



Dataset on Students' Physics Problem-Solving Strategies in Rwandan Secondary Schools

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Abstract

The data presented in this paper is related to Physics problem-solving strategies collected from Rwanda secondary schools. This comprehensive dataset is derived from five interrelated studies investigating the impact of systematic problem-solving strategy on students' achievement, engagement, and attitudes in Rwandan secondary school physics education. It comprises quantitative and qualitative data collected through quasi-experimental designs, involving around 160 students from two districts in Rwanda. Key data sources include pre-and post-test scores measuring problem-solving abilities, conceptual understanding and, Reformed Teaching Observation Protocol scores assessing classroom engagement, and survey responses analyzing students' attitudes towards systematic problem-solving. The dataset provides valuable insights for educators, policymakers, and researchers seeking to enhance physics education through systematic instructional approaches. It facilitates further research on the efficacy of structured problem-solving frameworks in STEM education and offers a foundation for comparative studies in diverse educational contexts.

Keywords: Systematic problem-solving, physics education, student achievement, instructional strategies, students attitudes, dataset, Rwanda

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Article information

Received: 20/02/2025;
Reviewed: 17/03/2025;
Revised: 20/03/2025;
Accepted: 21/03/2025

How to cite this article: Musengimana, T., Yadav, L.L., Uwamahoro, J., Nizeyimana, G. (2025) ' Dataset on Students' Physics Problem-Solving Strategies in Rwandan Secondary Schools', *Second Data*, 2(1), 01-04.

Available at: <https://doi.org/10.58197/prbl/VIGW4069>

Introduction

Problem-solving is a fundamental skill in physics education, enabling students to develop a deep understanding of concepts and apply their knowledge to real-world situations (Hung en Jonassen, 2006). Research has shown that structured problem-solving strategies can significantly enhance students' conceptual grasp, critical thinking, and problem-solving abilities (Reif en Heller, 1982). However, the effectiveness of these strategies varies based on instructional methods, student engagement, and contextual factors. To address these challenges, this dataset originates from a doctoral project that systematically investigated the impact of structured problem-solving strategies in Rwandan secondary school physics classrooms.

By presenting this dataset, we aim to provide to the students' teachers, researchers, educators, and policymakers with valuable empirical evidence on the role of structured problem-solving in physics education. The dataset enables further research (Ndayambaje *et al.*, 2024) on effective instructional strategies (Nzabahimana, Ndiokubwayo en Mugabo, 2024), comparative studies across different educational contexts, and the development of interventions to enhance student learning outcomes in STEM education (Ndiokubwayo, Uwamahoro en Ndayambaje, 2022).

Methodology

To collect the data we employed a quasi-experimental design (Olaniyan, Omosewo en Nwankwo, 2015). It conducted in two districts of Rwanda, Kamonyi and Nyarugenge involving a total of 160 Senior Five physics students with about half being control, and another half experimental group. Four classes were sampled, one from each district. Participants were selected through purposive sampling to ensure a representative mix of students from diverse educational settings.

The dataset consolidates data from five interrelated studies conducted to evaluate students' problem-solving skills, conceptual understanding, engagement levels, and attitudes toward structured problem-solving approaches. The dataset associated with these research studies discussed in this data article is free and accessible for reuse in the Figshare repository at the following DOIs:

- 1) <https://doi.org/10.6084/m9.figshare.27901977.v1>
- 2) <https://doi.org/10.6084/m9.figshare.28328717.v1>
- 3) <https://doi.org/10.6084/m9.figshare.27934563.v1>
- 4) <https://doi.org/10.6084/m9.figshare.28328774.v1>
- 5) <https://doi.org/10.6084/m9.figshare.28328789.v1>

Intervention

The experimental groups received instruction using the Systematic Physics Problem-Solving (SPPS) strategy, which incorporates Heller and Heller's five-step problem-solving framework (Heller, 2013). This approach emphasizes understanding the problem, devising a plan, executing the plan, evaluating the solution, and reflecting on the process. Control groups continued with traditional teaching methods. Data collection instruments were:

- **Physics Achievement Tests (PAT)** that assessed students' performance and problem-solving skills through pre- and post-tests.
- **Reformed Teaching Observation Protocol (RTOP)** (Piburn *et al.*, 2000) that evaluated teaching practices, classroom dynamics, and student engagement.

- **Inventory of Basic Conceptions – DC Circuits (IBCDC)** (Ivanjek et al., 2021; Becerra et al., 2023) that measured students' conceptual understanding on direct current.
- **Colorado Learning Attitudes about Science Survey (CLASS)** (Adams et al., 2006) that measured students' attitudes toward physics and problem-solving.

Data collection procedure and Data analysis

Data were collected over three months, from January to March 2024. Pre-tests were administered to both control and experimental groups to establish baseline performance. The experimental groups then underwent the SPSS intervention over a specified period, while the control groups received standard instruction. Post-tests were conducted subsequently to measure any changes in performance. RTOP observations were carried out during lessons to assess instructional practices and student engagement.

Quantitative data from PAT, RTOP, IBCDC, and CLASS were analyzed using statistical software (e.g., SPSS Version 26). Analyses included descriptive statistics, t-tests, and correlation assessments to determine the significance of observed differences and relationships. This comprehensive methodology ensures a robust evaluation of the effectiveness of structured problem-solving strategies in enhancing physics education among Rwandan secondary school students.

Ethics statement

All procedures involving human participants in these studies were conducted in strict accordance with the ethical standards. Before participation, informed consent was obtained from all students and teachers involved in these studies. Participants were thoroughly briefed on the study's objectives, procedures, potential risks, and benefits, ensuring their voluntary and informed involvement. Confidentiality and anonymity of the participants were maintained throughout the research process, with data securely stored and accessible only to the research team.

Acknowledgements

We extend our sincere gratitude to physics students and teachers from the selected schools in Kamonyi and Nyarugenge districts, whose cooperation and enthusiasm made this research possible. We also acknowledge the invaluable support and guidance provided by the University of Rwanda College of Education.

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