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Developing the RIDE (Research, Innovate, Design, and Empower) Ecosystem to facilitate equitable collaborations and impactful technology innovation to deliver safe water on tap.

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Engagement in Practice: Developing the RIDE (Research, Innovate, Design, and Empower) Ecosystem to facilitate equitable global collaborations and impactful technology innovation to deliver safe water on tap.

Introduction

Access to clean water remains one of the most pressing global challenges, particularly in resource-constrained rural communities. The United Nations Sustainable Development Goal 6 (SDG6) emphasizes the need to "ensure availability and sustainable management of water and sanitation for all," yet millions of people still lack reliable access to safe drinking water. [1] Addressing this challenge requires not only technological solutions but also strong, equitable partnerships that bridge academia, nonprofits, government entities, and local communities.

The Research, Innovate, Design, and Empower (RIDE) Ecosystem is a collaborative model that fosters long-term, sustainable impact through interdisciplinary partnerships. This ecosystem integrates academic research with real-world implementation, creating opportunities for students to apply engineering principles while working alongside community stakeholders and nonprofit organizations. Unlike traditional service-learning approaches, which can often inadvertently prioritize short-term student experiences over long-term community outcomes, the RIDE Ecosystem emphasizes ethical collaboration, shared knowledge, and sustainable infrastructure development. [2]

At the heart of this model is a partnership network that includes universities such as Cornell University, The Ohio State University, and the New Jersey Institute of Technology, as well as nonprofit organizations like AguaClara Reach (ACR) and Agua Para el Pueblo (APP). These collaborations have contributed to the construction of 25 gravity-powered water treatment plants across Central America, providing safe drinking water to over 100,000 people. The plants, designed to operate without electricity, are sustained by local communities, ensuring long-term functionality and impact.

This paper explores two critical aspects of the RIDE Ecosystem: (1) the partnership ecosystem—how key stakeholders collaborate to bridge the gap between research and practical implementation—and (2) an initial framework for the RIDE model, outlining its core principles and its potential for replication in other contexts. By examining the structure and impact of these partnerships, this paper seeks to provide reflective insights for equitable, community-driven engineering initiatives and invite further engagement from academic institutions interested in humanitarian engineering and sustainable development.

The Partnership Ecosystem

A well-structured partnership ecosystem is essential for bridging the gap between research, innovation, and real-world impact. The RIDE Ecosystem leverages multi-institutional collaboration to connect students, researchers, nonprofit organizations, and community stakeholders, ensuring that engineering innovations translate into sustainable, community-driven solutions. This section explores the roles of key partners, the collaborative structure that enables success, and the challenges and emerging insights for maintaining ethical, long-term partnerships.

Core Partners and Their Roles

The success of the RIDE Ecosystem is driven by a network of key stakeholders who contribute expertise, resources, and local knowledge to ensure long-term impact.

- Community Partners
  - Own and operate water treatment systems, ensuring long-term viability.
  - Provide contextual knowledge to guide appropriate technology design and implementation.
  - Participate in co-design processes to align solutions with local needs and cultural considerations.
- Nonprofit Organizations (AguaClara Reach, Agua Para el Pueblo)
  - Facilitate the implementation and scaling of water treatment solutions in resource-limited settings.
  - Serve as intermediaries between academic research and real-world application.
  - Provide technical and operational support to ensure sustainability.
- Universities (Cornell University, The Ohio State University, New Jersey Institute of Technology, Zamorano Pan-American Agricultural School)
  - Serve as research and innovation hubs, developing and refining water treatment technologies.
  - Provide experiential learning opportunities for students through coursework, fieldwork, and research projects.
  - Support knowledge generation and dissemination through academic publications and technical training.

This multi-sector collaboration ensures that each stakeholder plays a distinct yet complementary role, allowing for shared decision-making and long-term investment in both technology and human capacity.

The Collaborative Model: Bridging Research and Practice

The RIDE Ecosystem is structured to facilitate seamless collaboration between research institutions and implementation partners, ensuring that university-driven innovations are informed by community needs and practical constraints. The key mechanisms that support this collaborative model include:

- Knowledge Exchange & Open-Source Innovation
  - Research findings and technical innovations are openly shared among universities and nonprofit partners.
  - Safe Water on Tap (SWoT) course and affiliated research programs provide hands-on learning opportunities while generating real-world solutions.
  - AguaClara Textbook & AIDE Tool – The AguaClara textbook documents core principles of gravity-powered water treatment, serving as an educational resource for students, researchers, and practitioners. The AguaClara Infrastructure Design Engine (AIDE) is an open-source parametric design tool that enables real-time design and customization of water treatment plants.
  - Communities contribute insights into operational challenges, enabling iterative improvements to technology.

- Long-Term Community Engagement & Capacity Building
  - APP facilitates the establishment of local water boards, which oversee the operation, maintenance, and financial sustainability of AguaClara plants.
  - Unlike short-term service-learning projects, the RIDE model fosters sustained partnerships, enabling co-designed, community-driven solutions.
  - Training programs empower local operators to maintain and manage water treatment plants independently.
- Implementation and Sustainability Strategies
  - Gravity-powered water treatment plants designed within the RIDE Ecosystem are tailored to resource-limited settings, requiring minimal energy inputs.
  - A financially sustainable model—where community members contribute through affordable water tariffs—ensures that systems remain operational beyond the initial project phase.
  - AguaClara plants mostly use locally sourced materials and labor, fostering community ownership, economic empowerment, and long-term sustainability.

Through these mechanisms, the partnership ecosystem ensures that innovations are contextually appropriate, technically sound, and financially viable.

Challenges and Emerging Insights

While the RIDE Ecosystem has demonstrated success in delivering clean water solutions, navigating multi-stakeholder collaborations presents unique challenges. Some key challenges and corresponding emerging insights include:

- Challenge: Aligning Academic Timelines with Long-Term Community Needs
  - University courses operate on semester-based schedules, which can conflict with the continuous, iterative nature of community-based projects.
  - Emerging Insight: Foster multi-year research projects and student involvement across different academic stages (undergraduate, graduate, postdoctoral).
- Challenge: Ethical Engagement and Avoiding "Technological Saviorism"
  - Traditional humanitarian engineering projects often risk imposing solutions without fully considering local knowledge or community agency.
  - Emerging Insight: Center communities in decision-making through participatory design and long-term collaboration rather than one-time interventions.
- Challenge: Ensuring Financial and Operational Sustainability
  - Many water treatment initiatives fail due to a lack of long-term funding and maintenance structures.
  - Emerging Insight: Implement a community-run financial model, where local water boards oversee revenue collection and reinvestment for maintenance.

By addressing these challenges through intentional partnership structures and ethical engagement practices, the RIDE Ecosystem provides a replicable model for sustainable, community-driven engineering collaborations.

The RIDE Framework – An Emerging Model

The RIDE (Research, Innovate, Design, and Empower) framework provides a structured approach to integrating academic research with community-driven engineering solutions. This model bridges education, technology development, and community engagement to create sustainable and scalable solutions for water access. While still evolving, the framework establishes core principles that guide the equitable and ethical implementation of engineering interventions in resource-limited communities.

Core Elements of the RIDE Framework

The RIDE framework consists of four interconnected pillars that ensure sustainable impact and mutual benefit for all stakeholders:

Research

University-led scientific inquiry plays a key role in advancing gravity-powered water treatment technologies. Research topics are driven by real-world challenges identified through collaboration with community and nonprofit partners, ensuring that innovations are both practical and impactful. Areas of focus include water treatment process optimization, prefabrication advancements, and financial models for long-term sustainability.

Innovate

Engineering solutions within the RIDE Ecosystem are iterative and co-designed with stakeholders, ensuring that technologies are contextually appropriate and responsive to community needs. By prioritizing open-source innovation, the ecosystem fosters knowledge sharing and scalability, allowing for continuous improvement and broader impact. A key example is the AguaClara treatment plants, which operate without electricity and are specifically designed to function within rural infrastructure and resource limitations. [3]

Design

Ethical, community-centered design in the RIDE ecosystem ensures that technologies align with the cultural, environmental and economic conditions they will be implemented in. Students, faculty, and community members collaborate on needs assessments and implementation strategies. One example is the Engineering in Context course at The Ohio State University, where students engage with community partners, conduct field research, and apply participatory design principles, preparing them for ethical and impactful engineering practice. Ethical, community-centered design ensures that technologies align with cultural, environmental, and economic conditions. Students, faculty, and community members collaborate on needs assessments and implementation strategies. [4]

Empower

The RIDE framework prioritizes capacity building by providing training programs for local plant operators and engineers, empowering communities to manage their own water systems. Community ownership is central to sustainability, ensuring that these systems remain functional for decades. For example, local water boards oversee plant operations and financing, sustaining long-term access through affordable water tariffs.[5]

These four elements create a holistic, adaptable model that strengthens partnerships and ensures long-term sustainability.

Initial Implementation and Lessons Learned

The RIDE framework is being actively developed and refined through ongoing engagement with academic, nonprofit, and community partners. Key insights from implementation include:

- Long-Term Collaboration Yields Greater Impact
  - Short-term humanitarian projects often lack sustainability; the RIDE model fosters enduring partnerships through continuous research and field implementation.
  - Example: The AguaClara Reach network has sustained gravity-powered water treatment plants for over 15 years.
- Combining Engineering Education with Ethical Engagement Strengthens Outcomes
  - The RIDE model integrates experiential learning for students without compromising community agency or imposing top-down solutions.
  - Example: Safe Water on Tap (SWoT) course teaches students the fundamentals of fluid mechanics while designing real-world water treatment solutions.
- Scalability and Adaptability Are Key to Expansion
  - Prefabrication of treatment plants could increase accessibility and reduce implementation costs for communities worldwide.
  - Example: Ongoing research into modular, scalable designs to bring AguaClara plants to new regions beyond Central America.

These early findings validate the potential of the RIDE framework as a replicable model while also highlighting areas for further refinement.

Conclusion and Future Directions

The RIDE Ecosystem has demonstrated that ethical, long-term partnerships between universities, nonprofits, and communities can drive sustainable solutions to global engineering challenges. By aligning academic research with real-world needs, the RIDE framework bridges the gap between innovation and implementation, ensuring that engineering solutions are both technically sound and socially responsible. While creating meaningful experiential learning opportunities for students, the RIDE Ecosystem prioritizes equitable engagement, ensuring that participation strengthens rather than burdens marginalized communities and fosters inclusive collaboration.

Through the collaborative partnership model explored in this paper, RIDE has facilitated the development of sustainable water treatment technologies that have provided safe drinking water to over 100,000 people in Central America. The integration of research, innovation, design, and empowerment ensures that solutions remain adaptable and scalable while prioritizing community ownership and sustainability.

Expanding the RIDE Framework: key areas that present opportunities for further development:

Ongoing research is examining how the AguaClara model can be adapted to new regions with diverse cultural, economic, and environmental conditions. Future partnerships aim to expand its reach beyond Central America, with potential applications in Africa, South Asia, the United States, and other areas where access to safe water remains a critical challenge.

Continued investment in operator training programs and local leadership development will further strengthen community-driven water management, ensuring long-term sustainability. Expanding the use of digital tools and remote learning opportunities can broaden access to training, overcoming the limitations of physical travel.

At the same time, analyzing the role of policy frameworks and financial models will provide valuable insights into scaling these efforts effectively. Increased collaboration with government agencies and global development organizations could further enhance replicability and funding opportunities, ensuring that sustainable water solutions reach more communities worldwide.

Call to Action: create a scalable, replicable model for integrating humanitarian engineering into education and global development.

However, continued success depends on collaboration and knowledge exchange across institutions and disciplines. By fostering cross-sector collaboration, we can continue to enhance student learning outcomes while advancing sustainable solutions for global water challenges. Students engaged in RIDE-related coursework and research gain critical technical skills, cultural competency, and ethical engagement experience—preparing them to become future engineers and leaders in sustainable development.

We invite academic institutions, nonprofit organizations, and industry leaders to engage with the RIDE Ecosystem—whether by contributing to research, implementing pilot projects, or integrating the framework into engineering education. Through equitable and sustainable partnerships, we can work toward a future where engineering education and humanitarian impact reinforce one another, creating solutions that benefit both students and communities.

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