Research Article

Received: 1 November 2024 / Accepted: xx February 2025 / Published: 06 March 2025

Evaluation of Learning Outcomes Related to the "Water" Issue among Moroccan Primary School Pupils in the Fez-Meknes Region Using the Group Mean Profile Method

Youness Jardioui*

Abdelrhani Elachqar

Fatiha Kaddari

Laboratory of Computer Science, Signals, Automation, and Cognitive Science,
Faculty of Sciences Dhar El Mahraz,
Sidi Mohamed Ben Abdellah University,
Fez, Morocco
**Corresponding Author*

DOI: https://doi.org/10.36941/jesr-2025-0061

Abstract

Humans are strongly influenced by the distribution, abundance, quality, and accessibility of water (Brown et al., 2009), yet water resources worldwide face several challenges. Water quality is constantly deteriorating, and forecasts for the near future are even more worrying, with some countries already experiencing water shortages. Faced with this distressing situation, and since humans are the main contributors to water resource issues, it is essential to develop a conceptual understanding of hydrological phenomena (Nutbeam, 2008), especially as numerous studies have established a link between people's behaviors and their knowledge, perceptions, and attitude (Ajzen & Fishbein, 2004). Educating students, particularly from an early age, is key to fostering a generation capable of adopting responsible behaviors towards water. This article aims to provide an assessment of the learning outcomes of primary school pupils about the main concepts of water resources and conservation. A survey was conducted among 287 final-year primary school pupils in the Fez-Meknes region, covering both urban/rural areas and public/private sectors. The results were analyzed using the Group Mean Profile (GMP) method. The study highlights that, while students strongly understand some areas, significant gaps remain, particularly in global water issues and conservation practices. Addressing these gaps through integrated water-related education in school curricula could equip future generations with the knowledge and skills to make informed decisions and adopt responsible behaviors toward water use and conservation.

Keywords: *assessment; group mean profile (GMP); learning outcomes; primary school; water*

1. Introduction

1.1 Global Water Crisis - The Role of Education

Water is a vital resource for humanity (José Galizia & Takako, 2020), yet it faces growing threats from scarcity and quality degradation (Burns, 2000). According to the World Resources Institute (WRI), 25% of the global population experienced severe water shortages in 2019 (Ungureanu et al., 2020). Numerous measures have been implemented to tackle this crisis and guarantee water security (Mishra et al., 2021). However, it has become clear that better management and use of water resources cannot be limited to technical measures. Behavior and attitudes towards water must be considered, so to overcome this crisis, technical measures and work on changing behavior must be carried out in parallel.

In this sense, (Sammel & Hartwig, 2019) suggest that the "Water" issue should not focus on the technical aspect independently of social interactions and relationships. It's a multidimensional and multisectoral theme, involving multiple factors, most of which involve humans, hence the interest in "education" thinking.

Thus, the need to strengthen the educational approach as a factor that promotes better water management is increasingly attracting the interest of researchers (Syme et al., 2000). Numerous studies have highlighted education's role in instilling positive water-related behaviors (Mondéjar-Jiménez et al. 2011), (Beal et al., 2013; Fan et al., 2014), (Renwick & Green, 2000). Education equips future generations with the knowledge and attitudes necessary for responsible water use (Schaap, 2002).

Based on this conviction, namely that:

On the one hand, for rational water management, human education is essential,

On the other hand, training an enlightened citizen to be aware of environmental issues must start at an early age.

This research focuses on the primary cycle, which represents the start of schooling in almost all education systems worldwide.

1.2 The Primary Cycle: The Start of Environmental Awareness

The primary education cycle, which emphasizes foundational learning plays a pivotal role in shaping environmental awareness (Bru et al., 2010; Papachristou et al., 2020). Research suggests that environmental attitudes form early (Rejeski, 1982; Dieser & Bogner, 2016), leading many countries to integrate environmental education into primary curricula (Gruver et al., 2009). Studies, such as those by Coyle (2005) and Kuhlemeier et al. (1999) have demonstrated that early education positively influences environmental knowledge and behaviors. Similarly, Senol & Koca (2022) found that teaching primary pupils about water challenges enhances their understanding and attitudes. The critical question, then, is:

How can we assess learning outcomes at the end of the school curriculum, estimate the degree of assimilation of the concepts taught, and assess the impact on learners' attitudes and skills development about environmental protection and water conservation?

The following section summarizes the research that has attempted to answer this question.

1.3 Assessing Learning Outcomes about the "Water" Issue- A Synthesis of Research Findings

Educational institutions in Europe and the U.S. have stressed the importance of studying learning outcomes, which measure how well learners assimilate concepts and highlight their skills (European Centre for the Development of Vocational Training., 2022; Liebowitz et al., 2000). However, assessing learning outcomes is complex and involves multiple actors, such as learners, teachers, and curricula (Räisänen & Räkköläinen, 2014). The Bologna Process Report (Rauhvargers, Deane, & Pouwels, 2009)

defines learning outcomes as what a learner knows, understands, and can demonstrate after completing a course. Research on "water" learning outcomes has drawn interest worldwide, as seen in Table 1.

Table 1. Bibliographical Summary of Research on the Measurement of Student Learning about the "Water" Issue

Author/Country	Concept evaluated	Target population	Methodology	Main results
(Sharmin, 2003) / **Bangladesh**	Definition of freshwater, causes of water pollution, consequences of water pollution, drinking water treatment, ways to prevent water pollution.	420 primary school pupils	Interviews/Questionnaires The questionnaire consists of 36 questions covering the main challenges facing water.	Half of the pupils interviewed (52%) managed to define freshwater correctly, (59%) answered correctly about the causes of water pollution, and 50% provided a correct answer concerning the supply of drinking water, a considerable difference being present in favor of boys, with public schools also recording the highest scores of correct answers.
(Valenzuela-Morales et al., 2022) / **Mexico**	Water conservation	46 primary school pupils	The study is carried out in three stages: Step1:A pre-test to highlight the main gaps in water conservation Step 2: A course on environmental education was given to students Step 3:Assessment of student learning with a post-test (the same as the pre-test)	It was found that the students who took part in the educational program enriched their knowledge, attitudes, and perception of water.
(Jung et al., 2020) / **South Korea**	Change in water's state of matter	91 primary school pupils	A 5-question open-ended questionnaire on the state of matter of water was distributed first to students who had learned lessons on the state of matter and second to a group of students who had not taken any lessons on the subject studied.	The results show that students who had taken a course on the state of the subject recorded higher scores.

Research assessing learning outcomes related to the "water" issue has covered critical concepts like the water cycle, pollution, conservation, and water treatment. The methodology typically involves distributing questionnaires to students, either at the end of the course or at different stages (pre-test and post-test), using open-ended and closed-ended questions.

1.4 Study Objective and Research Question

In Morocco, the Supreme Council of Education (CSEFRS) has produced several reports and studies, including the 2008 and 2014 analytical reports, the 2015-2030 strategic vision, and the PNEA studies, which assess students' achievements based on the national curriculum (CSEFRS, 2015; CSEFRE, 2016). Morocco's participation in international assessments like PIRLS, TIMMS, and PISA has had a significant impact on the education system, providing valuable insights into student performance on a global scale (Mullis et al., 2012). These surveys have revealed concerning results regarding Moroccan students' achievements (Saoudi et al., 2020). However, research on learning outcome evaluation mainly focuses on higher education, with limited studies on primary and secondary cycles (Alami Talbi, 2023; Bouroumi & Fajr, 2014; Liouaeddine et al., 2018)).

It should be noted that research dedicated to evaluating pupils' knowledge of water issues in the Moroccan educational context is virtually nonexistent, hence the interest of this study.

As mentioned in the first part of this article, the primary cycle is a sensitive phase in a pupil's school career, and the water-related knowledge acquired during this cycle will impact learners' behavior towards this vital resource. Based on this hypothesis, we formulated the research question:

"At the end of the primary cycle, to what extent have Moroccan pupils succeeded in acquiring the basic concepts related to the "water" issue by the national curriculum, to thus promote responsible behavior towards water resources?"

Thus, this research aims to assess the degree to which pupils have acquired water-related concepts by the end of primary school.

2. Research Methodology

To address the research question, we followed a three-step methodology:

- **Curriculum Analysis**: This step involves analyzing primary school textbooks to identify the knowledge and concepts Moroccan pupils are expected to acquire.
- **Development of a Questionnaire**: An 8-question questionnaire was designed to cover key water-related concepts.
- **Questionnaire Distribution**: The questionnaire was distributed to pupils in their final year of primary school.

2.1 Textbooks Analyzed

Primary school is crucial for building the knowledge and social values that contribute to pupils' holistic development (Eccles & Roeser, 2011). This development relies on the curriculum, which defines the content and objectives of teaching. To evaluate how water is addressed in the Moroccan primary school curriculum, we conducted a detailed analysis of all textbooks across subjects from grades 1 to 6. These materials examined water as a multidisciplinary concept involving geography, science, culture, and socio-economic aspects. Table 2 lists the textbooks analyzed.

Table 2. List of Moroccan primary school textbooks analyzed

Primary cycle						
School subject	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**	**6th year**
Arabic language	Useful in Arabic	On the Edge of Arabic	My Arabic language guide	Useful in Arabic	Illuminating in Arabic	My Arabic language manual
Scientific Awakening	The Essentials in Scientific Awareness	The selected scientific awakening	The source of scientific awakening	The guide to scientific awakening	Scientific enlightenment	Scientific enlightenment
Islamic education	Science education essentials	On the outskirts of the Islamic education	Success in Islamic education	The oasis of Islamic education	On the outskirts of the Islamic education	On the outskirts of Islamic education
French language	Saying, doing, and acting to learn French	Oasis of words	Learning French	To communicate in French	Learning French	Practical French
History-Geography				The new in history-geography	The new in history-geography	The new in history-geography

2.2 Survey

a. Questionnaire design

Based on an in-depth review of the Moroccan primary school curriculum, an 8-question questionnaire was developed to assess pupils' water-related knowledge after six years of education. The questions were carefully designed to align with the concepts covered in the curriculum, ensuring that students could understand the topics being assessed. The questionnaire consists of seven closed-ended questions and one open-ended question. Answers were categorized as:

- Correct Answer **(C.A.)**
- Wrong Answer **(W.A.)**
- I Don't Know **(I.D.K.)**, to minimize non-responses.

Table 3 provides details of the questions and their intended learning outcomes.

Table 3. Water-Related Questions and Potential Student Learning Outcomes

Item	Question	Potential student learning outcomes to be determined
Natural springs	P1: What are the primary sources of water in nature?	This question aims to ensure that the learner can distinguish between the natural water sources in nature.
Processing steps	P 2: What is the main stage water must go through to become drinkable?	Water treatment is a fundamental process for making water drinkable, so this question aims to determine how much students have assimilated this procedure.
Water pollution	P3: How can water become polluted?	Water pollution is a universal scourge that causes massive degradation of water quality. This question explores the acquisition rate of the causes behind this problem.
Reduced water resources	P4: What is the current state of water resource availability worldwide?	Through this question, we seek to diagnose students' knowledge of dwindling water resources and thus determine their sensitivity to the seriousness of the issue.
Percentage of water in the soil	P5: What percentage of water is found in soil?	These two questions, dealing with the quantitative aspect of water, aim to highlight the validity of learners' knowledge about the percentages of water in the globe and the human body.
Percentage of water in the human body	P6: What is the percentage of water in the human body?	
Physical states	P7: What are the three physical states of water in nature?	The concept of the physical state of matter is a significant obstacle for learners, and with this question, we aim to measure the degree to which learners have acquired this notion.
Proposals for rationalizing water use	P8: Differentiating between good and bad behavior towards water.	This last question aims to determine to what extent a learner at the end of the primary cycle is capable of choosing responsible behavior toward water.

b. Population

The target population for this research is sixth-year primary school pupils chosen to assess learning achievements at the end of primary education. Previous studies have shown that knowledge acquisition can be influenced by factors like age, gender, curriculum, and socio-environmental contexts (Diakidoy et al., 1997; Mason et al., 2006; Andrietti & Su, 2019; Hellas et al., 2018). To explore these variables, questionnaires were distributed to 287 pupils (58% girls, 42% boys) aged 11-13 from diverse social backgrounds (urban, rural, public, and private). Stratified cluster sampling described by Harold John Butcher (Butcher, 1973) was used, and the study was conducted in the Fez-Meknès region.

c. Statistical study tool:

Student responses were processed using the "Sphinx" data analysis software and "Excel."

3. Results

3.1 Analysis of the Primary Cycle Curriculum

The following table (Table 4) highlights the various water-related themes covered throughout the primary school curriculum.

Table 4. Water-related themes in the Moroccan primary school curriculum

	Themes covered					
School subject	**First year**	**Second year**	**Third year**	**Fourth year**	**Fifth year**	**Sixth year**
Scientific awakening	The different Sources of water Areas of water Use Reduced water resources			Areas of water use Water pollution Drinking water treatment The Importance of water protection		
Arabic language		Water Pollution The importance of water protection	The Importance of water protection	The Importance of water protection		
Islamic education		The importance of water protection	The Importance of water protection		The Importance of water protection	The Importance of water protection
French language			The Importance of water protection		Drinking water treatment	Water cycle

Textbooks across nearly all subjects include at least one chapter on water. By the end of primary education, students are expected to understand water sources, uses, pollution, treatment, conservation, resource depletion, and the water cycle.

3.2 Data Analysis and Assessment of Students Learning Outcomes Related to the "Water" Issue

The questionnaire results were analyzed using two methods to enhance validity and interpretation. The first method, the classical approach, presents statistics as histograms to show response types. The second method, the Group Mean Profile (GMP), will be explained in the next section, highlighting its advantages for deeper data analysis.

3.3 Assessment of Learning Outcomes Using the First Method (Classical Method)

The results are presented in histograms for each study area: urban public, rural public, and private. Since private schools are only found in urban areas, the results are displayed in three graphs. Each graph categorizes responses into three modalities: Correct Answer (C.A.), Wrong Answer (W.A.), and I Don't Know (I.D.K.).

- *Urban public*

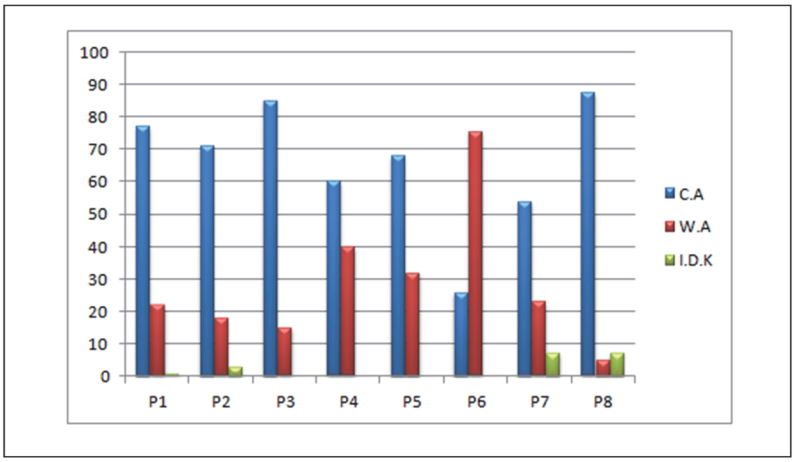

Figure 1. Responses from students in urban public schools

Figure 1 shows that correct answers (C.A.) exceed 60% for most questions, and "I do not know" (I.D.K.) responses are very low or nonexistent. However, question P6 (percentage of water in the human body) has a notably low answer rate, with over 70% of incorrect responses. Similarly, for question P4 (current state of water availability worldwide), nearly 40% of responses are wrong.

- *Rural public*

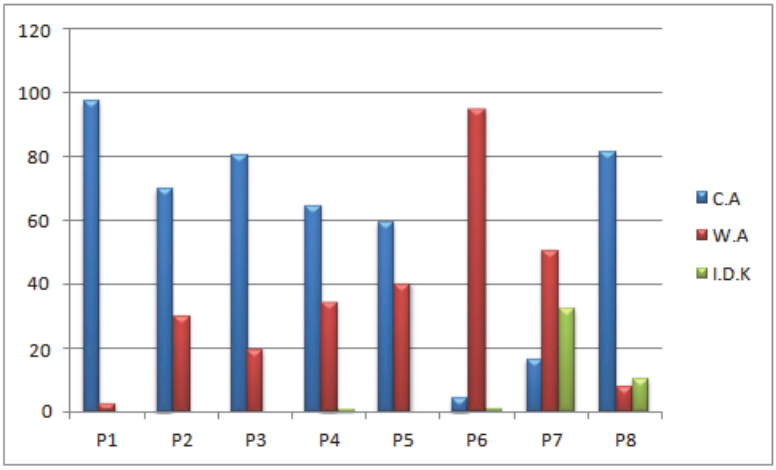

Figure 2. Responses from Students in Public Rural Areas

The results for rural and urban students are similar. Both groups show a high rate of correct answers (C.A.) for most questions. Rural students perform slightly worse but show similar data progression. The questions with the lowest correct answer rates are the same for both groups. For example, in question P6 (percentage of water in the human body), rural students had less than 5% correct answers, while urban students had around 25%. Question P7 (three physical states of water in nature) also had low correct answer rates, with only 17% of rural students answering correctly compared to

about 50% of urban students. Additionally, 32.5% of rural students answered "I do not know" (I.D.K.).

- *Private Education*

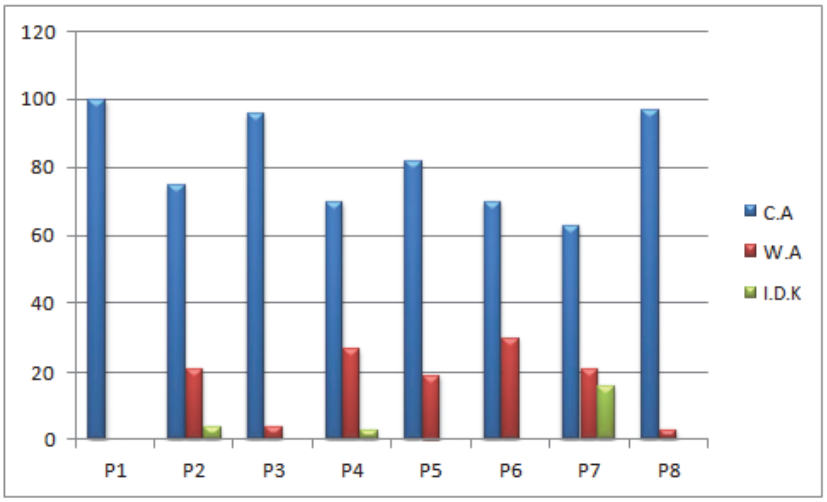

Figure 3. Responses from private-sector students

Private-sector students scored higher than both urban and rural public-sector students. However, questions P6 (percentage of water in the human body) and P7 (the three physical states of water in nature) remain challenging for this group, despite a generally higher rate of correct answers.

3.4 Assessment of Learning Outcomes Using the Second Method: Group Mean Profile (GMP) Method

- *Presentation of the Group Mean Profile (GMP) Method*

To better interpret the students' responses across different groups and obtain a more accurate assessment of learning outcomes, we applied an innovative technique known as the **Group Mean Profile (GMP)**. The GMP is calculated as the difference between the percentages of correct and incorrect responses. Since all of our questions are dichotomous (i.e., answers are either correct or incorrect), we subtract the percentage of incorrect responses from the percentage of correct responses. The resulting value represents the GMP for each group. This GMP serves as an index of the group's level of concept assimilation: the higher the GMP, the more significant the proportion of students who correctly answered the questions compared to those who answered incorrectly.

For graphical representation, we plot the GMP values on a curve to track the evolution of knowledge in each population. This analysis is enhanced by plotting the percentage of "I don't know" (IDK) responses. We can assess the students' understanding of each concept by calculating the gap (Δ) between these two curves. A more significant gap (Δ) indicates a better grasp of the topic, while a negative gap suggests poor assimilation. Overlaying the GMP curve with the IDK curve provides an original evaluation method for assessing the state of knowledge within different groups and allows for comparing them.

- *Urban public*

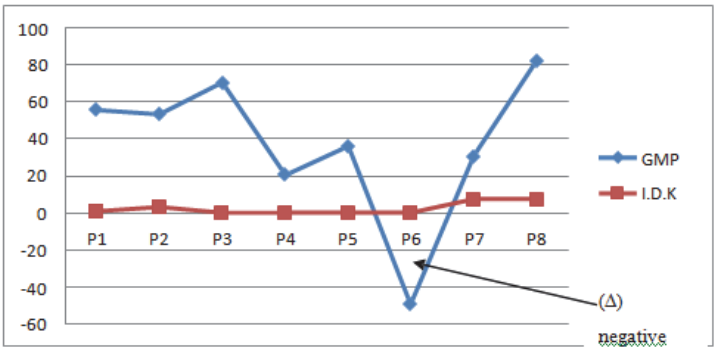

Figure 4. Group Mean Profile (GMP) of students in urban public schools

The analysis of **Figure 4** shows that the percentage of "I don't know" (IDK) responses is almost nonexistent across all questions. The **General Mastery Percentage (GMP)** is notably high for questions concerning the primary sources of water (P1), the stages involved in water treatment (P2), and the causes of water pollution (P3), with a significant gap between these GMP values and the IDK responses.

However, the GMP decreases for questions about the availability of global water resources (P4) and the percentage of water on Earth (P5), revealing that students have mixed perceptions and a somewhat unclear understanding of Earth's water distribution. The most poorly understood concept is the percentage of water in the human body (P6), where the GMP is negative -49.4, indicating that students struggle to understand that water constitutes about three-quarters of the human body. Additionally, there is some ambiguity in students' understanding of the physical states of water (P7), as reflected in the gap between the GMP and IDK responses.

Interestingly, the highest GMP is recorded for the question related to distinguishing between positive and negative behaviors towards water (P8), suggesting that students can differentiate between good and bad practices regarding water use.

- *Rural public*

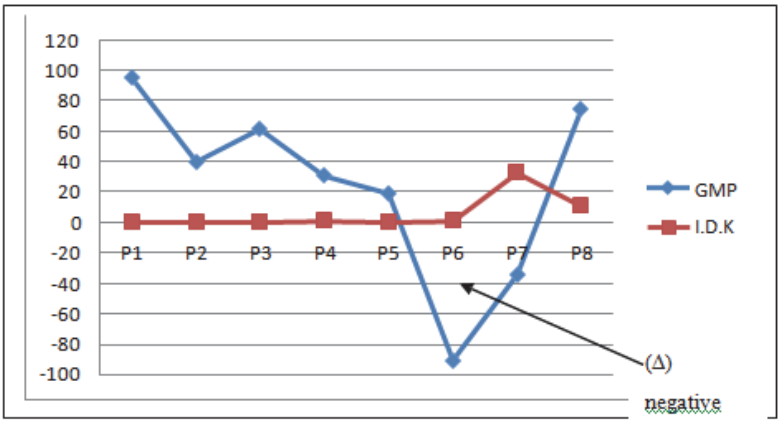

Figure 5. Group Mean Profile (GMP) of Students in Rural Public Schools

In the case of rural students, nearly all students are familiar with the primary sources of water in nature (P1), with a GMP approaching 100% and no IDK responses. However, for question P2 (the steps involved in making water drinkable), the GMP significantly drops to around 40%, suggesting that many students are unfamiliar with this process. For question P3 (the causes of water pollution), the GMP is relatively high, indicating that students understand the sources of pollution.

Lower GMP values are observed for questions about the percentage of water on Earth (P5), the percentage of water in the human body (P6), and the physical states of water (P7); this indicates that students have not fully assimilated the concepts related to these questions. Despite these gaps, students perform well on question P8, correctly distinguishing between good and bad behaviors towards water, which suggests that they understand appropriate water use practices.

- *Private Education*

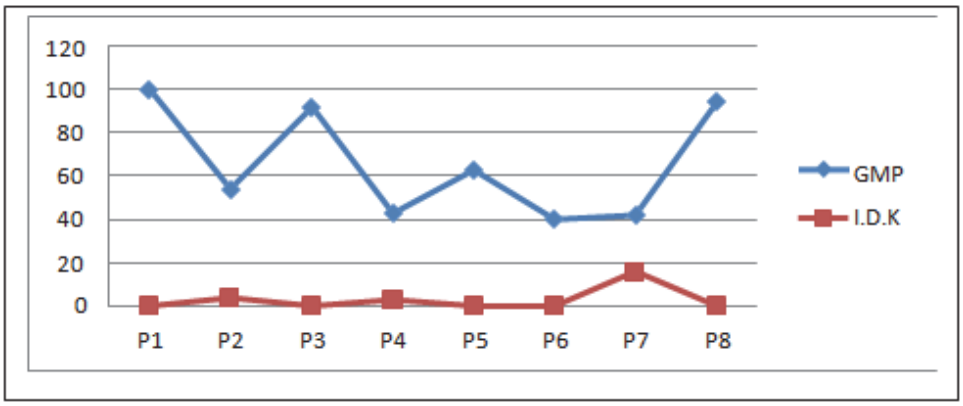

Figure 6. Group Mean Profile (GMP) of Private-Sector Students

In contrast to their public-sector counterparts (urban and rural), private-sector students exhibit a high level of understanding across all concepts, with no negative GMPs recorded. However, like public-sector students, certain concepts remain challenging for private-sector students. These include the current state of water resource availability worldwide (P4) and the percentage of water in the human body (P6), which have GMP values below 40%. Additionally, the GMP for understanding the physical states of water in nature (P7) is also low, around 40%, with the IDK rate close to 20%.

4. Discussion

The analysis of the primary cycle curriculum reveals that water-related themes are present across various subjects and grade levels. By the end of the primary cycle, students are expected to have acquired the fundamental concepts necessary to understand water-related issues. The initial presentation of data through histograms shows a generally good understanding of water-related concepts across urban, rural, and private schools, as evidenced by the high scores recorded for correct answers. Students excel in identifying sources of water and understanding water pollution, corroborating Sharmin's (2003) findings, which indicated that 60% of students answered questions about water pollution and treatment steps correctly. However, particular areas remain challenging for students in all sectors, notably regarding the percentage of water in the human body, the current state of global water availability, and, specifically, the physical states of water.

The Group Mean Profile (GMP) method provides a deeper insight into student responses. It reveals that students perform well in identifying water sources and understanding water pollution

but uncover significant gaps in knowledge, particularly concerning the physical states of water and the percentage of water in the human body. These findings align with previous research. For example, studies by Jung et al. (2020) and Malleus and Kikas (2019) highlight persistent difficulties in understanding the physical states of water and the transition to the gaseous state.

The "I don't know" responses further illuminate these learning outcomes. Many students, especially in rural public schools, selected "I don't know" for questions about the percentage of water in the human body and the physical states of water. This pattern suggests that these concepts must be better understood, and students may need more confidence in their knowledge. The prevalence of "I don't know" responses highlights a critical area for intervention. It points to the need for more effective teaching strategies and educational materials to bridge these knowledge gaps and improve student confidence.

The comparison across different educational settings—urban, rural, and private—shows that private school students generally perform better but face similar challenges with these concepts as their public school counterparts. This suggests that the issues are not solely related to supervision or resources but are indicative of broader, inherent difficulties in understanding certain water-related concepts.

The combined use of histograms and GMP methods thoroughly assesses students' learning outcomes. The findings highlight the need for specific educational interventions to enhance understanding of water-related concepts. To address these needs, it is recommended to integrate innovative teaching strategies, such as hands-on activities based on real-world experiences, contextualized explanatory videos, and interactive approaches that promote collaborative learning. For example, simulations or experiments on the physical states of water and activities exploring water distribution in the human body could strengthen the understanding of these abstract concepts. Additionally, continuous teacher training and the adaptation of textbooks to include concrete and culturally relevant examples would be essential steps to improve water-related education in Moroccan schools.

5. Conclusion

Water scarcity and water stress are beginning to be felt in many countries worldwide. Raising awareness of this universal problem mainly involves the educational approach. Indeed, numerous studies have shown that improving knowledge of water encourages individuals to adopt responsible behavior. In the Moroccan context, work on water education is extremely rare, which justifies our study on evaluating students' learning outcomes relating to water at the end of the primary cycle. The choice of this cycle is based on the fact that, on the one hand, scientific awareness begins at a young age, and, on the other hand, the theme of water is studied throughout the primary cycle. The study tool is a questionnaire developed based on an in-depth analysis of the primary school curriculum. The study population consists of 287 urban and rural students attending public and private schools in the Fez-Meknes region.

At first glance, the study results indicate that the various survey populations generally understand basic water-related concepts, as the percentages of correct answers are mostly satisfactory. A more detailed data analysis was conducted using the Group Mean Profile (GMP) tool we developed. This tool examined overall population performance by assessing the disparity between correct and incorrect answer rates. This difference value represents the group's comprehension index (GMP): the higher it is for an item, the more thoroughly the group has grasped its concept.

Using the "GMP" assessment method revealed more precise details: the water cycle, the decline in water resources, and the volume of water in the human body are the least retained concepts. The "GMP" method thus made it possible to draw up a more in-depth profile of student performance, highlighting concepts that were less understood. Indeed, this technique proves to be an innovative tool for evaluating the individual performance of students and comparing the achievements of different populations, thus offering a more exhaustive view of students' skills in terms of concepts

related to water.

Except for some minor differences, our study showed that the area of residence does not significantly impact the results, with GMP scores being similar in urban and rural areas. On the other hand, the teaching mode considerably influences student performance: learners in the private sector obtained higher GMP scores and did not record any negative scores. However, the least assimilated concepts remained identical to those in the public sector. This underlines the importance of an effective and adapted educational context.

Observing the weaknesses in learning outcomes for certain concepts related to water highlights a potential risk of students adopting less responsible behaviors regarding this vital resource. This raises concerns about achieving educational objectives aimed at fostering environmental awareness. While these findings underline the importance of improving water-related education, it is crucial to interpret them cautiously, as various factors shape educational outcomes.

6. Limitations and Research Suggestions

The small sample size and regional focus of this study limit the generalizability of its conclusions, emphasizing the need for future research to explore these issues on a broader scale. Longitudinal studies and investigations into diverse educational settings could provide deeper insights into the effectiveness of educational interventions. Ferraro & Price (2013), noted that education-focused interventions may have limited impact compared to integrated approaches that combine technical and academic measures. These findings call for developing targeted strategies that address conceptual gaps and practical behaviors to support sustainable water use and conservation.

References

Ajzen, I., & Fishbein, M. (2004). *The Influence of Attitudes on Behavior*.

Alami Talbi, F. Z. (2023). Impact of the Integration of OERs on Learning Outcomes: Case of Engineering Students in Morocco. In L. Daadaoui, D. Burgos, K. Berrada, & A. Ghanimi (Eds.), *Proceedings of the Erasmus Scientific Days 2022 (ESD 2022)* (Vol. 5, pp. 223–234). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-036-7_21

Andrietti, V., & Su, X. (2019). Education curriculum and student achievement: Theory and evidence. *Education Economics*, *27*(1), 4–19. https://doi.org/10.1080/09645292.2018.1527894

Beal, C. D., Stewart, R. A., & Fielding, K. (2013). A novel mixed method smart metering approach to reconciling differences between perceived and actual residential end use water consumption. *Journal of Cleaner Production*, *60*, 116–128. https://doi.org/10.1016/j.jclepro.2011.09.007

Bouroumi, A., & Fajr, R. (2014). Collaborative and Cooperative E-learning in Higher Education in Morocco: A Case Study. *International Journal of Emerging Technologies in Learning (iJET)*, *9*(1), 66. https://doi.org/10.3991/ijet.v9i1.3065

Brown, R. R., Keath, N., & Wong, T. H. F. (2009). Urban water management in cities: Historical, current and future regimes. *Water Science and Technology*, *59*(5), 847–855. https://doi.org/10.2166/wst.2009.029

Bru, E., Stornes, T., Munthe, E., & Thuen, E. (2010). Students' Perceptions of Teacher Support Across the Transition from Primary to Secondary School. *Scandinavian Journal of Educational Research*, *54*(6), 519–533. https://doi.org/10.1080/00313831.2010.522842

Burns, W. C. G. (2000). *From the harpoon to the heat: Climate change and the International Whaling Commission in the 21st century*. Pacific Institute for Studies in Development, Environment, and Security.

Butcher, H. J. (1973). *Sampling in Educational Research*. Manchester University Press. https://books.google.co.ma/books?id=DFbKwAEACAAJ

Conseil Supérieur de l'Éducation, de la Formation et de la Recherche Scientifique (CSEFRS). (2016). Programme national d'évaluation des acquis des élèves (PNEA): Résultats des élèves en 4e année du primaire et en 2e année du collège. [National program for the assessment of student learning outcomes (PNEA): Results of students in 4th year of primary and 2nd year of secondary school]Rabat, Maroc : CSEFRS. http://www.csefrs.ma/wp-content/uploads/2017/10/Rapport_PNEA_2016.pdf

Conseil Supérieur de l'Éducation, de la Formation et de la Recherche Scientifique (CSEFRS). (2015). La vision stratégique de la réforme 2015-2030: Pour une école de l'équité, de la qualité et de la promotion. [Strategic vision for the reform 2015-2030: For a school of equity, quality, and promotion.] Rabat, Maroc : CSEFRS. http://www.csefrs.ma/wp-content/uploads/2017/10/Vision_Strategique_2015_2030_Fr.pdf

Coyle, K. (2005). Environmental literacy in America: What ten years of NEETF/Roper research and related studies say about environmental literacy in the U.S. Washington, DC: The National Environmental Education & Training Foundation.

Diakidoy, I.-A., Vosniadou, S., & Hawks, J. D. (1997). Conceptual change in astronomy: Models of the earth and of the day/night cycle in American-Indian children. *European Journal of Psychology of Education*, *12*(2), 159–184. https://doi.org/10.1007/BF03173083

Dieser, O., & Bogner, F. X. (2016). Young people's cognitive achievement as fostered by hands-on-centred environmental education. *Environmental Education Research*, *22*(7), 943–957. https://doi.org/10.1080/13504622.2015.1054265

Eccles, J. S., & Roeser, R. W. (2011). Schools as Developmental Contexts During Adolescence. *Journal of Research on Adolescence*, *21*(1), 225–241. https://doi.org/10.1111/j.1532-7795.2010.00725.x

European Centre for the Development of Vocational Training. (2022). *Defining, writing and applying learning outcomes: A European handbook : second edition.* Publications Office. https://data.europa.eu/doi/10.2801/703079

Fan, L., Wang, F., Liu, G., Yang, X., & Qin, W. (2014). Public Perception of Water Consumption and Its Effects on Water Conservation Behavior. *Water*, *6*(6), 1771–1784. https://doi.org/10.3390/w6061771

Ferraro, P. J., & Price, M. K. (2013). Using Nonpecuniary Strategies to Influence Behavior: Evidence from a Large-Scale Field Experiment. *Review of Economics and Statistics*, *95*(1), 64–73. https://doi.org/10.1162/REST_a_00344

Gruver, J. B., Smith, S. S., & Finley, J. C. (2009). Water Curriculum Evaluation for Educators in Pennsylvania. *Applied Environmental Education & Communication*, *7*(4), 164–170. https://doi.org/10.1080/15330150902744210

Hellas, A., Ihantola, P., Petersen, A., Ajanovski, V. V., Gutica, M., Hynninen, T., Knutas, A., Leinonen, J., Messom, C., & Liao, S. N. (2018). Predicting academic performance: A systematic literature review. *Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education*, 175–199. https://doi.org/10.1145/3293881.3295783

José Galizia, T., & Takako, M.-T. (2020). *A Água* (1st ed.). Editora Scienza. https://doi.org/10.26626/978-65-5668-005-7/B0001

Jung, J., Chang, J., & Park, J. (2020). An Analysis of Different Grade Levels of Elementary School Students' Reasoning about the Changes of State of Water within a Learning Progression. *Asia-Pacific Science Education*, *6*(2), 548–563. https://doi.org/10.1163/23641177-BJA10004

Kuhlemeier, H., Van Den Bergh, H., & Lagerweij, N. (1999). Environmental Knowledge, Attitudes, and Behavior in Dutch Secondary Education. *The Journal of Environmental Education*, *30*(2), 4–14. https://doi.org/10.1080/00958969909601864

Liebowitz, J., Rubenstein-Montano, B., McCaw, D., Buchwalter, J., Browning, C., Newman, B., & Rebeck, K. (2000). The knowledge audit. *Knowledge and Process Management*, *7*(1), 3–10. https://doi.org/10.1002/(SICI)1099-1441(200001/03)7:1<3::AID-KPM72>3.0.CO;2-0

Liouaeddine, M., Bijou, M., & Naji, F. (2018). The Main Determinants of Moroccan Students' Outcomes. *American Journal of Educational Research*, *5*(4), 367–383. https://doi.org/10.12691/education-5-4-5

Malleus, E., & Kikas, E. (2019). *Student Knowledge About the Water Cycle and Its Change in Different Interest Groups*. *3*(1).

Mason, L., Boldrin, A., & Zurlo, G. (2006). Epistemological understanding in different judgment domains: Relationships with gender, grade level, and curriculum. *International Journal of Educational Research*, *45*(1–2), 43–56. https://doi.org/10.1016/j.ijer.2006.08.003

Mishra, B., Kumar, P., Saraswat, C., Chakraborty, S., & Gautam, A. (2021). Water Security in a Changing Environment: Concept, Challenges and Solutions. *Water*, *13*(4), 490. https://doi.org/10.3390/w13040490

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *Timss 2011 international results in mathematics*. TIMSS & PIRLS International Study Center.

Nutbeam, D. (2008). The evolving concept of health literacy. *Social Science & Medicine*, *67*(12), 2072–2078. https://doi.org/10.1016/j.socscimed.2008.09.050

Papachristou, E., Flouri, E., Midouhas, E., Lewis, G., & Joshi, H. (2020). The Role of Primary School Composition in the Trajectories of Internalising and Externalising Problems across Childhood and Adolescence. *Journal of Abnormal Child Psychology*, *48*(2), 197–211. https://doi.org/10.1007/s10802-019-00584-9

Räisänen, A., & Räkköläinen, M. (2014). Assessment of learning outcomes in Finnish vocational education and training. *Assessment in Education: Principles, Policy & Practice*, *21*(1), 109–124. https://doi.org/10.1080/0969594X.2013.838938

Rauhvargers, A., Deane, C., & Pauwels, W. (2009). Bologna Process Stocktaking Report 2009. http://media.ehea.info/file/2009_Leuven_Louvain-la-Neuve/94/7/Stocktaking_report_2009_FINAL_594947.pdf.

Rejeski, D. W. (1982). Children Look at Nature: Environmental Perception and Education. *The Journal of Environmental Education*, *13*(4), 27–40. https://doi.org/10.1080/00958964.1982.9942653

Renwick, M. E., & Green, R. D. (2000). Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies. *Journal of Environmental Economics and Management*, *40*(1), 37–55. https://doi.org/10.1006/jeem.1999.1102

Sammel, A., & Hartwig, L. D. (2019). Making Sense of Hydrosocial Patterns in Academic Papers on Extreme Freshwater Events. *Human Ecology Review*, *25*(1), 111–130. https://doi.org/10.22459/HER.25.01.2019.06

Saoudi, K., Chroqui, R., & Okar, C. (2020). Student Achievement in Moroccan Student Achievement in Moroccan Educational Reforms: A Significant Gap Between Aspired Outcomes and Current Practices. *Interchange*, *51*(2), 117–136. https://doi.org/10.1007/s10780-019-09380-2

Schaap, W. (2002). *Ideas for water awareness campaigns*. Global Water Partnership.

Senol, F. B., & Koca, N. (2022). A Pilot Study for Developing Water Literacy of Preschool Children. *Journal of Education in Science, Environment and Health*, 253–263. https://doi.org/10.55549/jeseh.1158504

Sharmin, L. (2003, December). Assessment of environmental awareness of the students with primary education. Research Reports (2003): Social Studies, Vol – XXXI, 74–103.

Syme, G. J., Nancarrow, B. E., & Seligman, C. (2000). The Evaluation of Information Campaigns to Promote Voluntary Household Water Conservation. *Evaluation Review*, *24*(6), 539–578. https://doi.org/10.1177/019384100240060 1

Ungureanu, N., Vlăduț, V., & Voicu, G. (2020). Water Scarcity and Wastewater Reuse in Crop Irrigation. *Sustainability*, *12*(21), 9055. https://doi.org/10.3390/su12219055

Valenzuela-Morales, G. Y., Hernández-Téllez, M., Ruiz-Gómez, M. D. L., Gómez-Albores, M. A., Arévalo-Mejía, R., & Mastachi-Loza, C. A. (2022). Water Conservation Education in Elementary Schools: The Case of the Nenetzingo River Catchment, Mexico. *Sustainability*, *14*(4), 2402. https://doi.org/10.3390/su14042402