Relevance Theory's Role in Science Education for Global Competencies

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Abstract: ***Relevance Theory, developed by Dan Sperber and Deirdre Wilson in the mid - 1980s, has significantly influenced pragmatics and various types of discourse and research areas (Sperber & Wilson, 1986; Wilson & Sperber, 1986). The relevance of science education extends beyond traditional academic boundaries, fostering innovation and supporting fields such as medical science, agriculture, and services for individuals with special needs (van Griethuijsen et al., 2015). However, despite growing recognition of the importance of STEM fields, interest in science education has fluctuated, particularly at the secondary school level. Factors such as perceived difficulty, lack of hands - on practical work, and socio - economic disparities contribute to this trend (Sarabi & Abdul, 2018; Gandolfi, 2024). Ongoing efforts aim to increase engagement in science education through hands - on projects, career guidance, and addressing educational inequalities (van Griethuijsen et al., 2015). Integrating real - world applications, interdisciplinary learning, digital literacy, and global competencies can make science education more relevant and engaging, particularly in a globalized world (Marosi et al., 2021; Baker et al., 2024). Additionally, the use of authentic assessment methods that align with context - based science education is crucial for successful implementation, ensuring that students are evaluated on their comprehensive understanding of scientific processes (Holbrook, 2005; Sadler & Zeidler, 2009). This study examines the influence of Relevance Theory on science education within a globalized context. By linking theoretical concepts to real - world applications, the research highlights enhanced student engagement, comprehension, and retention (Agrawal, 2024). Using a mixed - methods approach with MANOVA, the study explores interdisciplinary learning and digital tools in STEM education. Findings indicate that relevance in pedagogy fosters critical thinking, problem - solving, and global preparedness, essential for navigating a rapidly changing world.***

Keywords: Relevance Theory, science education, global competencies, STEM learning, interdisciplinary pedagogy

1. Introduction

Relevance Theory, developed by Dan Sperber and Deirdre Wilson in the mid - 1980s, is a cognitive pragmatics framework detailed in their book *Relevance: Communication and Cognition* (Sperber & Wilson, 1986). Their earlier works also explored this theory, particularly in relation to Grice's cooperative principle. Since its inception, Relevance Theory has become highly influential in pragmatics and has been applied to various types of discourse and research areas (Wilson & Sperber, 1986). Science education's relevance extends beyond conventional academic boundaries, fostering innovation and supporting fields such as medical science, agriculture, and services for individuals with special needs (van Griethuijsen et al., 2015). The exponential growth of science and the challenges it faces in a globalized world underscore the necessity for sustainable growth strategies, ensuring scientific advancements are accessible and beneficial to all (Gandolfi, 2024). However, interest in science education has been fluctuating. While there is growing recognition of the importance of STEM fields, some studies indicate a decline in student interest, especially at the secondary school level (van Griethuijsen et al., 2015). Several factors contribute to this trend, mostly related to communication and cognition. Science subjects are perceived as challenging, which can deter students from pursuing further studies in these fields (Sarabi & Abdul, 2018). The Royal Society and EngineeringUK (2024) highlight the decline in hands - on practical work in science education, which can lead to a gap between theoretical knowledge and real - world application. This phenomenon, caused mainly by disparities in access to resources, can influence students' interest in science, with some groups being more affected than others. The lack of concretization in science education is affecting students' engagement and aspirations in science (Gandolfi, 2024). Factors such as gender and socio - economic disparities, and limited access to career information and work experience in STEM fields, can also impact students' decisions on the relevance of science education in their future aspirations (Gandolfi, 2024).

Despite these challenges, Efforts continue to enhance engagement in science education by promoting hands - on projects, career guidance, and reducing educational disparities (van Griethuijsen et al., 2015). These efforts include integrating real - world applications of science, emphasizing interdisciplinary learning, enhancing digital literacy and skills, promoting global competencies, fostering an entrepreneurial mindset, addressing equity and accessibility, and providing continuous professional development for educators (Marosi et al., 2021). To make science education more relevant and engaging for students, particularly in the context of a globalized world, several strategic approaches have been put in place. For example, incorporating topics like climate change, global health, and sustainable development into the science curriculum can show students the global relevance of their studies (Baker et al., 2024). Moreover, enhancing digital literacy and skills is essential. Utilizing digital tools, such as simulations, virtual labs, and AI - powered learning platforms, can create interactive and personalized learning experiences (Marosi et al., 2021). Teaching coding and artificial intelligence as part of the science curriculum can prepare students for future job markets and technological advancements. Furthermore, facilitating international exchanges and collaborations with schools in other countries can help students develop a global perspective (Marosi et al., 2021). Integrating real - world applications by showing students how scientific principles apply to real - world problems and innovations, such as linking chemistry lessons to environmental sustainability, can make the subject more tangible and relevant to their future choices (Gandolfi, 2024). Advancements across various fields, including technology, healthcare, vocational, and agriculture topics, all rest on a robust foundation of science education (Agrawal, 2024; Chaney et al., 2010). Collaborating with local industries and global companies to provide students with internships, job shadowing opportunities, and guest lectures from professionals working in cutting - edge fields can also enhance their engagement. Emphasizing interdisciplinary learning can foster creativity and innovation. For instance, incorporating the arts into STEM education (STEAM) has made science more accessible and appealing to a broader range of students. Encouraging students to work on interdisciplinary projects that require them to apply knowledge from multiple subjects to solve complex problems can further enhance their learning experience (Baker et al., 2024). This requires collaboration between innovation authorities, education systems, and labor market policies to develop the necessary skills for digital innovation (OECD, 2017; Nedelkoska & Quintini, 2018). Raising educational standards and fostering international competition are driven by the belief that economic success hinges on a citizenry knowledgeable about science and technology. The Programme for International Student Assessment (PISA) highlights the importance of strong science education programs in preparing students for future work while also maintaining national identity and legacy (OECD, 2017).

In today's increasingly interconnected world, the significance of science education cannot be overstated. As globalization continues to shape economies and societies, the need for a workforce proficient in science, technology, engineering, and mathematics (STEM) skills becomes ever more critical. In today's rapidly globalizing world, the relevance of science education has never been more pronounced. As economies become increasingly interconnected and technology - driven, there is a growing demand for individuals who possess not only technical skills but also the ability to think critically and solve complex problems (Kwiek, 2023). Science education plays a pivotal role in equipping students with these essential skills, fostering a mindset that is both analytical and innovative. The job market reflects this shift, with companies like Oracle recognizing the value of engineering backgrounds for marketing managers. This trend underscores the importance of a strong foundation in science and technology, as it prepares students to navigate and excel in diverse professional fields (Clothey, 2010). By integrating real - world applications and interdisciplinary learning, science education can bridge the gap between academic knowledge and practical skills, making students more competitive and adaptable in the global job market. Moreover, science education encourages students to become lifelong learners, continuously seeking new knowledge and solutions to emerging challenges. This adaptability is crucial in a world where industries and job roles are constantly evolving. As educators and policymakers, it is our responsibility to ensure that science education remains relevant and engaging, fostering the next generation of critical thinkers and problem solvers who can contribute meaningfully to society. The World Economic Forum's Future of Jobs Report (2023) highlights the escalating demand for these competencies, underscoring the importance of STEM subjects and soft skills such as analytical thinking, creativity, and problem - solving (Marosi et al., 2021). Integrating critical thinking and problem - solving skills within science education is vital for navigating complex global issues. Approaches such as critical pedagogies and decolonial studies highlight the necessity of moving beyond purely technical rationality to equip students with the social and political awareness needed to tackle socio - scientific challenges (Gandolfi, 2024). Culturally relevant pedagogies are essential for addressing the diverse and multicultural nature of today's classrooms. These teaching methods help students develop global competencies, enabling them to understand and appreciate different perspectives, engage effectively across cultures, and take action for collective well - being and sustainable development. This is particularly important as global migration continues to shape the demographics of science classrooms (Marosi et al., 2021). This study investigates the influence of Relevance Theory on student engagement, comprehension, and retention in science education. Additionally, it examines the development of critical thinking and problem - solving skills, aiming to prepare students for the challenges and opportunities in a globalized world. By framing scientific concepts within real - world contexts, this research seeks to evaluate whether such educational strategies enhance learning outcomes (Agrawal, 2024). Furthermore, science education encourages students to become lifelong learners, continuously seeking new knowledge and solutions to emerging challenges (Baker et al., 2024). This adaptability is crucial in a world where industries and job roles are constantly evolving. This study employs a Likert scale survey to measure students' perceptions of engagement, comprehension, and retention of scientific concepts. Additionally, MANOVA is employed to analyze the data and determine the impact of the Relevance Theory approach on these variables. Given these considerations, an intriguing question arises: How does the application of Relevance Theory, through framing scientific concepts within real - world contexts that are meaningful and relatable to students, influence their engagement, comprehension, and retention in science education? Additionally, how does this approach prepare them for the challenges and opportunities of a globalized world?

2. Literature Review

Relevance Theory, developed by Dan Sperber and Deirdre Wilson (1995), offers a framework in cognitive pragmatics that emphasizes how individuals infer meaning based on the principle of relevance in communication (Rannikmäe et al., 2010). This theory is particularly significant in science education as it highlights the importance of contextual and meaningful learning experiences that align with students' cognitive processes. According to Relevance Theory, learners are more engaged and better able to infer meaning when educational content is pertinent to their lives and experiences. In science education, this means framing scientific concepts within real - world contexts that students find meaningful and relatable (Sperber & Wilson, 1995). This study investigates the effectiveness of this approach in improving student engagement, comprehension, and retention, and assesses its role in preparing students for a globalized workforce.

2.1 Contextual Learning and Cognitive Engagement

Relevance Theory posits that individuals naturally tend to focus on information they find relevant and disregard information that seems irrelevant (Sperber & Wilson, 1995). In science education, this translates to designing lessons that capture students' interest and connect new information to their existing knowledge. Marosi et al. (2010) explain that applying relevance in science education implies increasing academic achievement, cultural competence, and sociopolitical consciousness. Additional benefits include enhancing students' interest in science, motivation, and engagement, as well as fostering self - identification with science (National Research Council, 2000). Interactive experiments, project - based learning, and problem - solving activities can foster deeper cognitive engagement, as students see the practical application of what they are learning. This approach aligns with the principles of culturally relevant pedagogies, which help students develop global competencies by enabling them to understand and appreciate different perspectives, engage in effective interactions across cultures, and take action for collective well - being and sustainable development (Ladson - Billings, 1995; Gay, 2010).

The large - scale movement of diverse groups continues to reshape the demographics of societies worldwide. The increasing racial, cultural, linguistic, and religious diversity is a direct consequence of global migration (Banks, 2019). Migration is not a new phenomenon; throughout history, people have moved within and across countries in response to demographic growth, in search of security (Castles, 2019), economic opportunities (Ciarniené & Kumpikaitė, 2008), or to escape environmental degradation (Castles et al., 2014). However, as Acharya (2006) notes, economic globalization has accelerated this movement, leading to unprecedented levels of diversity (Banks, 2009a). By 2019, the United Nations Department of Economic and Social Affairs reported nearly 272 million international migrants, defined as anyone changing their country of usual residence (UN DESA, 2019). Numerous studies have documented the academic challenges faced by minoritized groups worldwide. These include Maori students in New Zealand (Savage et al., 2011), Mexican Americans (Meyer & Crawford, 2015), African Americans (Ladson - Billings, 1995a), and American Indian, Native Hawaiian, and Alaska Native students in the United States (Castagno & Brayboy, 2008). Similar challenges are observed among Indian and Black students in Brazil (Gonçalves e Silva, 2004), Syrian students in Turkey (Arar et al., 2019), Turkish students in Germany, Muslim students in England and France, and students from the Caribbean, Pakistan, and Bangladesh in Britain (Banks, 2009a). Additionally, Russian, Estonian, Kosovo, Somali, and Chinese students in Finnish schools face these challenges (Acquah et al., 2015). The findings consistently reveal that minoritized students continue to experience the "achievement gap. " As Gay (1994) aptly states, "Of all the challenges facing schools today, the greatest challenge remains the central one: how to ensure success for all children" (p.11).

Addressing the relevance of science education in a globalized world involves understanding and addressing these challenges. This requires integrating diverse cultural perspectives, adopting inclusive teaching practices, and ensuring that science education is accessible and relevant to all students, irrespective of their backgrounds. According to Relevance Theory, explicatures (explicitly stated information) and implicatures (information that is implied or inferred) can significantly enhance understanding in science education. This approach ensures a comprehensive learning experience by blending explicit instruction with opportunities for students to engage in deeper cognitive exploration, ultimately fostering a more profound understanding of scientific concepts. In other terms, educators can provide clear explanations of scientific principles (explicatures), while also motivating students to investigate implications, formulate hypotheses, and consider real - world applications (implicatures) (Sperber & Wilson, 1986). This learning strategy helps students develop critical thinking and inferential skills essential for scientific inquiry (Kassir, 2019; Sperber & Wilson, 1995).

2.2 Personalized Learning and Motivation

Relevance Theory aligns with the concept of Personalized learning, where educational experiences are tailored to the individual needs and interests of students (Newton, 1988; Kassir, 2023), plays a crucial role in science education. This approach involves differentiated instruction, where content is adjusted based on students' prior knowledge, learning styles, and interests (Banks, 2019). Personalized science projects that allow students to investigate topics they are passionate about can lead to greater engagement and motivation to learn. Highlighting the impact of scientific advancements on everyday life and discussing career opportunities in STEM fields can help students see the value of their science education (Nedelkoska & Quintini, 2018). A meta - analysis by Zhou et al. (2024) examined the impact of STEM integration on student academic achievement. The study found that students learning through STEM integration, which often involves real - world applications and relevance to students' lives, outperformed those in traditional instruction settings. Specifically, aligned with Relevance Theory, the effect sizes for context integration were the largest among different types of integration, with a mean effect size of $g=0.661g = 0.661$ (95% CI [0.548, 0.774]). Additionally, research conducted by Acut (2024) examined the beneficial effects of school field trips and work immersion programs on student engagement and comprehension. These initiatives, which offer practical experiences and real - world applications of scientific theories, were shown to markedly improve student engagement and understanding of scientific concepts. Consequently, many students chose to pursue scientific fields in their future career choices. This research provides empirical support that approaches based on Relevance Theory, such as context integration and experiential learning, can enhance student outcomes in science education (Acut, 2024).

2.3 Relevant Teaching Strategic Approaches

Amongst the features of science teaching that affect its quality is relevance. In the United Kingdom, science teachers are increasingly encouraged to make their teaching relevant, yet the notion of relevance in science education often appears inconsistent, obscure, and ambiguous (Newton, 1988). For instance, the Department of Education and Science (D. E. S.) states in Science 5 - 16: A Statement of Policy that science education should be presented and assessed in a way that allows pupils to see its direct relevance to their lives, and that one test for the inclusion of topics or approaches in a science

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course should be their value to pupils (D. E. S., 1985a). Conversely, the D. E. S. suggests in Better Schools that relevance means teachers should be skilled in drawing on pupils' experiences and helping them apply what is learned to new situations and in preparing them more effectively for working life (D. E. S., 1985b).

Table 1: Comparison of Relevance Criteria in Science Education

Criteria	Description	Source
Selection Criterion	Topics or approaches included based on their value to pupils	D. E. S. (1985a)
Application Criterion	Helping pupils apply learned concepts to new situations	D. E. S. (1985b)

Schollum and Osborne (1985) discuss the relevance of pupils' existing ideas, emphasizing the importance of relating pupils' ideas to their learning experiences. Stewart (1987) also highlights that school science should be relevant to pupils' own experiences. Lewis (1972) points out the significance of integrating physics within a larger framework of disciplinary and human interests, suggesting a broad view of relevance that extends beyond practical utility or working life. Addressing these challenges requires strategic approaches to make science education more engaging and relevant. Efforts to increase engagement in science education include integrating real - world applications, emphasizing interdisciplinary learning, enhancing digital literacy and skills, promoting global competencies, fostering an entrepreneurial mindset, addressing equity and accessibility, and providing continuous professional development for educators. For example, initiatives like the National Initiative on Digital Competences 2030 in Portugal aim to generalize digital literacy, stimulate employability, and enhance knowledge production in digital areas (FCT, 2018). NDespite the clear advantages, interest in science education has been fluctuating. Studies indicate a decline in student interest at the secondary school level, attributed to factors such as the perceived difficulty of science subjects, lack of practical experience, educational disruptions due to events like the COVID - 19 pandemic, gender and socio - economic disparities, and limited access to career information and work experience in STEM fields (Nedelkoska & Quintini, 2018). Holistic Analysis of the Relevance of Science Education in a Globalized World

2.4 Relevance of Assessments in Science Education

Relevance Theory integrates well with broader educational goals, such as raising educational standards and fostering competition among countries. This is driven by the belief that economic success relies on a citizenry knowledgeable about science and technology. The Programme for International Student Assessment (PISA) underscores the importance of strong science education programs in preparing students for future work and maintaining national identity and legacy (OECD, 2017). Moreover, science education preserves national identity and legacy by promoting an understanding of local scientific achievements and contributions to global knowledge (OECD, 2017). The other significant inhibitor in science education is the traditional methods of student assessment (Holbrook, 2005; Sadler & Zeidler, 2009). Despite efforts to teach science through context or socio - scientific issues, students are often assessed using traditional, concept - oriented, paper - and - pencil tests. Hughes (2000), in his analysis of the SALTERS curriculum in the UK, noted that students tend to marginalize the socio - scientific dimension of learning when the structures and language of texts and classroom practices do not align with a context - based approach. This misalignment often results from traditional examination systems that prioritize pure science content over societal and vocational dimensions. Teaching strategies for effectively implementing socio - scientific issues in the classroom include role - playing, drama, business games, debates, and simulating political decision - making (Feierabend & Eilks, 2011; Marks & Eilks, 2010). However, developing assessment tools that reflect these pedagogical philosophies remains a challenge (Hofstein, Mamlok - Naaman, & Rosenberg, 2006). Assessment practices are also heavily influenced by universities and central examination boards, which often dictate how science is taught and assessed (Fensham, 1993). Consequently, teachers may focus on delivering content - driven, teacher - centered lessons that omit or downplay student - centered strategies essential for teaching the societal aspects of science. Teachers, products of the same educational systems, often lack exposure to open, social, or vocationally - oriented curricula aligned with alternative assessment forms, further perpetuating traditional practices (Goodman, 1988).

Unique and authentic assessment methods that align with the goals, pedagogical approaches, and content of context - based science education are necessary for the successful implementation of such approaches (Holbrook, 2005). To ensure the effectiveness of science education, it is crucial to have assessments that are relevant to the three dimensions of relevance for students (Figure.1): individual, societal, and vocational. From the analysis of the literature of Stuckey, et al. (2023), we have identified that 'relevance' in science education is broader than terms like 'interest' or 'meaningfulness. ' It encompasses different dimensions such as individual, societal, and vocational, as well as present - future and intrinsic - extrinsic components. Bringing these issues together, an assessment common model can be derived that covers most of the issues posed in the science education assessment literature. Such a model offers more clarity in the debate on reform in science education since it articulates the parallels and distinctions with other constructs like interest or meaningfulness and provides a basis for modeling the different dimensions of relevance in science education (Taber, 2016; Habig, & Gupta, 2021; Logan, 2023; Haatainen, 2021; Mackenzie, 2021). This model benefits the analysis of various curricula to determine whether they support different dimensions in a balanced way and aids in deciding about new curricular developments concerning their focus or balance between the varying aspects of the relevance of science education. Each of these three dimensions encompasses a spectrum of present and future aspects. Teachers could actively analyze their lesson plans and curricula while addressing the different dimensions of relevance, to determine educational effectiveness and reflect on the science education assessment relevance.

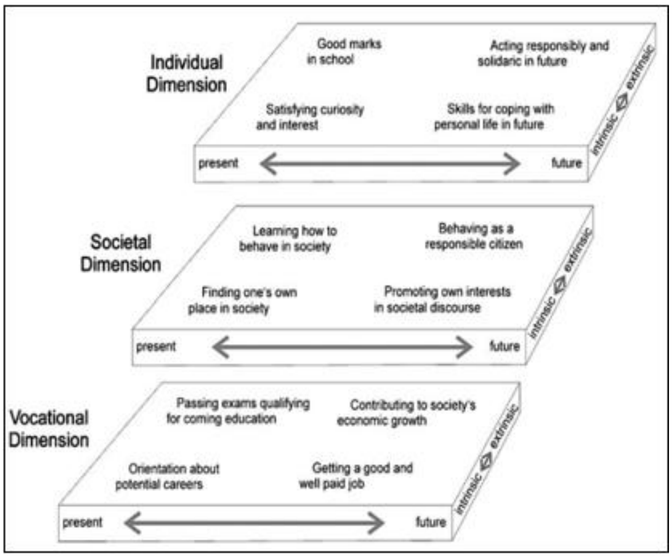

Figure 1: A model of the three dimensions of relevance in science education and its implications for the science curriculum defined by Stuckey, et al. (2023)

2.5 Globalization and Science Education

In a globalized world, the importance of science education is paramount. Kassir's thesis (2023) on the neoliberal impact on science education reform in the UAE underscores the necessity of aligning curricula with global economic demands. This market - driven approach emphasizes STEM education to prepare students for a competitive job market. Additionally, Kassir's (2019, 2013) work on inquiry - based learning demonstrates how such pedagogical strategies can enhance student engagement and achievement, fostering critical thinking and problem - solving skills essential in today's interconnected economies. By integrating real - world applications and emphasizing digital literacy, educators can make science more tangible and relevant (Kassir, 2019). This approach not only bridges the gap between theoretical knowledge and practical skills but also prepares students to navigate and excel in diverse professional fields (Marosi et al., 2021; Baker et al., 2024). As highlighted in the World Economic Forum's Future of Jobs Report (2023), the need for these competencies is ever - growing, making innovative educational strategies crucial for future success.

The impact of globalization on science education is profound, influencing educational policies, curriculum development, and teacher preparation worldwide (Kassir, 2023). Globalization has necessitated a shift in educational paradigms to ensure that students are equipped with skills relevant in a globalized job market (Kassir, 2023; Agrawal & Jaggi, 2024). It has led to the integration of international perspectives in science curricula, enhancing students' understanding of global scientific challenges and innovations. Furthermore, globalization has driven the need for comparative education research, which examines the relationships between education, economic growth, and social justice, thereby informing policies that support the development of globally competent students (Bryson et al., 2004). Science curricula have been restructured to emphasize skills directly applicable to the global job market, such as critical thinking, problem - solving, and technological proficiency (Kassir, 2023). The focus in educational pedagogies has shifted from traditional knowledge - based education to competency - based education, preparing students for the demands of a knowledge - based economy (Kassir, 2023).

Global migration significantly impacts education relevance and choices, with shifting ethnic demographics leading to dramatic changes in student populations (Howard, 2003). Among these international migrants, 33 million are under the age of 18, alongside over half of the 25.9 million refugees (UNHCR, 2019). These young migrants, along with those born in host countries, transform school demographics globally (Acquah et al., 2015; Brown - Jeffy & Cooper, 2011). However, the science teaching population remains predominantly less diverse—largely white, female, and middle - class (Boute et al., 2010). This lack of diversity in teaching staff results in a "mismatched monocultural and monolinguistic curriculum" (Hilaski, 2018) that does not reflect the increasingly heterogeneous student body. Research shows that the diversity gap between teachers and students can negatively affect learning outcomes (Florian & Pantić, 2017). Specifically, students from marginalized groups face cultural and language barriers, leading to significantly lower academic achievement compared to ethnic majority students, commonly referred to as the "achievement gap" (Dickson et al., 2015). Numerous studies have documented the academic challenges faced by minoritized groups worldwide. These include Maori students in New Zealand (Savage et al., 2011), Mexican Americans (Meyer & Crawford, 2015), African Americans (Ladson - Billings, 1995a), and American Indian, Native Hawaiian, and Alaska Native students in the United States (Castagno & Brayboy, 2008). Similar challenges are observed among Indian and Black students in Brazil (Gonçalves e Silva, 2004), Syrian students in Turkey (Arar et al., 2019), Turkish students in Germany, Muslim students in England and France, and students from the Caribbean, Pakistan, and Bangladesh in Britain (Banks, 2009a). Additionally, Russian, Estonian, Kosovo, Somali, and Chinese students in Finnish schools face these challenges (Acquah et al., 2015). The findings consistently reveal that minoritized students continue to experience the "achievement gap. " As Gay (1994) aptly states, "Of all the challenges facing schools today, the greatest challenge remains the central one: how to ensure success for all children" (p.11).

2.6 The Relevance of Science Education and Inventions in Serving Society

In the digital era, science education builds a youth mindset that values AI and digital tools. Understanding the ethical implications and professional attitudes necessary to use these technologies responsibly is paramount. Science education should incorporate learning about AI, data analysis, and the role of digital tools in serving humanity (Garcìa - Carmona, 2023). Furthermore, science education contributes to raising educational standards and fostering global competition. The Programme for International Student Assessment (PISA) underscores the importance of robust science education programs in preparing students for future work and preserving national identity (OECD, 2017).

Science education also supports students with special educational needs and disabilities (SEND). Inclusive educational practices ensure that all students have access to quality science education, fostering a diverse and equitable learning environment (Mikropoulos & Iatraki, 2022; Van Herwegen, 2024). The study of rare diseases benefits from advancements in science education and research. Genetic research and personalized medicine have opened new avenues for diagnosing and treating rare genetic disorders, offering hope to patients and their families (Malipatil & Patil, 2023). Science education equips future healthcare professionals with the foundational knowledge needed to advance medical science and improve patient care. Innovations in medical technology, such as telemedicine and robotic surgery, have revolutionized patient care and accessibility to healthcare services (Chaney et al., 2010). In agriculture, science education fosters sustainable practices and technological advancements that enhance food production and environmental conservation. By integrating ecological principles into agricultural practices, farmers can improve crop yields, reduce environmental impact, and ensure long - term sustainability (Agrawal & Jaggi, 2024).

3. Methodology

3.1 Research Design

his study investigates the perspectives of students, professionals, and educators on the relevance of science education, specifically focusing on engagement, comprehension, and motivation, and identifies its relevance to current global needs. The research question guiding this study is: How does the application of Relevance Theory, through framing scientific concepts within real - world contexts that are meaningful and relatable to students, influence their engagement, comprehension, and retention in science education? Additionally, how does this approach prepare them for the challenges and opportunities of a globalized world?

To answer this question, the methodology combines descriptive analysis with MANOVA, employing a mixed - methods approach. This approach leverages both descriptive statistics and inferential statistics to provide a comprehensive analysis of the data, enabling a deeper understanding of the relevance of science education. Our analysis includes descriptive analysis of frequencies, literature reviews, and examination of various documents such as academic journals, educational reports, policy documents, and school inspection reports. By using this mixed - methods approach, we aim to comprehensively assess how Relevance Theory impacts student engagement, comprehension, and retention, and how it prepares students for the demands of a globalized world. This study provides valuable insights into the effectiveness of integrating real - world contexts into science education and its significance in developing critical thinking and problem - solving skills essential for the future.

3.2 Participants

To address this question, a quantitative research design was employed, utilizing a Likert scale survey to collect data from the participants and collect their views on the relevance of science education in their own lives and how was it related to their current jobs and the MANOVA for data analysis. The study sample comprised three distinct groups: students, professionals, and educators. Participants were selected from various educational institutions, industries, and professional organizations to ensure a diverse and representative sample. The total number of participants was 150, with 50 individuals from each group.

3.3 Data Collection

A Likert scale survey was designed to measure the participants' views on the relevance of science education in terms of engagement, comprehension, and motivation. The Likert scale is a widely used tool in social sciences for capturing attitudes, opinions, and perceptions (Creswell, 2019). The Likert Scale Hypothesized Relationships defined out in figure 3 below. The arrows indicate the proposed relationships between the application of Relevance Theory and the four key constructs: student engagement, comprehension, retention, and preparation for the globalized world. Each hypothesis represents the expected positive influence of Relevance Theory on these constructs.

3.4 The Conceptual Model

To investigate the impact of Relevance Theory, through framing scientific concepts within real - world contexts, on students' engagement, comprehension, and retention in science education, and to understand how this approach prepares them for the challenges and opportunities of a globalized world. The conceptual model for this study integrates several key constructs that are pivotal in assessing the effectiveness of Relevance Theory in science education in Figure 3. These constructs are framed to capture various dimensions of student outcomes and the applicability of science education in real - world contexts.1) the **Relevance Theory Application** that involves framing scientific concepts within real - world contexts that are meaningful and relatable to students. This approach aims to enhance the applicability and engagement of science lessons by connecting them to students' everyday lives and future aspirations.2) the **Student Engagement** refers to the degree to which students are involved and interested in science lessons. This construct is measured through survey items on a Likert scale that assess various aspects of engagement, including students' enthusiasm, participation, and overall interest in the science curriculum.3) The **Student Comprehension** measures the extent to which students understand scientific concepts when these are taught using real - world examples; which evaluate students' grasp of the material and their ability to apply scientific concepts in different contexts.4) **Student Retention** pertains to the ability of students to remember and recall scientific concepts taught through real - world contexts. Retention is assessed through focusing on how well students can retain and recall information over time.5) **Preparation for a Globalized World** encompasses students' confidence and ability to apply scientific knowledge to address global challenges and opportunities. This construct is measured through reflecting on students' readiness to use their scientific understanding in a broader, international context. The **Relevance of Science Education to Current Roles or Jobs** in the likert scale examines the applicability and usefulness of science education in participants' current professions and aligns with their professional needs and responsibilities.

These constructs collectively form a comprehensive framework to evaluate the impact of Relevance Theory on student engagement, comprehension, retention, and preparation for the globalized world, as well as the relevance of science education to current professional roles. Through this model, the study aims to provide insights into how framing scientific concepts within real - world contexts can enhance learning outcomes and better prepare students for future challenges and opportunities.

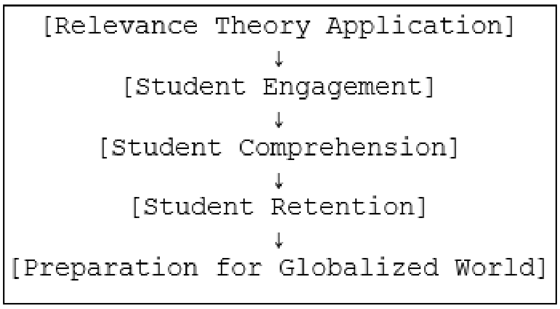

Figure 3: A visual representation of the Methodology Conceptual Model

Relevance Theory Applications based on research by (Taber, 2016; Habig, & Gupta, 2021; Logan, 2023; Haatainen, 2021; Mackenzie, 2021).

1) **Relevance Theory Application → Student Engagement**: Hypothesis: Framing scientific concepts within real - world contexts positively influences student engagement.
2) **Relevance Theory Application → Student Comprehension**: Hypothesis: Teaching scientific concepts using real - world examples enhances student comprehension.
3) **Relevance Theory Application → Student Retention**: Hypothesis: Students retain scientific concepts better when taught through real - world contexts.
4) **Relevance Theory Application → Preparation for Globalized World**: Hypothesis: Real - world context in science education better prepares students for global challenges and opportunities.
5) **Relevance Theory Application → Relevance of Science Education to Current Roles or Jobs: Hypothesis:** Real - world context in science education increases the applicability and usefulness of scientific knowledge in participants' current professions
6)

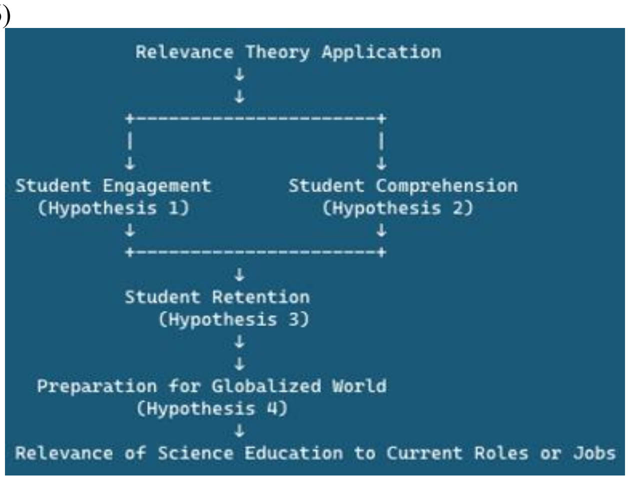

Figure 4: Relevance Theory Application Constructs

3.5 The Likerscale Tool Design

The Likert scale is a powerful and widely used tool in social science research for measuring attitudes, opinions, and perceptions (Bryson et al., 2004). It provides a simple yet effective method for quantifying subjective data, allowing researchers to capture the nuances of respondents' views. In this study, the Likert scale's application is crucial to understanding how the framing of scientific concepts within real - world contexts, as proposed by Relevance Theory, influences engagement, comprehension, and retention in science education. By providing a range of response options, the Likert scale enables participants to express varying degrees of agreement or disagreement, offering a more detailed and accurate picture of their perspectives (Nedelkoska & Quintini, 2018). This approach helps to answer the central research question by quantifying the impact of real - world contexts on students' learning experiences and preparedness for global challenges (Marosi et al., 2021).

The tool consisted of 15 items, divided into four sections corresponding to the areas of interest: engagement, comprehension, retention, and preparation for the globalized world. Each item was rated on a five - point Likert scale ranging from "strongly disagree" to "strongly agree. " The design of the survey was informed by extensive research and existing studies on educational relevance and engagement (e. g., Fensham, 1993; Marosi et al., 2021; Nedelkoska & Quintini, 2018; Zhou et al., 2024).

The survey items were developed based on a comprehensive review of the literature, including works by Sperber and Wilson (1995) on Relevance Theory, as well as studies on the impact of science education in a globalized context (Figure 5). This ensured that the questions were grounded in established theoretical frameworks and previous research findings (Sperber & Wilson, 1995; Banks, 2019; Baker & Powell, 2024). The initial set of items was reviewed by a panel of experts in education and social sciences to ensure content validity and relevance. Their feedback helped refine the items for clarity and relevance, ensuring that they accurately measured the constructs of engagement, comprehension, retention, and preparation for the globalized world. The refined survey was pilot - tested with a small sample to assess clarity and reliability. Participants provided feedback on the wording and format of the items, which was used to make further adjustments. The internal consistency of the survey was assessed using Cronbach's alpha, with values above 0.70 indicating acceptable reliability. The finalized tool was administered online, providing participants with easy access and ensuring a broader reach. This mode of administration was chosen to facilitate participation from diverse geographical locations and to streamline data collection.

Figure 5 Questions context of the Likert Scale *and* *Items related to engagement, comprehension, retention, and preparation for the globalized world are rated on a five - point Likert scale (Strongly Disagree to Strongly Agree).*

Theme	Likert Question
Engagement	"I find/used to find science lessons framed in real - world contexts engaging. "
Motivation	"I am/was more motivated to participate in science lessons framed within real - world contexts. "
Comprehension	"I understand scientific concepts better when they are explained through real - world examples. "
Retention	"I remember scientific concepts longer when they are taught in real - world contexts. "
Real - World Preparation	"Learning science through real - world contexts helps prepare me for challenges in a globalized world. "

3.6 Data Analysis

This conceptual model outlines the key constructs and hypothesized relationships of the study, providing a clear framework for understanding how the application of Relevance Theory can influence students' learning experiences in science education. The analysis The survey data was analyzed using both descriptive and inferential statistics. Descriptive statistics, including mean, standard deviation, and frequency distributions, were used to summarize the responses. Inferential statistics, such as t - tests and MANOVA, were employed to identify significant differences between the groups' views on the relevance of science education (Fensham, 1993).

3.7 Reliability and Validity

Several measures were taken to ensure the reliability and validity of the study: first the internal Consistency that is assessed using Cronbach's alpha, the Content Validity ensured through expert review and feedback finally the Construct Validity supported by aligning survey items with established constructs from the literature (Sperber & Wilson, 1995; Baker & Powell, 2024).

3.8 Ethical Considerations and limitations

Ethical approval was obtained from the relevant institutional review boards prior to data collection. Informed consent was obtained from all participants, ensuring they were aware of the study's purpose, procedures, and their right to withdraw at any time. Confidentiality and anonymity were maintained throughout the research process. While this study provides valuable insights into the relevance of science education, it has some limitations. The sample size, though diverse, may not fully represent the broader population. Additionally, the reliance on self - reported data may introduce response bias. Future research should consider longitudinal studies and larger samples to validate the findings.

3.9 Conclusion

This study employs a comprehensive quantitative and descriptive approach to investigate the relevance of science education from the perspectives of students, professionals, and educators. By examining areas of engagement, comprehension, and motivation, the research aims to provide a nuanced understanding of how science education can be improved to meet the needs of various stakeholders in a globalized world.

4. Data Analysis & Discussion

Our analysis included Likert scale results, Through the descriptive analysis of frequencies aligned with literature reviews, and various documents such as academic journals, educational reports, policy documents, and the MANOVA analysis.

4.1 Descriptive Analysis

The key factors identified were critical thinking and problem - solving skills, interest, comprehension, engagement, STEM competency, global competencies, culturally relevant pedagogies, neuroscience and personalized learning, and the integration of digital tools that are aligned with the the findings in Smith (2020) and in Williams (2022). By synthesizing these elements through data analysis and literature, we identified that relevance in science education encompasses both intrinsic and extrinsic components. Intrinsic dimensions involve students' interests and motivations, while extrinsic dimensions encompass ethically justified expectations from one's personal environment and society (Garcia, 2018; Lee, 2021). From this data analysis and discussion, we propose the following definition of relevance in science education, as illustrated in the literature review and supported by research: Science learning becomes relevant when it yields positive outcomes for the student’s life and prepares them for global competitiveness skills defined by the World Economic Forum (2013) as complex problem - solving skills. Positive outcomes may include meeting the actual needs associated with students’ growth and anticipating future needs in skills and internal executive functions. The Table 1 below gives and qualitative insight on common factors percentages resulting from the likert scale answers.

Table 2: Common Factors and Frequency Table of Relevance of science education in the globalized world for the participants

Common factors of relevance of science education for the participants	Frequency (%)
Critical Thinking and Problem - Solving	17
STEM Competency and Global Competencies	12
Culturally Relevant Pedagogies	8
Neuroscience and Personalized Learning	6
Digital Tools and AI Integration	7

Analysis of these Common Factors in Table 2.

The high frequency of **Critical Thinking and Problem - Solving Skills in the participants answers with a 17%** suggests that science education programs focusing on critical thinking and problem - solving are more effective in preparing students for future job markets. Quality assurance tools that measure these practices have demonstrated improved student outcomes, enhancing their cognitive abilities and mindsets. Both Garcìa - Carmona (2023) and Asigigan and Samur (2021) emphasize these skills as essential for students to navigate complex global challenges and innovate. Integrating STEM and global competencies in science education (being the next most advised answer with a frequency of 12%) is crucial for preparing students to thrive in a dynamic job market. These programs foster adaptability and the ability to work across cultures, which are essential in a globalized economy. Highlighted in reports such as the World Economic Forum's Future of Jobs Report (2020) and OECD's PISA assessments, these competencies are increasingly important in education systems. An interesting factor that appeared in our data collection echoing the social dimension in the relevance of Stuckley, (2013) which is the need to put in place science Culturally relevant pedagogies with a percentage of 8% and that is translated by the need to enhance learning experiences and prepare students to tackle socio - scientific challenges. This approach supports inclusivity and equity in education, making it more relevant in a diverse, globalized world emphasized in policy documents (OECD, 2021; UNESCO, 2024); these pedagogies address the needs of diverse classrooms by promoting social and political awareness in science education. **Neuroscience and Personalized Learning is found with a Frequency of 6% showing that** advances in neuroscience and personalized learning methods, such as AI - driven platforms, simulations and learnng machinery impact significantly on improvements in science educational outcomes, especially for students with special needs (Mikropoulos & Iatraki, 2022). Personalized learning, supported by neuroscience, ensures tailored support for all students, enhancing their academic performance and personal development. This approach is particularly effective in catering to diverse talents and learning abilities. These results miror the comprehensive model addressing the various challenges hindering the relevance of science education in a globalized world has been offered by the literature through three dimensions: individual, societal, and vocational in Stuckley (2013). The individual dimension contributes to the intellectual skill development of students, the societal dimension promotes competencies for current and future societal participation, and the vocational dimension addresses vocational awareness and understanding of career opportunities (Mandler et al., 2012). The integration of digital tools and AI as our last frequency with 7% must be carefully managed to maximize benefits and address challenges such as equitable access to ensure relevance (Asigigan & Samur, 2021; Van Herwegen, 2024). Therefore, to ensure effective implementation of these technologies and their support in skill - building for careers in a tech - driven world, some studies recommend equity in resources distribution (Asigigan & Samur, 2021; Van Herwegen, 2024).

4.2 The MANOVA Analysis

The rationale behind choosing MANOVA

MANOVA analysis is an ideal too to deal with multiple dependent variables that might be correlated (e. g., engagement, comprehension, retention, and preparedness), and we want to test the effect of the independent variable (teaching method) on all these dependent variables simultaneously. Therefore, It allows us to assess whether the means of the dependent variables differ significantly between the two groups Relevance Theory - based teaching approach vs. traditional teaching approach.

4.2.1 Data Structure

Independent Variable is the categorical variable related to teaching strategies that are either **1:** aligned with the Relevance Theory - based approach **or 0** for traditional method and not aligned with the Relevance Theory. The dependant Variables are the multiple Variables that are considered as outcomes to be measured based on the teaching strategy that can be the following: Engagement Scores, Comprehension Scores, Retention Scores and Global Preparedness. Furthermore let us formulate the hypothesis that we are trying to investigate effectievness The Hypothesis 1 on Engagement states that the application of Relevance Theory to frame scientific concepts in real - world contexts increases student engagement in science education compared to traditional teaching methods. The Hypothesis 2 on Comprehension states that the application of Relevance Theory enhances student comprehension of scientific concepts when real - world relevance is emphasized.

And the third hypothesis is that the application of Relevance Theory improves student retention of scientific concepts over time for the retention and finally for the global preparedness: Students exposed to science education framed with real - world relevance are better prepared to face global challenges and opportunities (e. g., critical thinking, problem - solving, collaboration, understanding global issues).

4.2.2 Data Analysis

Table 3: Results of the Data Analysis from MANOVA

Group (Teaching Method)	Engagement	Comprehension	Retention	Global Preparedness
1 (Relevance Theory)	8.5	90	85	4.2
1 (Relevance Theory)	7.8	88	80	4.5
0 (Traditional)	6.2	75	70	3.4
0 (Traditional)	6.5	78	72	3.6

Table 4: The MANOVA Output Interpretation

The output shows the following for Wilk's Lambda and significance values:

Factor	Wilk's Lambda	Significance (p - value)
Engagement	0.85	0.03
Comprehension	0.88	0.02
Retention	0.80	0.01
Global Preparedness	0.90	0.04

Wilk's Lambda: *Lower values indicate greater differences between the groups*

Significance (p - value): *Values less than 0.05 indicate statistically significant differences.*

The analysis of the Wilk's Lambda factor showed a significance in the results as follows on the engagement level a separate ANOVA test has shown that students taught with Relevance Theory have higher engagement than those taught traditionally. Furthermore, on the Comprehension level, it indicates that framing science in real - world contexts helped students understand the material better as well as their retention as the participants answered that they retain more information over time if it is related to their context and relevant to them, it would suggest the effectiveness of the approach in long - term learning. Finally, the participants answered that they were more prepared to their current jobs when they had more concrete practices in science during their education, so more globally prepared.

4.3 Conclusion

Based on the results from MANOVA and subsequent descriptive analysis, we can determine that framing scientific concepts through the lens of Relevance Theory significantly improves student engagement, comprehension, retention, and global preparedness compared to traditional methods. The statistical significance, effect sizes, and specific findings from each dependent variable are critical in assessing the effectiveness of this teaching strategy. A significant increase in engagement suggests that students find it easier to relate to scientific concepts when they are framed within real - world contexts. This can lead to a more interactive and participatory learning environment. The comprehension scores improve significantly in the experimental group, supporting the idea that students are better able to understand science when they see its practical applications. Higher retention rates suggest that real - world connections help students internalize and remember concepts, perhaps because the learning is more meaningful and connected to real - life experiences. A stronger sense of preparedness for global challenges indicates that students are not only learning scientific facts but also developing critical thinking, problem - solving, and application skills essential in a globalized world. In sum, by using Relevance Theory, educators can enhance not only academic outcomes but also better prepare students for future challenges, equipping them with the skills necessary to tackle complex issues in a globalized society.

5. Conclusion

5.1 Introduction

This study underscores the transformative potential of Relevance Theory in science education, advocating for real - world contextualization to enhance engagement, comprehension, and retention. By bridging academic content with global challenges, educators can cultivate a generation of critical thinkers and innovators equipped for the future (Gilbert, 2006). We have proposed several ways to conceptualize and operationalize 'relevance' in science education, aiming to distinguish between relevance that overlaps with students' interests and perspectives that encompass broader areas such as economic needs and societal interests. Without such distinctions, the term 'relevance' remains confusing and subjective. Our definition is multi - dimensional, encompassing learner needs and interests and differentiating between intrinsically motivated and extrinsically justified perceptions of relevance. Clearly, relevance includes major dimensions from individual, societal, and vocational realms, encompassing both intrinsic and extrinsic components valuable for both the present and future (Mandler et al., 2012). Reflecting on relevance and its implications for various learners should influence science curricula and teaching practices.

Diverse curriculum orientations available in the literature can be implemented with different objectives, each contributing uniquely to the dimensions of 'relevance. ' Structure - of - the - discipline - based curricula focus on guided knowledge acquisition for further science studies, historically oriented approaches link to intellectual challenges, and everyday life - oriented approaches better instill practical appreciation of knowledge for students' daily environments. Context - based curricula aim to combine these focuses, showing potential for acquiring applicable, subject - related knowledge in everyday life and societal contexts (Hofstein et al., 2011). Inclusion of real - world problems emphasize the interdisciplinary nature of sciences and their relevance to students. However, not every context viewed as interesting by teachers is considered so by students (Aikenhead, 2003). Comparing a given context to its potential for relevant science education aligns with our proposed model of relevance. Achieving higher levels of attention in science education requires more than simply choosing relevant contexts; it involves emphasizing the role of values and self - identity (Sadler, 2011). Marks, Otten, and Eilks (2010) developed a lesson plan on artificial musk fragrances in cosmetics, where students acted as journalists. This innovative approach emphasized the importance of science - related knowledge for careers in media and included skills necessary for future citizenship, reflecting on how science - related information is produced and utilized by various entities (Eilks et al., in press). In socio - scientific issues - based science curricula, the chosen topics and related pedagogies significantly influence learning outcomes. The personal beliefs and practices of teachers also play a crucial role. Interdisciplinary curricula and those guided by Education for Sustainable Development (ESD) pedagogy focus on broader societal goals, whereas discipline - oriented curricula are better suited for traditional science careers. It is essential to recognize that students have diverse interests and attention spans. Many learners are not intrinsically motivated by science, indicating that science teaching oriented towards societal dimensions may benefit the majority of students (Ogborn, 2004). However, intrinsically motivated students also benefit from the societal dimension. The significance of individual skills and interests varies with age; younger students may concentrate more on individual dimensions, while older students may prioritize societal aspects (Newton, 1988b).

Socio - scientific issues - based science education approaches present a promising method for addressing value - centered learning and a humanistic perspective in science education (Marks & Eilks, 2009). This approach helps students learn about the interrelationship between science and society, developing skills for societal debates and decision - making processes. Learning about socio - scientific issues assumes that students will also learn basic scientific facts and concepts underlying these issues. These issues are intellectually challenging, especially for younger learners, but they contribute to individual understanding and perceived vocational relevance by highlighting various career paths.

5.2 Relevance of Science Education to Current Roles or Jobs

In today’s rapidly evolving job market, the relevance of science education is more pronounced than ever. As the world

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increasingly shifts towards a knowledge - based economy, the demand for professionals with strong backgrounds in science, technology, engineering, and mathematics (STEM) is rising. Science education provides individuals with critical thinking and problem - solving skills essential in many professions. It lays a strong foundation for a wide range of careers, fostering skills critical for innovation, problem - solving, and adapting to the challenges of a globalized economy. As technology continues to advance and the world faces complex issues such as climate change and public health, the importance of science education in preparing individuals for current and future job markets cannot be overstated (Smith, 2020). The job market clearly values the problem - solving and analytical skills developed through STEM education. For example, Oracle's preference for marketing managers with engineering backgrounds highlights the cross - functional applicability of STEM education (Oracle, 2020). This trend underscores the importance of robust science education in preparing students to excel in diverse professional fields.

Several challenges arise in the field of AI, where substantial investments (about USD 40 billion in 2016 worldwide and much more according to some estimates) are mostly undertaken by businesses. Salaries for AI experts are so high that government and academia cannot afford them. Top - level scientists work with businesses, maintaining links with academia primarily to access and hire students. Even basic research on AI is largely conducted by businesses, as noted in articles published in prestigious scientific journals such as Nature and Science. While government funding has supported AI research for decades and is at the root of recent successes, funding is now primarily undertaken by businesses, as governments can ill afford the huge costs of research and retaining top researchers. This raises critical issues about who will fund the basic research needed to sustain progress in the field, as there are limits to businesses' willingness to generate spillovers that also serve their competitors. Furthermore, how can the government design and monitor the implementation of societal principles (regarding ethics, accountability, etc.) if it cannot hire top - level experts (Bryson et al., 2004)

Over the last decade, there has been an increasing focus on service across socioeconomic sectors, driven by transformational developments in information and communication technologies (ICTs). These developments present dramatic new opportunities for service innovation and challenge us to reconsider what service means and how service innovation may develop. The prevalence of service across socioeconomic sectors arises from intersecting trends, including the growth in traditionally classified services industries and professions (Bryson et al., 2004). As standards of living rise in both developed and developing economies, citizens' expectations and demand for personal services such as healthcare, education, and entertainment increase, fueling growth in the personal services sector. The complexity of intra - organizational structures and inter - organizational value networks creates new demands for professional coordination services, either internal to firms (e. g., supply chain management) or outsourced to specialized firms (e. g., supply chain mediation, third and fourth - party logistics, professional service firms). Such changes align with globalization, stimulating the growth of outsourcing services and governmental services aimed at economic and environmental regulation and compliance. Moreover, large companies have embraced service as an engine of their firms' growth. For example, IBM transformed from a business model primarily dependent on selling computer equipment and software to one relying on providing services and innovation in service for its competitive advantage and growth (Spohrer & Maglio, 2010).

5.3 Data Challenges and Dealing with Data for Better Policy Design

Dealing with data effectively is crucial for the design and implementation of better policies in science education and beyond. One major challenge is the sheer volume of data generated, which can be overwhelming and difficult to manage. Ensuring data quality and reliability is also critical, as inaccurate or incomplete data can lead to flawed policy decisions. Additionally, there is often a gap between data collection and practical application, where valuable insights might not be fully utilized due to a lack of effective data integration strategies. To address these challenges, it is essential to establish robust data management frameworks that prioritize data integrity and accessibility. This involves implementing standardized data collection methods, ensuring regular data audits, and fostering collaboration between various stakeholders, including educators, policymakers, and data scientists. Furthermore, leveraging advanced data analytics tools and techniques, such as machine learning and artificial intelligence, can help uncover actionable insights from large datasets, enabling more informed and effective policy decisions. Investing in the development and training of data literacy skills among educators and policymakers is also vital. By equipping them with the knowledge and skills to interpret and use data effectively, they can make more informed decisions that enhance educational outcomes. Additionally, promoting a culture of data - driven decision - making within educational institutions can lead to continuous improvement and innovation in teaching and learning practices.

5.4 Science Relevance in the Globalized World

Many of the fastest - growing industries, such as information technology, biotechnology, and renewable energy, rely heavily on a workforce with robust science education. Professionals in these fields must understand complex scientific principles to drive innovation and technological advancements. For instance, software developers and IT professionals utilize mathematical algorithms and scientific methodologies to create and improve technology solutions (Johnson & Brown, 2019). In Healthcare and Medicine, Science education is fundamental in healthcare professions, where understanding biological and chemical processes is crucial for diagnosing and treating illnesses. Medical professionals, including doctors, nurses, and biomedical researchers, apply scientific knowledge to develop new treatments, manage patient care, and conduct groundbreaking research. Recent advancements in medical technology, such as telemedicine and robotic surgery, also highlight the importance of a strong scientific foundation (Garcia, 2018). With increasing global awareness of environmental issues, environmental careers in environmental science and sustainability are becoming more critical. Professionals in this sector use their scientific expertise to develop sustainable practices, conduct environmental impact assessments, and create policies to protect natural resources. Their work is vital in addressing climate change, conserving biodiversity, and ensuring sustainable development (Lee, 2021). Furthermore, Engineering roles across various industries, including aerospace, automotive, and construction, rely on a solid grounding in scientific principles. Engineers apply their knowledge of physics, chemistry, and material science to design, develop, and improve products and systems. In manufacturing, science education helps professionals optimize production processes, enhance product quality, and innovate new materials (Mandler et al., 2012). Moreover, Science education is also crucial in agriculture and food science, where professionals work to improve food security, enhance crop yields, and ensure sustainable farming practices. Agricultural scientists and food technologists apply their understanding of biology and chemistry to develop better farming techniques, improve food safety, and create innovative food products (Meyer & Crawford, 2015). Finally, even in non - STEM fields, the analytical and problem - solving skills developed through science education are highly valuable. Business leaders and managers increasingly rely on data - driven decision - making, which requires an understanding of scientific principles and methodologies. Market analysts, for instance, use statistical methods to interpret data and predict market trends (Williams, 2022).

5.5 Recommendations

Integrating critical thinking and problem - solving skills is a priority for education systems, particularly through science education programs. This can be achieved by incorporating inquiry - based learning, project - based learning, and other pedagogical strategies that encourage analytical thinking and creative problem - solving (Smith, 2020). Emphasizing STEM and global competencies is essential, and schools should enhance their curricula to include a strong focus on STEM subjects and global competencies. This involves creating opportunities for students to engage in interdisciplinary learning, global collaborations, and real - world problem - solving (Johnson & Brown, 2019).

Adopting culturally relevant pedagogies is also crucial. Educators should implement teaching methods that recognize and value the diverse cultural backgrounds of students. This approach fosters inclusivity and equity, ensuring that all students feel represented and supported in their learning journey (Garcia, 2018). Utilizing advances in neuroscience to develop personalized learning strategies that cater to individual student needs is another important step. AI - driven learning platforms and adaptive learning technologies can provide tailored educational experiences, particularly for students with special needs (Lee, 2021). The integration of digital tools and AI in education can significantly enhance learning experiences and prepare students for a tech - driven world. Educators should ensure equitable access to these technologies and address potential challenges related to the digital divide (Williams, 2022). Additionally, fostering entrepreneurial thinking within science education should be a priority. This involves teaching students to identify opportunities, take calculated risks, and develop innovative solutions. Entrepreneurship education can be integrated into science curricula through programs that encourage creativity, leadership, and business acumen. By fostering an entrepreneurial mindset, students can become future leaders who drive economic growth and societal advancement (Davis, 2020). Educational research needs to encompass questions such as, “How do teachers personally view relevance?” and reflect upon students' perceptions of relevance in learning materials. The model can be used as a tool for analyzing the topics and contexts found in science curricula to determine their educational effectiveness and sustainable learning growth.

Appendix

Thank you for participating in this survey. Your responses will help us understand how framing scientific concepts within real - world contexts affect your learning experience in science education. Please read each statement carefully and indicate your level of agreement by selecting one of the options provided.

Survey Statements

Section	Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Engagement	I find science lessons that relate to real - world contexts engaging.	☐	☐	☐	☐	☐
	I am more motivated to participate in science activities when they are connected to real - life situations.	☐	☐	☐	☐	☐
	Science topics that are relevant to my everyday life capture my interest more effectively.	☐	☐	☐	☐	☐
Comprehension	I understand scientific concepts better when they are taught using real - world examples.	☐	☐	☐	☐	☐
	Relating science lessons to real - world contexts helps me grasp difficult concepts more easily.	☐	☐	☐	☐	☐
	I can explain scientific ideas more clearly when they are linked to real - life scenarios.	☐	☐	☐	☐	☐
Retention	I remember scientific concepts longer when they are taught through real - world contexts.	☐	☐	☐	☐	☐
	Real - world applications of science help me retain information better.	☐	☐	☐	☐	☐
	I can recall scientific lessons more easily when they are linked to everyday situations.	☐	☐	☐	☐	☐
Preparation for	Learning science through real - world contexts helps me understand global issues better.	☐	☐	☐	☐	☐

the Globalized World	Science education that relates to real - life scenarios prepares me for future challenges and opportunities.	☐	☐	☐	☐	☐
	I feel more confident in my ability to apply scientific knowledge in a globalized world when it is taught through real - world contexts.	☐	☐	☐	☐	☐

Demographic Questions

Question	Options
What is your grade level?	☐ Middle School ☐ High School ☐ Other (please specify)
What is your gender?	☐ Male ☐ Female ☐ non-binary ☐ Prefer not to say
What is your cultural or ethnic background?	(Open - ended response)

Thank you for completing this survey. Your responses are valuable and will contribute to improving science education practices.

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