming but also instills in them a profound understanding of the real-world implications of their learning. The curriculum's ability to bridge the gap between theoretical knowledge and practical application, while addressing social, ecological, and engineering challenges, underscores the need for interdisciplinary collaboration in today's rapidly changing world. As climate change intensifies and communities grapple with unprecedented challenges, the importance of preparing the next generation of STEM practitioners who are not only academically proficient but also socially and environmentally aware cannot be overstated. This curriculum showcases the potential of education modules to inspire critical thinking, problem-solving skills, and a sense of social responsibility in young minds. It provides a model that can be adapted and expanded to empower students across diverse contexts and communities.

Author's Contributions

TN has been teaching high school physics at the Academy of Our Lady of Mercy Lauralton Hall since 1993. RN and TN created the physics materials. HR, MM, GQ, and DH provided social science context. DH provided context about rural Alaska.

Acknowlegements

This material is based upon work supported by the National Science Foundation under Grant BCS-2121909, IIS-2123343, and ICER-1927827. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The authors want to acknowledge the high school students eager to try out the materials. Ayse Akyildiz, the PhD student in Rural Sociology, and Rakeh Saleem, the PhD student in Architectural Engineering, provided great assistance with the field work conducted as part of the data for this project. Dr. Thomas Boothby provided invaluable empirical knowledge about bridges and bridge design. Steve Colligan flew the drone to get the images of the Wood River Bridge. Joe Kallas, PhD student, made the 3D photogrammetry model of the bridge.

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