2026 International Nuclear Atlantic Conference – INAC 2026
Escola de Guerra Naval, Rio de Janeiro, RJ, August 24 - 28, 2026

A Mobile Application for Science Communication on Nuclear Energy: Preliminary Development and a Proposed Multidimensional Evaluation Protocol

Alessandro Augusto Jordão[1 2], Mauricio Correa[2], Luan Santos da Cunha[2], Valter Arthur[1], Felipe Marques e Silva[2,3], Carlos Henrique Calegari[2,3]

[1] *Universidade de São Paulo (USP), Instituto de Pesquisas Energéticas e Nucleares (IPEN)*
[2] *Universidade Paulista (UNIP), Instituto de Ciências Exatas e Tecnologia (ICET)*
[3] *Universidade Federal de São Carlos (UFSCar)*
**jordao@usp.br*

1. Introduction

Nuclear technologies contribute to low-emission electricity generation, healthcare, agriculture, food security, environmental protection, and industrial applications [1]. Nevertheless, public perceptions of these technologies are shaped not only by factual knowledge but also by institutional trust, values, technological familiarity, and the sociocultural context [2–4]. Public communication should therefore not be reduced to the one-way transmission of information or assume that greater exposure to content will, by itself, lead to learning or acceptance.

Mobile applications can combine written content, audiovisual resources, interactive activities, and immediate feedback. However, technical functionality alone does not demonstrate usability, accessibility, or educational effectiveness. Similar studies have employed heterogeneous architectures, target audiences, and evaluation approaches, often involving small samples or lacking a comparison group [9–11]. This study aims to describe the preliminary development of an application for nuclear energy science communication and knowledge management and to propose a protocol for its evaluation with external users, separately addressing usability, learning, satisfaction, engagement, perception, knowledge retention, and intention to use.

2. Methodology

This is an applied, exploratory, and technological study organized into four stages. The first stage comprised a review of public science communication, public perceptions of nuclear energy, and digital educational resources, followed by the selection and adaptation of scientific and technical content concerning the peaceful uses of nuclear technologies.

In the second stage, informational, functional, and interaction requirements were defined. The Android prototype was developed using MIT App Inventor and featured a reconfigurable single-screen interface, modular programming, dynamic lists, bilingual content, preference storage through TinyDB, and data transmission through Web1. Written content, images, videos, myths-and-facts activities, a quiz, feedback, avatars, and gamification elements were incorporated.

The third stage comprised internal checks of navigation, screen updating, scrolling, response validation, visual feedback, language preference persistence, scoring, and data transmission. These procedures constituted software testing rather than a usability study: no external users participated, no standardized scale was administered, and neither learning nor perception was evaluated.

The fourth stage consisted of developing an evaluation protocol grounded in ISO 9241-11 [5], the Brazilian version of the System Usability Scale (SUS-BR) [6], the Brazilian Portuguese adaptation of the User Engagement Scale (UES-Br) [7], the Web Content Accessibility Guidelines (WCAG) 2.2 [8], and principles of test validity [13]. The formative phase will involve 20 external users. The controlled pilot phase will include 60 participants randomized in a 1:1 ratio to either the application or the same content presented in a static format, with an equivalent exposure duration. The sample size for a subsequent confirmatory study will be determined through an a priori statistical power analysis informed by the pilot results.

Eligible participants will be individuals aged 18 years or older who are able to provide informed consent and understand Portuguese, have no academic or professional background in the nuclear field, and were not involved in developing the application. Visual, auditory, or motor impairments and low digital literacy will not constitute exclusion criteria. Recruitment will seek diversity in age, gender, race/ethnicity, educational attainment, income, geographic region, digital experience, prior knowledge, and use of assistive technologies. Participants' own Android smartphones and standardized devices with different screen sizes and operating system versions will be used. Device model, screen resolution, operating system version, and accessibility settings will be recorded.

During the formative phase, sessions will last approximately 45–60 minutes and will include the

following tasks: selecting the interface language; locating a topic; consulting an informational module; completing a myths-and-facts activity; answering the quiz and interpreting the feedback; accessing an audiovisual resource; changing a preference; and completing the data-submission process. Task completion time, independent completion, requests for assistance, critical and noncritical errors, navigation paths, and observed or verbalized difficulties will be recorded. Success will be defined as task completion without assistance or critical errors; assisted completion will be classified as partial success. After the tasks, participants will complete the SUS-BR and take part in a semi-structured interview.

During the controlled phase, knowledge and perception will be assessed before the intervention, immediately after exposure, and at a 30-day follow-up. The knowledge test will be independent of the application's quiz and will undergo expert review, content-validity assessment, cognitive testing, and pilot analyses of item difficulty, discrimination, and reliability. The questionnaire integrated into the application will not be used for inferential purposes until its constructs, items, response processes, internal structure, and reliability have been evaluated in a dedicated methodological validation study. Previously validated or cross-culturally adapted scales will be used to measure perceived risk, perceived benefits, trust, and acceptability. The study involving participants will be conducted only after ethics approval has been obtained, and all participants will provide informed consent.

3. Results and Discussion

The development process resulted in a functional Android application. The "Unveiling Nuclear Energy" module covers five thematic areas: aerospace, industrial applications, nuclear power plants, nuclear medicine, and agriculture and food. The "Myths and Truths" module contains 16 statements accompanied by explanatory feedback, whereas the quiz comprises 24 multiple-choice questions. The application also includes videos, avatars, gamification elements, bilingual support, and an experimental questionnaire.

The reconfigurable single-screen architecture and dynamic lists facilitate system maintenance and the incorporation of new content. Internal checks led to adjustments in scrolling, navigation, response validation, scoring, visual feedback, language preference persistence, and data transmission. These results support the preliminary technical feasibility of the application but do not demonstrate its usability with external users or its educational effectiveness.

Table I: Comparison of digital educational resources.

Resource	Architecture and target audience	Content and accessibility	Evaluation and results
Kanematsu *et al*. [9]	Second Life environment combined with an in-person activity; six elementary school students.	Radioactivity and nuclear safety; accessibility criteria were not reported.	Post-activity questionnaire without a control group or standardized scale; favorable impressions but limited inferential value.
Ürek [10]	Mobile applications, sensors, and augmented reality; 17 preservice science teachers.	Science experiments; accessibility was not evaluated separately.	Single-group pretest–posttest study using validated scales; improvements in digital literacy and disposition toward technology use.
Wang *et al*. [11]	Augmented reality for iOS and Android devices; 75 patients.	Personalized visualization of radiotherapy; no systematic accessibility audit.	Single-arm pretest–posttest study; self-reported improvement in understanding and a partial reduction in anxiety, without a control group.

Similar to the applications reported in the literature [9–11], the proposed app combines mobile access, multimedia content, interactive activities, quizzes, immediate feedback, and gamification elements to support science communication and learning. Its distinctive design features include bilingual content, a modular low-code architecture based on a reconfigurable single-screen interface, and the integration of

informational modules on the peaceful uses of nuclear technologies with myth-or-fact activities and audiovisual resources. However, the comparison also indicates that interactivity and mobility alone do not demonstrate educational effectiveness or changes in public perception. Accordingly, the main original contribution of this study is the integration of the preliminary technological product with a prospective multidimensional evaluation framework that explicitly defines the participant profile, context of use, devices, tasks, validated instruments, outcome domains, and analytical criteria.

Table II summarizes the proposed multidimensional evaluation protocol. Each dimension will be assessed independently using a specific instrument or data source, thereby avoiding the interpretation of usability, engagement, satisfaction, learning, and perception as equivalent outcomes.

Table II: Proposed Multidimensional Protocol for External Evaluation.

Dimension	Main measure or instrument	Assessment point
Usability	Task success, time, errors, assistance, and SUS-BR [6]	Formative study
Learning	Knowledge test developed independently of the in-app quiz; expert review, cognitive testing, and pilot item analysis	Pre- and post-intervention
Satisfaction	QUIS [14], following cross-cultural review and psychometric evaluation for Brazilian Portuguese	Post-intervention
Engagement	UES-Br [7] and usage records	During and post-intervention
Public perception	Validated scales of risk, benefit, trust, and acceptability	Pre, post, and 30-day follow-up
Knowledge retention	Parallel form of the knowledge test	30-day follow-up
Intention to use	TAM-based behavioral-intention items [12], following content validation and cognitive testing	Post and 30-day follow-up
Accessibility	WCAG 2.2 audit [8], task performance, and reported barriers	Formative study and controlled pilot

Task success will be defined as completion without assistance or critical errors. Formative data will be analyzed using descriptive statistics and thematic analysis of observed difficulties. Controlled-pilot outcomes will be examined through within- and between-group comparisons, effect estimates, and 95% confidence intervals. The in-app quiz and perception questionnaire will not be used as outcome measures until adequate validity evidence has been established.

4. Conclusions

This study aimed to describe the preliminary development of a mobile application for science communication and knowledge management in the nuclear field and to propose a multidimensional protocol for its external evaluation. This objective was achieved through the development and functional documentation of a bilingual Android prototype and the definition of a protocol that separately assesses usability, learning, satisfaction, engagement, public perception, knowledge retention, intention to use, and accessibility.

The application's contribution lies in integrating scientific and technical content on the peaceful uses of nuclear technologies, interactive activities, and audiovisual resources for nonspecialist audiences into a modular and updatable mobile resource. The product contributes to expanding opportunities for science communication and knowledge management in the nuclear field, while the proposed protocol provides a systematic framework for assessing its different dimensions without conflating technical functionality with educational impact or changes in public perception.

The absence of evaluation with external users limits inferences regarding usability, accessibility, educational effectiveness, public perception, and social impact. Future studies should validate the assessment instruments, conduct formative testing with users from different backgrounds, and perform controlled evaluations incorporating pre-intervention, post-intervention, and knowledge-retention

measures.

Acknowledgements

The authors would like to thank the Brazilian Nuclear Energy Association (ABEN), especially Dr. Olga Mafra, and the Vice-Rectorate of Universidade Paulista (UNIP), especially Dr. Marina da Camino Ancona Lopez Soligo and Dr. Laura Ancona Lee, for their valuable support. The authors also thank the anonymous ad hoc reviewers for their constructive comments and suggestions.

References

[1] World Nuclear Association, Nuclear's Contribution to Achieving the UN Sustainable Development Goals, World Nuclear Association, London, United Kingdom (2021).
[2] S. S. Ho et al., "Science literacy or value predisposition? A meta-analysis of factors predicting public perceptions of benefits, risks, and acceptance of nuclear energy," Environmental Communication, vol. 13, pp. 457–471, https://doi.org/10.1080/17524032.2017.1394891 (2019).
[3] P. Brauner et al., "Public perception of technologies in society: Mapping laypeople's mental models in terms of risk and valence," Digital Society, vol. 3, art. 62, https://doi.org/10.1007/s44206-024-00148-5 (2024).
[4] J. I. M. de Groot, E. Schweiger, and I. Schubert, "Social influence, risk and benefit perceptions, and the acceptability of risky energy technologies," Risk Analysis, vol. 40, pp. 1226–1243, https://doi.org/10.1111/risa.13457 (2020).
[5] International Organization for Standardization, ISO 9241-11:2018—Ergonomics of Human-System Interaction—Part 11: Usability: Definitions and Concepts, ISO, Geneva, Switzerland (2018).
[6] D. F. Lourenço, E. V. Carmona, and M. H. B. M. Lopes, "Translation and cross-cultural adaptation of the System Usability Scale to Brazilian Portuguese," Aquichan, vol. 22, e2228, https://doi.org/10.5294/aqui.2022.22.2.8 (2022).
[7] D. M. Miranda, C. L. Juy, and T. Darin, "UES-Br: Translation and cross-cultural adaptation of the User Engagement Scale for Brazilian Portuguese," Proceedings of the ACM on Human-Computer Interaction, vol. 5, art. 278, https://doi.org/10.1145/3474705 (2021).
[8] World Wide Web Consortium, Web Content Accessibility Guidelines (WCAG) 2.2, W3C Recommendation, https://www.w3.org/TR/WCAG22/ (2024).
[9] H. Kanematsu et al., "Virtual STEM class for nuclear safety education in metaverse," Procedia Computer Science, vol. 35, pp. 1255–1261, https://doi.org/10.1016/j.procs.2014.08.224 (2014).
[10] H. Ürek, "The impact of a mobile phone and mobile application-supported science laboratory on the digital literacy of preservice teachers and their disposition toward using technology in class," Journal of Science Education and Technology, vol. 33, pp. 983–997, https://doi.org/10.1007/s10956-024-10138-4 (2024).
[11] L. J. Wang et al., "Smartphone-based augmented reality patient education in radiation oncology," Technical Innovations & Patient Support in Radiation Oncology, vol. 29, art. 100229, https://doi.org/10.1016/j.tipsro.2023.100229 (2024).
[12] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," MIS Quarterly, vol. 13, pp. 319–340, https://doi.org/10.2307/249008 (1989).
[13] American Educational Research Association, American Psychological Association, and National Council on Measurement in Education, Standards for Educational and Psychological Testing, AERA, Washington, DC (2014).
[14] J. P. Chin, V. A. Diehl, and K. L. Norman, "Development of an instrument measuring user satisfaction of the human-computer interface," Proceedings of CHI '88, pp. 213–218, https://doi.org/10.1145/57167.57203 (1988).