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PISA science framework 2018 vs 2025 and its impact in physics education: Literature review

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Abstract: Program for International Student Assessment (PISA) evaluates education systems in participating countries. Junior high school students are tested in math, science, and reading for the PISA Scientific Literacy test. This study contrasts the PISA Science Framework 2018 and 2025. This literature research uses systematic Literature Review (SLR) and bibliometric analysis. The method finds, reviews, evaluates, and interprets all research related to scientific literacy, PISA Framework 2018 and 2025, and its impact on Physics Education. The research used the Scopus database to find PISA Science Framework-related scientific articles. Results showed that PISA Framework 2025 evolves science literacy and scientific information function. The language is simplified to be more coherent by emphasizing the main idea of science. Procedural and epistemic knowledge are expanded and clarified. The finding is also supported by VOSviewer visualization of data results. This framework implies that physics education will assess students' understanding of fundamental physics principles and their rationality in applying them, including decision-making. In conclusion, the PISA Science Framework 2018 needs to be updated to the PISA Framework 2025 by the OECD to accommodate the students' needs in this era.
Keywords: PISA; scientific literacy; decision making; physics education

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Introduction

The 21st century is one of the most critical factors contributing to rapid progress in all fields. In this era of globalization, the education industry is actively trying to achieve the goal of implementing learning models that are more in line with the 21st century. In this case, students must face the 21st century, such as analytical and critical thinking, creative and innovative problem-solving, clear and effective communication, teamwork, and collaboration skills (Thornhill-Miller et al., 2023). 21st-century skills strengthen this social and intellectual capital, abbreviated as 4C: communication, collaboration, critical thinking and problem-solving, and creativity and innovation. Operationally, the 4c's are described as ways of thinking, including creating, innovating, being critical, solving problems, making decisions, and learning proactively. In developing skills, namely the role of communication technology, information, digital networks, and literacy (Ningsih et al., 2019; Yu et al., 2017).

Learners need 21st-century skills to face the rigorous challenges faced as a paradigm in the education system (Soh et al., 2010). Various studies show that the concepts and characteristics of 21st-century education it is also a significant demand and challenge for teachers in organizing learning and balancing the needs of the 21st century. The impact of this is all seen in the results of learning achievement. Especially in science learning by applying science concepts in science education so that students are expected to be able to solve real-life problems in this 21st-century era(Arifin & Sunarti, 2017). Students who understand scientific facts and the relationship between science, technology, and society can apply their knowledge to solve real-life problems with science literacy. The demands of the 21st century require developed countries to improve the quality of education by developing critical thinking through measuring scientific literacy.

A contextualized, operational definition of 21st-century learning goals in physics (and STEM in general) is provided, as well as a justification of the importance of these outcomes for today's students, according to a conceptually defined 21st-century teaching and learning framework. Research in physics education is briefly reviewed per the twenty-first century's learning objectives to provide context for future work in fostering high-end reasoning skills and encouraging deep learning simultaneously (Bao & Koenig, 2019). Research on education in physics is briefly examined, considering the learning objectives for the 21st century to set the stage for future work on deep learning and the development of high-end reasoning skills concurrently (Susanti et al., 2021). Physics is more than merely an academic field studied in textbooks and lecture halls; it is the science that defines the mechanisms of the universe and equips individuals to comprehend and engage with it. One crucial ability grows in the pursuit of physics education: decision-making. Making decisions in physics education involves more than just choosing the correct formula or resolving equations; it also involves giving students the analytical resources they need to use their knowledge effectively, make sense of complex occurrences, and progress science (Helen Quinn et al., 2012).

In the twenty-first century, the problems caused by globalization are becoming more and more severe. The 21st century needs competent human resources who can master the many skills required to meet its problems. Education in higher institutions should be able to do this. To meet the difficulties of the twenty-first century, students should prepare themselves with decision-making and problem-solving skills (Binkley et al., 2012). One of the most difficult intellectual abilities is decision-making. Decision-making must also consider assessment ethics, well-reviewed preparation, and test standardization. Physics education requires hands-on work, such as experiments and problem-solving tasks, but needs more class time for lectures and other instruction forms (Tunggyshbay et al., 2023).

One of the skills considered essential in the 21st century by the World Economic Forum is science literacy (World Economic Forum, 2015). The public's literacy in science is crucial. Thus, enhancing science education should prioritize this aim (DeBoer, 2000). Science literacy views the importance of critical thinking and acting skills that involve mastery of thinking by using scientific thinking in introducing and responding to social issues. Science literacy is essential for understanding the environment, economy, modern and technological side (Santhalia & Yuliati, 2021). As a result, students can attain a high or good level of science literacy, which can assist Indonesia's education system in competing with those of other nations. The outcomes of students' performance in science literacy on the PISA are a crucial indicator of a nation's educational system's quality (OECD, 2014).

Based on research conducted by (Zhang et al., 2023) and (Wilson & Urick, 2022), the PISA 2015 assessment and analysis framework shows that the current research focuses on literacy as a theoretical framework and consistency to changes in modern learning environments. Research results show a worldwide trend of researchers exploring the relationship between the influence of student ICT and mathematical and student performance on student learning outcomes (Courtney et al., 2022; Sun et al., 2022). Program for International Student Assessment (PISA) test scores frequently serve as the main focus of research (Aditomo & Klieme, 2020; König et al., 2021; Radišić et al., 2021). The importance of motivation in implementing innovative learning outcomes in improving science learning cannot be separated through the latest PISA assessment, which has been analyzed quantitatively by the research conducted. OECD issued the PISA 2025 framework, which has three competencies: Explain phenomena scientifically; Construct and evaluate designs for scientific inquiry and interpret scientific data and evidence critically; and research, evaluate, and use scientific information for decision-making and action (OECD, 2023), but there is little research which studied this. There are many reasons why the PISA 2025 framework has yet to be widely researched, among other things because the framework PISA 2025 is relatively new, and scientific research takes time to plan, implement, and analyze data. In addition, some researchers may still focus their research on the Pisa framework before PISA 2018, as they have begun research projects before the framework PISA 2025 is released. Furthermore, researchers have a wide range of research interests and priorities. They may be more interested in exploring different educational topics or issues deemed more urgent in their context. Therefore, this research was conducted to compare the PISA 2015 science framework with the PISA 2025 science framework through a literature review consisting of Systematics Literature Review (SLR) and Bibliometric Analysis. Performing this research will help teachers provide more focused instruction. Additionally, teachers might enhance their pedagogical approaches by understanding the modifications to the PISA framework. Teachers can modify their methods of instruction to fulfill the requirements of PISA 2025.

Method

This research is a type of descriptive research using the Literature Review method. This method allows researchers to analyze relevant articles and focus on the study using Systematics Literature Review (SLR) and Bibliometric Analysis.

The SLR describes distinct study procedures or research and development activities to compile and assess research linked to a given topic area (Paul et al., 2021). All currently available research must be found, reviewed, evaluated, and interpreted. This approach was chosen because it allows researchers to systematically examine and discover articles following the specified stages (Kühl et al., 2019). In order to prevent the subjective identification of journal identification findings, SRL is frequently required for defining research agendas (Kuei-Ping Shih et al., 2020; Razavian et al., 2019).

Bibliometric analysis is used as a quantitative method with an evaluative approach and the characteristics of a series of publications supporting evidence in the form of bibliometric visualization of related research (Garfield, 2009). Based on the study's results, researchers collected journal articles with the keywords PISA Science Framework, Science Literacy, or a combination of both. Data is collected by documenting all articles from the Google Scholar and Scopus databases. In supporting the research study's results, researchers also use the bibliometric analysis method from the Scopus database because it has an internationally recognized quality and reputation by research institutions (Guleria & Kaur, 2021).

This study incorporated a systematic literature review method using a bibliometric analysis. This method uses SLR as a leading framework for identifying and evaluating relevant articles and keywords on the research topic. The data from SLR was then further analyzed using the bibliometric analysis tool. Combining SLR with bibliometric analysis provides a more complete understanding of scientific literature. This helps identify highly influential articles, research trends, and the contributions of scientific works in one area. They can also help identify research gaps that require further attention.The stages of the method used in this study are based on Figure 1.

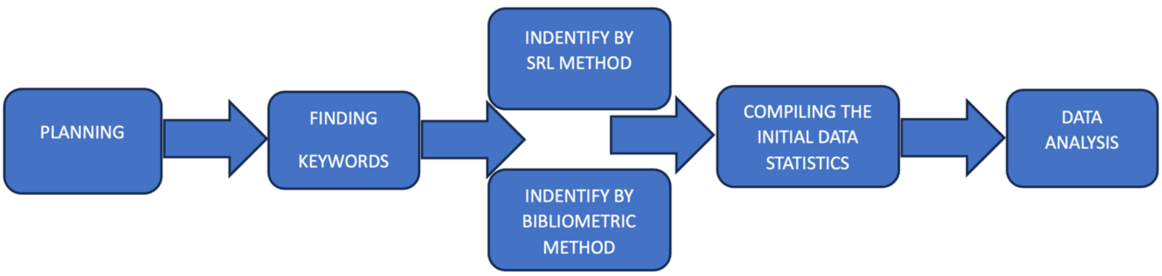

Figure 1. Five steps in the research

Results and Discussion

The PISA Science Framework 2018 can be seen in Figure 2. The forms of context, knowledge, and competence indicated in the PISA tasks used to assess science literacy. The assessment and communication of students' science performance is also covered in this framework.

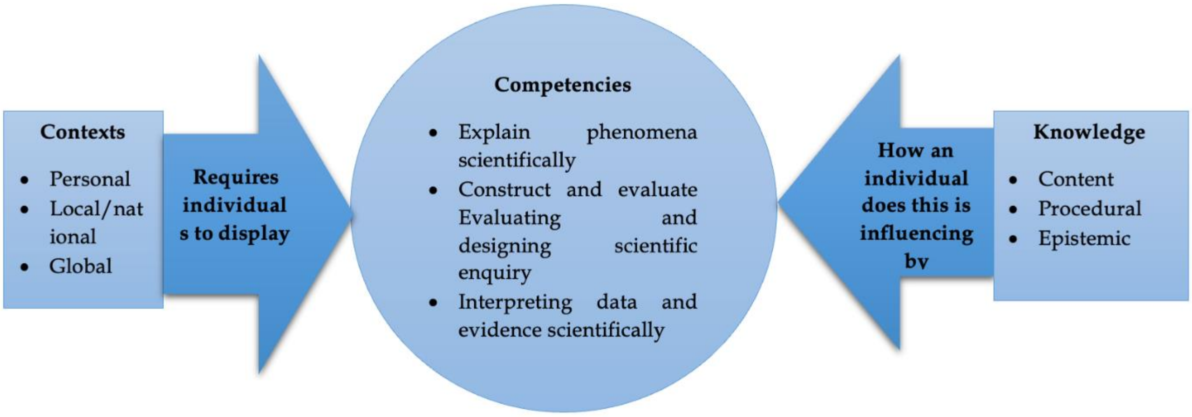

Figure 2. Framework of PISA science 2015/2018 (OECD, 2019)

The PISA 2018 science literacy framework can be divided into three aspects with each component of the assessment framework: contexts, competencies, and knowledge. Contexts consist of personal, local/national, and global. The PISA test context is categorized into five applications: science and technology, including health and disease, natural resources, environmental quality, hazards, and the limits of science and technology. Three competencies comprise science literacy, reflecting that science is best seen as an ensemble of social and epistemic practices generally divided into all fields.

The last aspect in PISA Science Framework 208 is knowledge. Content Knowledge is a sample from the domain of science content that can be assessed in the PISA 2018 science assessment, the criteria for combining the selection of expertise considered. Procedural knowledge is the underlying purpose of science, which is to produce explanatory notes on empirical investigations such as the idea of variables equipped with concepts and procedural so-called "concept evidence.". Epistemic knowledge is a knowledge of construction and defining features important for building knowledge in science. The science literacy in PISA 2018 is determined by three competencies, namely:

1. Explain phenomena scientifically. Science has succeeded in developing a set of theories that have changed understanding, such as explaining phenomena science and technology are required by content knowledge.
2. Evaluating and designing scientific enquiry. Science literacy requires students to choose some understanding of the objectives of scientific inquiry, such as generating reliable knowledge in nature to obtain scientific claims and hypotheses.
3. Interpreting data and evidence scientifically. Interpreting data is a core activity for all researchers. Start by looking for patterns, perhaps with simple tables or graphical visualizations.

A new version of the PISA Framework for 2024 is released in June 2020. Late in 2022, PISA implemented changes to the PISA Framework 2024, resulting in the PISA Framework 2025. Figure 3 provides a visual representation of the PISA Framework 2025.

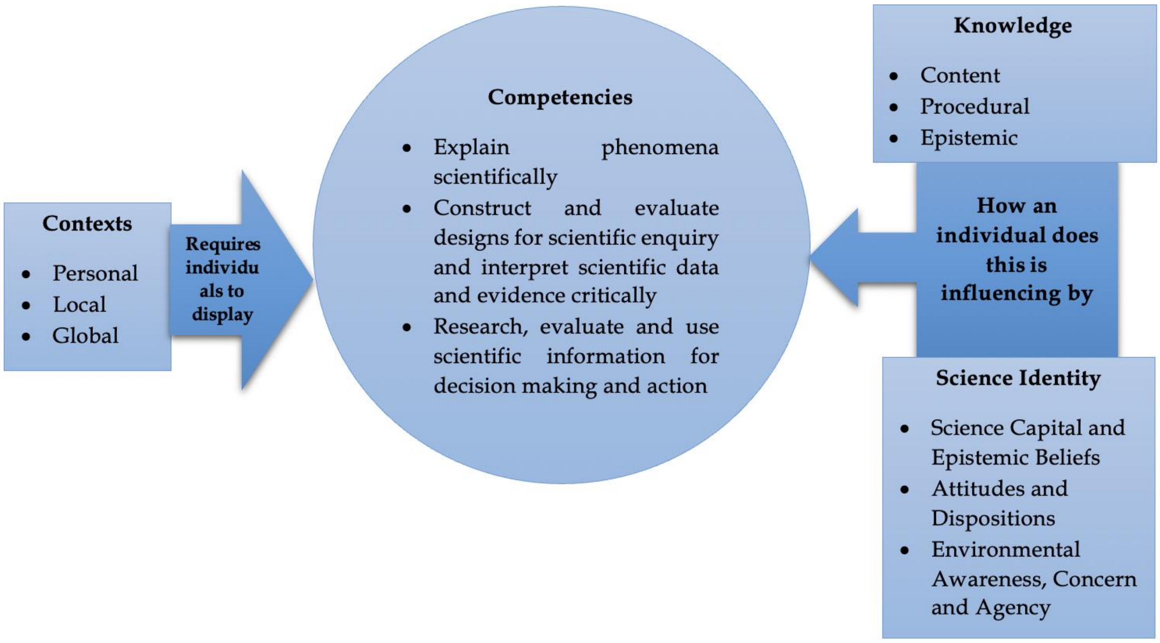

Figure 3. Framework of PISA 2025 (OECD, 2023)

According to Figure 3 of the PISA Framework 2025, the assessment's objective is to prioritize the practical application of scientific knowledge in real-world scenarios, encompassing topics related to Sustainable Development Goals (SDGs). Scientific concepts, ideas, procedures, and strategies are utilized to investigate phenomena related to living organisms, thereby supporting these phenomena (which may be debated within the scientific community). Furthermore, a decision-making skill is introduced in this Framework.

The PISA Framework 2025 comprises four interrelated aspects: contexts, knowledge, competencies, and science identity. The contexts of PISA Framework 2025 are personal, local, and global demands of understanding science and technology. Knowledge (content, procedural, and epistemic) emphasizes understanding scientific knowledge, including natural knowledge and technology, through procedural knowledge based on justification for its use. Three competencies are given to optimize essential elements of science education outcomes. Science identity (science capital and epistemic beliefs; attitudes and dispositions; and environmental awareness, concern, and agency) evaluates the scientific approach to research as an interest in science and technology.

The science literacy in PISA 2025 is determined by three competencies, namely:

1. Explain phenomena scientifically. This competency can be obtained from an understanding of scientific and cultural theory tools that can change the knowledge of nature and better implement the ability to support the explanation of scientific, technological, and environmental phenomena.
2. Construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically. This competency builds students' scientific knowledge to investigate theoretical ideas against observational data sets. Then, the data obtained will be evaluated in the evaluation stage.
3. Research, evaluate, and use scientific information for decision making and action. This competency requires students to possess a combination of procedural and epistemic knowledge while potentially relying on their science content knowledge to different extents.

The transformation of the PISA framework from 2018 to 2025

The primary objective of the scientific literacy assessment in the PISA 2015 is to enhance the understanding that "science knowledge" can be further elucidated and categorized into two distinct types: procedural knowledge and epistemic knowledge. The PISA framework was expanded to incorporate attitude components within science and technology literacy education. OECD proposes that student attitudes can be measured through two distinct methods: questionnaires and tests (OECD, 2019). A disparity was observed in the outcomes obtained from the administered questions and the responses from the background questionnaire about the variable of "interest in science". PISA exclusively employed student questionnaires to evaluate attitude features without using embedded questions. The primary adjustment in terminology necessary to capture the measurement process pertains to evaluating the scientific investigation methodology.

In order to ensure a more consistent heading for the 2025 assessment, the assessment context in PISA 2015 underwent a modification from "Personal, Local/National, and Global" to "Personal, Local, and Global" in the 2025 examination. The PISA Framework 2025 underwent four significant revisions. The initial decision entailed merging the two preexisting components, namely "Evaluate and design scientific inquiry" and "Interpret data and evidence scientifically," into a singular component referred to as "Construct and evaluate the design for scientific inquiry and interpret scientific data and evidence critically." The language modification specifically highlighted the importance of conducting a design review due to the potential involvement of multiple adult participants in the experiment. An adjustment was made due to the perception that including both competencies was essential for inquiry involvement.

Furthermore, the prevalence of online sources of information has undergone a significant transformation within contemporary society. Given the widespread presence of scientific content, there is an increased emphasis on equipping students with the ability to engage in research, critically evaluate, and proficiently employ scientific information to inform decision-making processes and facilitate effective action. Consequently, an additional competency is integrated as the third competency.

The second modification is an adjustment from a definition that focuses mainly on science literacy to a definition that, while covering this idea, is wider. Due to science education, the Framework had previously used the phrase "science literacy." The 2025 framework has removed the time to make sure everything is clear. These changes brought it in line with mathematical and reading frameworks. The third improvement is to evolve the affective factors shaping ability from concentrating on attitudes toward science to assessing the more significant idea of "science identity," that were more comprehensive in describing students' engagement in science. This change is based on research by Pan (Pan et al., 2018) that shows how understanding and exposure to science in society work in tandem with scientific competence to increase interest and contribution.

The fourth section of the paper examines growth scales utilized in evaluating various aspects of human bodies in the context of the Anthropocene epoch and their relevance to sustainability education. The assessment of the level of comprehension and capacity for action regarding environmental issues among fifteen-year-olds, as influenced by their science education, is a pivotal aspect evaluated in the Program for International Student Assessment (PISA) 2025. This study substantiates and elucidates young individuals' need to possess agency within the Anthropocene epoch, wherein they must effectively engage in independent and collaborative efforts to confront forthcoming global challenges.

The fifth change is the importance of decision-making, especially regarding information in the context of science literacy and digital media literacy. The study's results by sarah et al. show that students' ability to evaluate sources could be more vital (McGrew et al., 2018). Supported research by Khondker, which examines the evolution and transformation of the concept of globalization, highlights the relationship between sociology and globalization (Khondker, 2004). Japanese society uses sociological discussions widely of concepts, theories, and developments of the times. According to the idea of cytology, this is one of the foundations that decision-making becomes one of the appropriate and efficient methods.

Moreover, by intentionally emphasizing the fundamental principle of science, the substance of knowledge has been altered to improve its coherence. On the other hand, there has been significant expansion and clarification in procedure and cognitive knowledge domains. In the subsequent section, we will examine the visual representation of the research keyword map about the correlation between Scientific Literacy and Physics Learning.

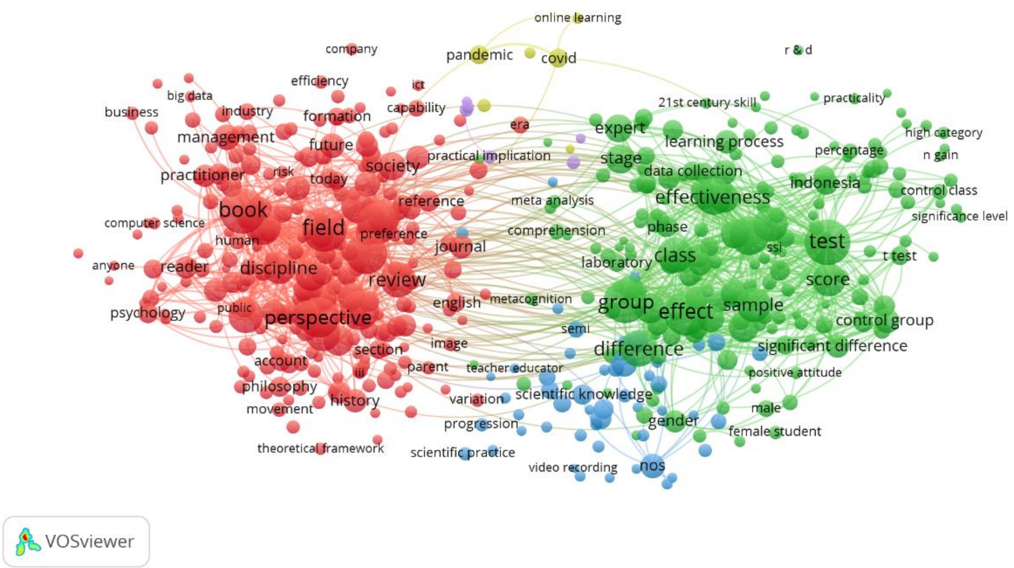

Figure 4. Network Visualization of physics learning oriented scientific literacy

The VOS viewer software analysis, as depicted in Figure 4, yields a comprehensive bibliometric network visualization encompassing various elements such as journals, titles, authors, and publications. The study's findings indicate four distinct clusters, which can be further categorized into two primary clusters (red and green) and two secondary clusters (blue and yellow). The initial cluster, indicated by the color red, pertains to a comprehensive examination of scientific literacy in the context of physics education. The influence on scientific literacy's second cluster (green) includes factors such as the effect, test, class, grade, questioner, and learning process. The third cluster, denoted by the color blue, pertains to the various components of the nature of science as inferred from the analysis of research trend keywords. The yellow cluster represents a pedagogical approach employed amidst the COVID-19 pandemic for educational purposes.

Figure 5 presents a visual representation that centers on the concept of science literacy about the terms book, questionnaire, test, group, example, and nos. Two key attributes of an individual with scientific literacy are the comprehension of scientific concepts or principles and the utilization of logical reasoning when making informed judgments regarding scientific phenomena. The literature indicates that cultivating science literacy in educational institutions is crucial for facilitating the attainment of primary objectives in science education (Deta et al., 2019; Mahtari et al., 2021; Milda et al., 2022).

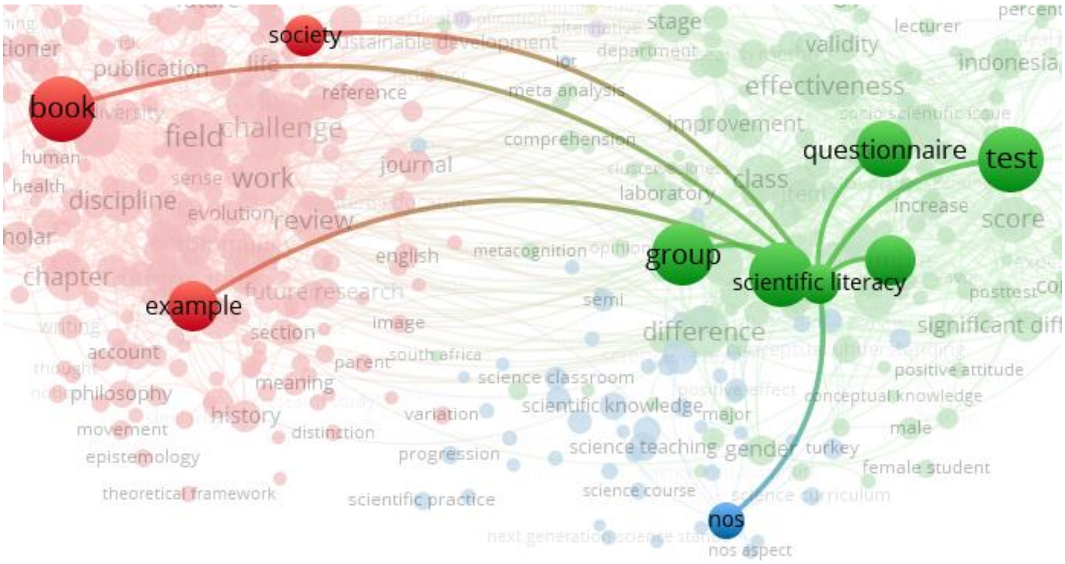

Figure 5. Visualization focusing on the Scientific Literacy keyword

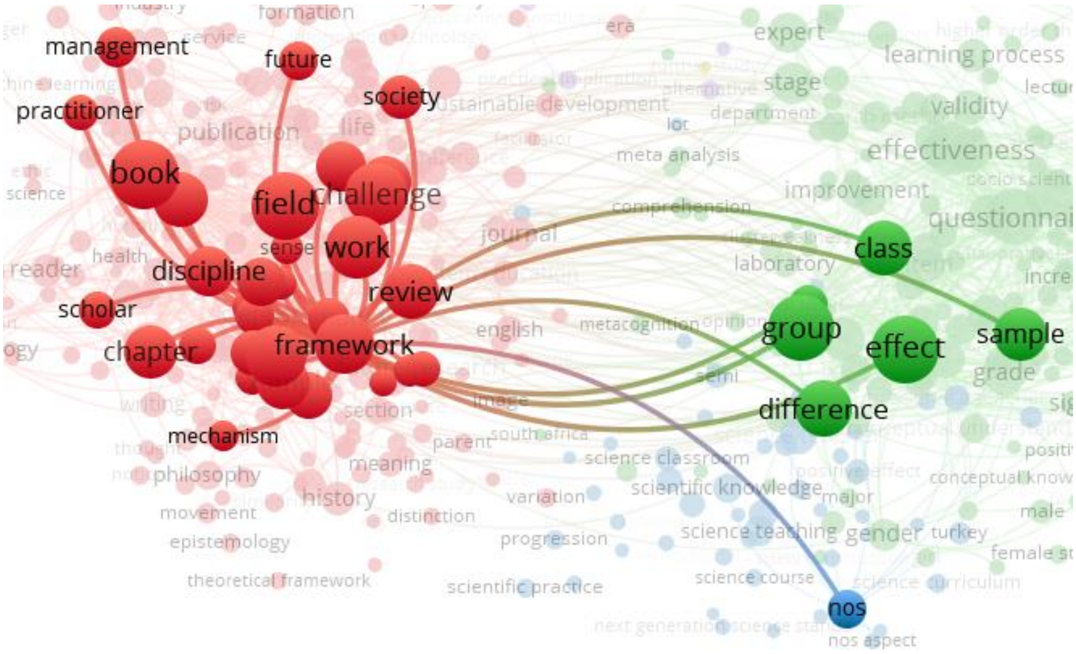

Figure 6. PISA Framework releted with some NOS (nature of science)

The keyword "Nature of science" is also classified within the same cluster as "scientific literacy." This association further signifies the close correlation between the four words. The findings from the map indicate that Scientific Literacy encompasses the epistemological aspects of science, namely its role as a means of acquiring knowledge, as well as the inherent values and beliefs associated with the advancement of scientific inquiry. The significance of comprehending the Nature of Science (NOS) as a fundamental component of Scientific Literacy has been substantiated through Garcia's research (García-Carmona, 2022). The study demonstrates that various facets of NOS comprehension are imperative as they contribute to generating, administering, and manipulating scientific and technological entities.

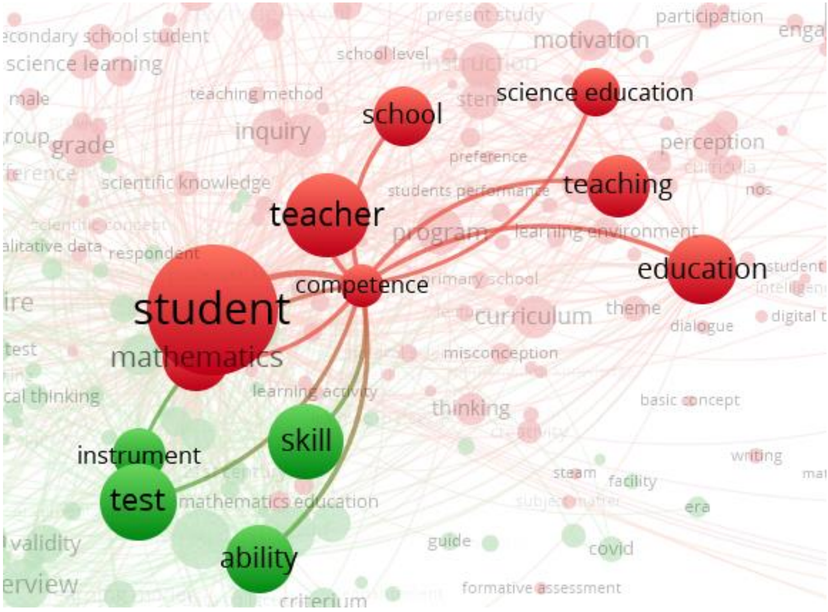

Figure 7. The relationship science competence

The research conducted by Wuryanto in 2022 examined the PISA results as a learning innovation strategy for enhancing literacy and numeracy skills. The PISA test evaluates the proficiency of 15-year-olds in terms of their mastery of skills and knowledge necessary for active engagement in contemporary society. According to the Organisation for Economic Cooperation and Development (OECD) in 2023, in defining the concept of PISA 2025 in terms of science education outcomes, four interconnected elements are considered: context, knowledge, competence, and identity of science. These aspects are depicted in Figure 7, which presents the bibliometric findings obtained through VOS Viewer. The Programme for International Student Assessment (PISA) strongly correlates with various factors encompassing students, teachers, schools, science education, assessment instruments, tests, skills, abilities, teaching practices, and educational systems.

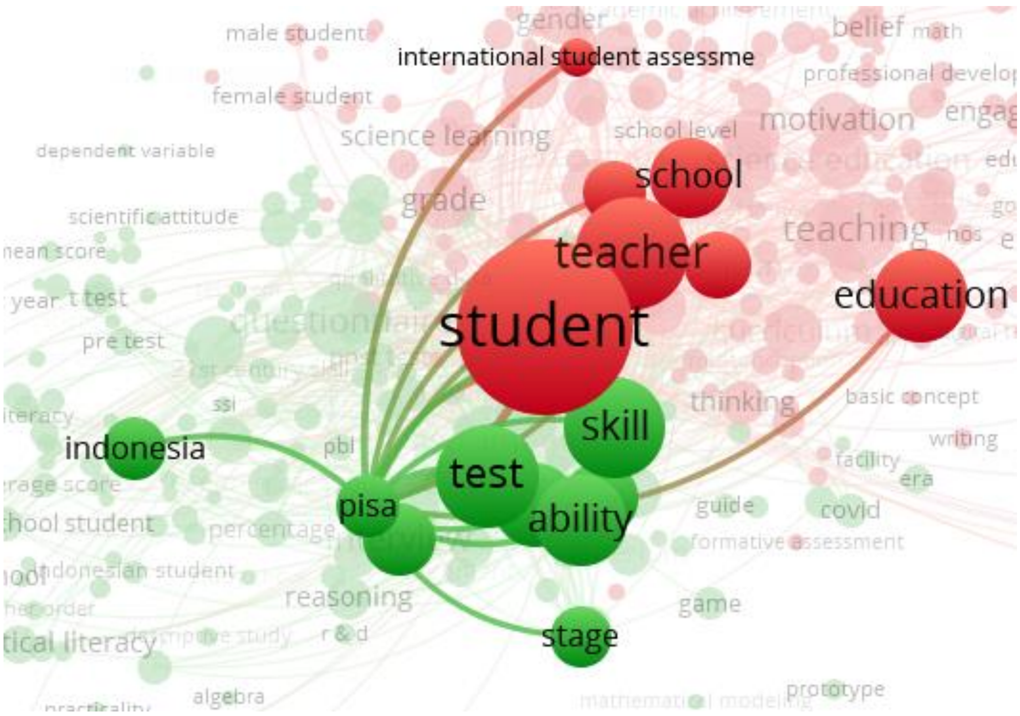

Figure 8. Visualization focusing on the PISA word word

According to a study conducted by White (White et al., 2023), the primary emphasis in the forthcoming Program for International Student Assessment (PISA) 2025 will be on evaluating the degree to which 15-year-old students possess knowledge, demonstrate concern, and exhibit proactive behavior toward environmental concerns as a consequence of their science education. When employing a VOS viewer that utilizes documents, abstracts, titles, and keywords, it becomes apparent that the proficiencies required by contemporary youth to address local and global obstacles effectively encompass the ability to operate autonomously and collaboratively while comprehending diverse perspectives to foster an improved future.

Physics education is significantly affected by the PISA 2025 framework, focusing on students' ability to make decisions in particular. PISA Framework 2025 attempts to assess and strengthen students' capacity to use their knowledge and skills to solve issues in the real world (OECD, 2023). The emphasis on evaluating students' capacity for decision-making in challenging real-world scenarios is one of the major adjustments made by PISA 2025 (Marconi et al., 2020). This change recognizes that students must use their understanding of physics principles effectively to solve issues and reach choices (Bell et al., 2018). The curriculum for physics classes will need to change to reflect the new focus by including more assignments that require decision-making and problem-solving (Jose et al.,2011). This framework implies that in physics education, students will be evaluated on their understanding of fundamental physics principles and their capacity to act rationally in the context of those principles (Hestenes, 1987; Redish, 2004).

Making decisions allows students to apply their theoretical knowledge to real-life situations, an essential aspect of studying physics. Even daily, people frequently have to make many easy decisions. Decision-making is the bridge that connects theory to practice, enabling students to navigate the intricate web of natural phenomena that physics seeks to explain (Wolf et al., 2022). As students engage in decision-making tasks within the realm of physics, they deepen their understanding and prepare themselves for a future where the ability to analyze, evaluate, and decide is invaluable (Hariyono et al., 2018). It includes making decisions by thoroughly assessing information, using scientific reasoning, and using their evaluation to decide how to set goals to bring about change and take responsible action (Coffay et al., 2022).

In various fields, from engineering to environmental science, physics concepts, and principles are frequently used in real-world situations (Astalini et al., 2022). Students are better prepared for careers in STEM professions and are better ready to handle challenging situations when they can make judgments based on their understanding of physics (Choueiri & Choueiri, 2023). The concentration on decision-making in the PISA 2025 framework highlights the belief that physics education should go beyond rote recall of formulas and ideas (OECD, 2023). Students should be given the tools to examine issues, look for answers, and make wise decisions (Wise & Jung, 2019). This method improves their problem-solving abilities and encourages a deeper comprehension of the material.

Conclusion

Science will be the primary dominant in the PISA 2025 definition, building and developing the PISA 2015 definition, expanding competencies, and clarifying the necessary ideas and knowledge. As a result, the 2015 framework combined two competencies, namely, evaluating and designing scientific enquiry and interpreting data and evidence scientifically, into one while additionally including a third new competency: Research, evaluate, and use scientific information for decision-making and action. All competencies and the ideas of procedural and epistemic knowledge presented in 2015 have been further developed. Additionally, the 2025 framework has developed the required conceptualizations of cognitive aspects of items that give good direction to item authors to produce more items that fall at the opposite end of the cognitive ability continuum. As a result, the PISA 2025 framework is an evolution of science literacy and a reaction to the current environment, which increasingly emphasizes assessing and applying scientific information. The Framework implies that in physics education, students will be evaluated on their understanding of fundamental physics principles and their capacity to act rationally in the context of those principles. As well as expanding upon and developing some of the key concepts present in the prior Framework.

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