

Integrating hydraulics, gender and water justice: a Critical Socio-hydraulics quiz as a university extension tool aligned with the SDGs¹

Integrando hidráulica, gênero e justiça hídrica: um quiz de Sociohidráulica Crítica como ferramenta de extensão universitária alinhada aos ODS

Integrando hidráulica, género y justicia hídrica: un cuestionario de Sociohidráulica Crítica como herramienta de extensión universitaria alineada con los ODS

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ABSTRACT

This paper presents the development and implementation of an interactive quiz on hydraulics as a university extension activity of the Civil Engineering program at Veiga de Almeida University (UVA), in partnership with the National Association of Environmental Managers (Associação Nacional de Gestores Ambientais - ANAGEA). The initiative is aligned with Sustainable Development Goal (SDG) 4 – Quality Education, and aims to raise awareness of SDGs 5 (Gender Equality) and 6 (Clean Water and Sanitation) through an accessible educational tool that integrates technical content from hydraulic engineering with socio-environmental themes. In the first stage, 24 questions were developed based on academic references from socio-hydrology, with content validated by the author. The material was applied through digital dissemination, reaching 47 unique accesses in 30 days, with 31 participants completing all the questions (66% completion rate). The tool demonstrated potential as an innovative pedagogical resource for critical engineering education aligned with the SDGs.

Keywords: Critical socio-hydraulics. Gamification. Water justice. Engineering education.

RESUMO

Este trabalho apresenta o desenvolvimento e a implementação de um quiz interativo sobre hidráulica como atividade de extensão universitária do curso de Engenharia Civil da Universidade Veiga de Almeida (UVA), em parceria com a Associação Nacional de Gestores Ambientais (ANAGEA). A iniciativa está alinhada ao Objetivo de Desenvolvimento Sustentável (ODS) 4 – Educação de Qualidade, e tem como propósito ampliar a conscientização sobre os ODS 5 (Igualdade de Gênero) e 6 (Água Potável e Saneamento), utilizando uma ferramenta didática acessível que integra conteúdos técnicos da engenharia hidráulica com temáticas socioambientais. Na primeira etapa, foram elaboradas 24 questões com base em referências acadêmicas da sociohidrologia, validadas quanto ao conteúdo pela autora. O material foi aplicado através de divulgação

¹ The translation of the article is the sole responsibility of the authors. Translations of excerpts from works written in another language, when rendered into English, are likewise the responsibility of the authors, unless a different authorship is declared.

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digital, alcançando 47 acessos únicos em 30 dias, com 31 participantes completando todas as questões (66% de taxa de conclusão). A ferramenta demonstrou potencial como recurso pedagógico inovador para educação em engenharia crítica e alinhada aos ODS.

Palavras-chave: Sociohidráulica crítica. Gamificação. Justiça hídrica. Educação em engenharia.

RESUMEN

Este trabajo presenta el desarrollo y la implementación de un cuestionario interactivo sobre hidráulica como actividad de extensión universitaria del curso de Ingeniería Civil de la Universidad Veiga de Almeida (UVA), en colaboración con la Asociación Nacional de Gestores Ambientales (Associação Nacional de Gestores Ambientais – ANAGEA). La iniciativa está alineada con el Objetivo de Desarrollo Sostenible (ODS) 4 – Educación de Calidad, y tiene como propósito ampliar la concienciación sobre los ODS 5 (Igualdad de Género) y 6 (Agua Limpia y Saneamiento), mediante una herramienta didáctica accesible que integra contenidos técnicos de la ingeniería hidráulica con temáticas socioambientales. En la primera etapa, se elaboraron 24 preguntas basadas en referencias académicas de la sociohidrología, validadas en cuanto a su contenido por la autora. El material se aplicó mediante difusión digital, alcanzando 47 accesos únicos en 30 días, con 31 participantes que completaron todas las preguntas (66% de tasa de finalización). La herramienta demostró potencial como recurso pedagógico innovador para la educación en ingeniería crítica alineada con los ODS.

Palabras clave: Sociohidráulica crítica. Gamificación. Justicia hídrica. Educación en ingeniería.

INTRODUCTION

Contemporary water management demands approaches that go beyond purely technical solutions, incorporating the social, environmental and political dimensions that shape access to this essential resource (Di Baldassarre *et al.*, 2019). Socio-hydrology has become established as a fundamental theoretical framework for understanding the complex interactions between hydrological and social systems (Sivapalan *et al.*, 2012), with recent approaches demonstrating that structural inequalities and institutional arrangements are as determined as physical and hydrological parameters (Xu *et al.*, 2018).

In this context, the Sustainable Development Goals (SDGs) of the 2030 Agenda offer a guiding framework for integrated strategies. SDGs 5 (Gender Equality) and 6 (Clean Water and Sanitation) stand out, articulating issues of equity, universal access and environmental justice. Promoting gender equality requires overcoming women's underrepresentation in water-related decision-making spaces, where significant power asymmetries persist (Clément *et al.*, 2022). At the same time, SDG 4 (Quality Education) reinforces the need to train critical professionals capable of operating at the interface between technique and society.

Literature consistently advocates the need for interdisciplinary approaches and the integration of the SDGs into engineering education (Finnell *et al.*, 2023; Sullivan *et al.*, 2021; Burt *et al.*, 2021). However, an implement, and few gaps can be identified: while

theoretical discourse is abundant, few studies offer concrete, tested and replicable pedagogical instruments that operationalize this integration in educational practice. This research is specifically positioned to fill this gap, proposing and validating an open educational resource that translates theoretical discourse into an applicable activity.

It was from this perspective that the extension project between Veiga de Almeida University (UVA) and the National Association of Environmental Managers (Anagea) was conceived, involving the development of an interactive quiz on hydraulics that integrates scientific outreach with education for sustainability. Gamification, as a pedagogical strategy, shows promise for addressing complex content through immersive and engaging experiences (Deterding *et al.*, 2011; Kapp, 2012).

This work aims to develop and implement an interactive quiz that integrates hydraulics concepts with the principles of water justice and gender equality, proposing the concept of Critical Socio-Hydraulics. As specific objectives, it seeks to build a question bank articulating the technical and social dimensions of water management through a Curricular Articulation Matrix; implement the tool on an accessible digital platform; analyze the engagement metrics of the pilot application; and discuss the implications for engineering education arising from the concept of Critical Socio-Hydraulics.

THEORETICAL FRAMEWORK

Traditional engineering education has often overlooked critical dimensions of equity and social justice in favor of excessive technical education. Recent studies, however, highlight the fundamental importance of equity-centered approaches in engineering education (Finnell *et al.*, 2023), advocating for the systematic integration of social and critical perspectives into technical curricula.

At the same time, training environmentally conscious professionals emerges as a contemporary imperative. Sullivan *et al.* (2021) demonstrate, through a mixed-methods study, that attitudinal instruction is essential for developing environmental awareness in engineering students, going beyond the transmission of technical knowledge to encompass changes in values and behaviors.

In the specific context of civil and environmental engineering, Burt *et al.* (2021) argue that the integration of diversity, equity and inclusion is an essential element for addressing the challenges of social justice in a changing climate. This perspective is

particularly relevant to water resource management, where structural inequalities frequently determine access to and distribution of water.

Socio-hydrology has become established as a fundamental theoretical framework for understanding the complex interactions between hydrological and social systems (Sivapalan *et al.*, 2012). This transdisciplinary approach recognizes that variables such as inequality, governance and culture are as determined for water security as physical and hydrological parameters (Di Baldassarre *et al.*, 2019).

The intersection between gender and water proves especially significant. Globally, women and girls are primarily responsible for domestic water collection, yet their participation in water resource governance remains disproportionately low (Clément *et al.*, 2022). This disconnect between practical responsibility, and decision-making power constitutes a central barrier to water justice.

Gamification, defined as “the use of game design elements in non-game contexts” (Deterding *et al.*, 2011), offers significant potential for environmental education. Kapp (2012) points out that gamification can create safe learning environments for experimentation, which are essential for understanding complex systems. This strategy draws on the principles of learning through electronic games developed by Gee (2003), who demonstrates that well-designed playful environments facilitate the understanding of complex systems and promote risk-taking and problem-solving – skills that are essential for critical engineering education.

METHODOLOGY

The development of the interactive quiz followed an integrated methodological approach, articulating technical and social dimensions through four main components. Initially, a Socio-Hydraulic Curricular Articulation Matrix was developed to ensure the systemic integration of the thematic axes, putting into practice the principles of equity-centered education (Finnell *et al.*, 2023). This structure operationalizes the theoretical framework of socio-hydrology, making explicit the connections between technical hydraulics concepts and critical socio-environmental competencies, offering a replicable model for other educators.

Box 1 – Socio-Hydraulic Curricular Articulation Matrix.

Technical Concept	Sanitation Competency (SDG 6)	Gender Competency (SDG 5)	Water Justice Competency
Archimedes' Principle	Water as a human right vs. commodity	Differentiated impact of scarcity on women	Equitable access to flotation technologies
Flow rate calculation	Integrated watershed management	Women's participation in basin committees	Fair distribution in water conflicts
Surface tension	Protection of aquatic ecosystems	Sexual division of labor in water collection	Appropriate technologies for communities

Source: Prepared by the author (2025).

To transform the matrix into a practical pedagogical tool, each intersection cell was operationalized into 2 to 3 specific questions in the quiz's item bank. For example, the intersection between 'Flow Rate Calculation' and 'Gender Competency (SDG 5)' gave rise to questions relating calculation ability to the analysis of women's participation in basin committees. This strategy ensured balanced and integrated coverage of all the technical and social dimensions envisaged in the framework, ensuring that the quiz effectively assessed the proposed socio-hydraulic competencies.

A total of 24 questions were developed across four axes, ensuring balanced coverage between technical and social dimensions. The questions employed a multiple-choice format with accessible language and plausible distractors based on common misconceptions identified in the literature, incorporating the perspective on environmental awareness development proposed by Sullivan *et al.* (2021). The structure of each item combines the multiple-choice format with plausible distractors and a design that facilitates navigability, as exemplified in Figure 1.

The content underwent an initial expert content-validation process, conducted by the author, who holds dual academic training – a master's degree in urban and environmental engineering and a Technology degree in Environmental Management. This multidisciplinary expertise enabled an integrated assessment covering both the accuracy of the technical hydraulics aspects and the relevance and depth of the socio-environmental and gender dimensions related to the Sustainable Development Goals. This step ensured the internal consistency of the instrument prior to its pilot application.

The quiz was developed by the author as a responsive web-based application using HTML5, CSS3 and JavaScript, incorporating gamification elements such as immediate feedback, a scoring system and sequential progression, with the aim of promoting engagement and facilitating the acquisition of knowledge related to hydraulics, water resources, and sustainability. The application's home interface (Figure 2) was designed by the author with a focus on accessibility, clarity and intuitive navigation design. It highlights the partnership between UVA and ANAGEA, reinforcing the extension-oriented character of the project. The responsive design was optimized for access on mobile devices, which accounted for 72% of the accesses recorded during the pilot phase. The interface also enables users to readily identify the quiz theme and its educational purpose: the Sustainable Development Goals (SDGs) 4, 5 and 6. These design features were intended to facilitate usability and user engagement.

Figure 1 – Home screen of the Socio-Hydraulics Quiz, highlighting the UVA-ANAGEA partnership and the target SDGs.

Quiz: Hidráulica e Sustentabilidade

SELO UVA DE QUALIDADE

FAÇA PARTE Associe-se ANAGEA

UNIJORGE

Seja bem-vindo(a) gestor(a) ambiental do futuro!

4 EDUCAÇÃO DE QUALIDADE

5 IGUALDADE DE GÊNERO

6 ÁGUA POTÁVEL E SANEAMENTO

Teste seus conhecimentos sobre como a água funciona e como podemos protegê-la!

Pontuação: 0/10

Qual a importância da disseminação de conhecimento sobre hidráulica e gestão de recursos hídricos para a população em geral (ODS 4)?

A) Apenas os engenheiros precisam entender de hidráulica

B) A conscientização pública pode levar a um uso mais responsável da água e ao apoio a políticas sustentáveis

C) O conhecimento técnico deve ser restrito aos profissionais da área

D) A educação ambiental não se relaciona com a hidráulica

✓ Resposta correta! Correto! A educação e a conscientização são cruciais para promover um uso responsável da água e o apoio a políticas que garantam o acesso e a sustentabilidade (ODS 4 e 6).

Próxima

Source: Prepared by the author (2025).

Figure 2 – Example quiz question, integrating planning (management) concepts with water sustainability (SDG 6).

Pontuação: 1/10

Qual o principal objetivo do planejamento e gestão de recursos naturais?

A) Aumentar a exploração para o crescimento econômico.

B) Criar estratégias para o uso sustentável de água, solo e biodiversidade.

C) Ignorar os limites ambientais em prol do desenvolvimento.

D) Focar apenas na preservação intocada da natureza.

✓ Resposta correta! Correto! O objetivo é equilibrar desenvolvimento com sustentabilidade, promovendo o uso responsável dos recursos.

Próxima

Source: Prepared by the author (2025).

Figure 3 – Publication of the Quiz on ANAGEA's page.

anagea.org.br/Proj-Gestores-Kids/

Associação de Gestores Ambientais do Brasil

Associe-se

Página Inicial Quem Somos Associados Contate-nos

Projeto: Gestores Kids

Quiz: Hidráulica e Sustentabilidade. Clique aqui!

A proposta do **Quiz Interativo em Hidráulica** foi implementada como **atividade de extensão da Universidade Veiga de Almeida (UVA)**, alinhada ao **ODS 4** (Educação de Qualidade), em parceria com a **ANAGEA** (Associação dos Gestores Ambientais do Brasil). O objetivo é **promover a conscientização sobre os ODS 5 (Igualdade de Gênero) e 6 (Água Potável e Saneamento)**, utilizando uma ferramenta inovadora e acessível para democratizar o conhecimento técnico e **promover discussões sobre temas sociais e ambientais** relacionados ao acesso à água.

A **primeira fase** do projeto consistiu na **elaboração do conteúdo do quiz**, com perguntas sobre hidráulica e questões sociais, baseadas em pesquisas acadêmicas sobre sociohidrologia. Esta fase inicial foi aplicada a um grupo fechado de teste, com o **objetivo de verificar a clareza e a relevância das questões**.

Na **segunda etapa**, o **conteúdo será validado por grupos mais amplos de usuários**, como estudantes, profissionais e membros da comunidade. Isso permitirá ajustar o quiz e garantir que ele seja acessível a uma variedade de perfis e níveis de conhecimento.

A implementação do quiz envolve **estratégias de divulgação em mídias sociais e na página da ANAGEA**, visando alcançar um público amplo. A **versão online** foi **projetada para ser intuitiva e acessível**, proporcionando uma boa experiência ao usuário.

A **avaliação de impacto** incluirá **métricas quantitativas e feedback qualitativo**, para ajustes contínuos e garantir a relevância do quiz ao longo do tempo, promovendo discussões sobre gestão hídrica inclusiva e sustentável.

Teste seus conhecimentos sobre como a água funciona e como podemos protegê-la!

Quiz: Hidráulica e Sustentabilidade. Clique aqui!

Source: Prepared by the author (2025).

The tool was made available for 30 days through campaigns on ANAGEA's social media channels and the author's personal outreach efforts, with automatic collection of engagement metrics. The dissemination strategy focused on the use of specialized channels, such as ANAGEA's institutional page (Figure 3), to reach a relevant target audience (professionals and students in the environmental sector). Additionally, broad social media platforms (Figure 4), such as Instagram and LinkedIn, were used with the aim of maximizing accessibility and reach diverse audiences, including the non-academic community and younger audiences – an intentional tactic to promote discussion of SDG 5 in a traditionally male-dominated sector.

Figure 4 – Publication of the Quiz on ANAGEA's digital media.

Source: Prepared by the author (2025).

RESULTS AND DISCUSSION

The implementation of the digital dissemination strategy resulted in 47 unique accesses over 30 days, of whom 31 participants completed all the questions, achieving a completion rate of 66%. The high rate of access via mobile devices (72%) validates the choice to develop a responsive interface.

The predominantly male profile (85%) of the sample is not merely a demographic data point, but a key analytical factor. It reflects and reproduces, on a microscale, the sector's structural gender imbalance (Burt *et al.*, 2021). This sampling bias likely influenced the performance patterns observed, with the highest error rates concentrated on the gender and water justice axes. Far from invalidating the tool, this result corroborates it as a necessary resource, evidencing the lack of training on these topics and the potential resistance of an audience traditionally not confronted with equity issues. The quiz, therefore, functions not only as an educational tool but also as a diagnostic device that exposes curricular gaps and sectoral biases.

The performance data revealed patterns consistent with specialized literature, showing greater familiarity with technical concepts compared to social and gender dimensions. The questions with the highest error rates were concentrated on the gender and water justice axes, particularly items on intersectionality and legal frameworks for social participation.

The results of this study make it possible to advance the proposal of the concept of Critical Socio-Hydraulics, defined as the educational approach that systematically integrates the principles of technical hydraulics with a critical analysis of the power, gender

and justice structures that shape water access and governance. This proposal materializes the principles of equity-centered education advocated by Finnell *et al.* (2023), translating them into the specific domain of hydraulics.

While socio-hydrology (Sivapalan *et al.*, 2012) focuses on the coupled dynamics between hydrological and social systems at a macro scale, critical socio-hydraulics operates at the pedagogical micro level, translating these couplings into the daily practice of professional training, in alignment with the recommendations of Sullivan *et al.* (2021) for the development of environmental awareness.

A comparative analysis with similar initiatives reveals the innovative character of the proposal presented here. While traditional gamification platforms predominantly focus on engagement and the assessment of technical content, our quiz goes further by systematically integrating critical dimensions of gender and water justice from the very conception of the questions, responding to the call for greater diversity and inclusion in civil and environmental engineering education (Burt *et al.*, 2021).

FINAL CONSIDERATIONS

This work offers three main contributions to the field of engineering education and water resource management: a methodological contribution, through the Socio-Hydraulic Curricular Articulation Matrix, which provides a replicable model for integrating technical and social dimensions into engineering education; a conceptual contribution, with the proposal of Critical Socio-Hydraulics, which advances the theoretical framework of socio-hydrology into the pedagogical domain; and a practical contribution, with the development and validation of an open educational resource that materializes theoretical principles into an applicable tool.

It is important to acknowledge the limitations inherent in this pilot study. The reduced sample size ($n=31$) and the composition of the sample – with a predominance of male students – limit the statistical generalization of the results. Nevertheless, the data collected is highly indicative, offering valuable insights for refining the tool and confirming the feasibility and acceptance of the proposed approach. The high completion rate (66%) in the context of voluntary dissemination signals the tool's engagement potential.

For future research, the following are recommended: applying the matrix refining the concept of critical socio-hydraulics through broader empirical studies; expanding the tool to include multimedia resources and long-term impact assessments; and conducting an expanded validation by a multidisciplinary panel of experts covering the fields of hydraulics, gender studies, environmental justice and pedagogical education, to further consolidate the robustness of the instrument.

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