Ed Process Int J

www.edupij.com

ISSN 2147-0901 (Print), 2564-8020 (Online)

EDUCATIONAL PROCESS INTERNATIONAL JOURNAL

Research Article

Cite this article: Lotfi, F. Z., Suwartono, T., Maziane, B., Nurhayati, S., Laajan, Y., & Nachit, B. (2025). Collaborative Concept Maps in Higher Education: Pedagogical Contributions, Cognitive Challenges, and Optimization Strategies for Interactive Visual Learning. *Educational Process: International Journal, 14*, e2025085. https://doi.org/10.22521/edupij.2025.14.85

Received January 15, 2025
Accepted March 7, 2025
Published Online March 12, 2025

Keywords: Collaborative, concept map, higher education, pedagogical, challenges, learning

Author for correspondence:
Tono Suwartono
suwartononewton@gmail.com
Universitas Muhammadiyah Purwokerto, Purwokerto, Central Java, Indonesia

Collaborative Concept Maps in Higher Education: Pedagogical Contributions, Cognitive Challenges, and Optimization Strategies for Interactive Visual Learning

Fatima Zahra Lotfi, Tono Suwartono, Brahim Maziane, Sri Nurhayati, Youssef Laajan, Brahim Nachit

Abstract

Background/purpose. Collaborative concept maps (CCMs) stand out for their ability to organize knowledge and enhance retention. However, their use in higher education raises questions about their effectiveness. This study aims to evaluate the effect of CCMs on learning of students enrolled in the Master's program in Training and Supervision Professions in Morocco, identify the challenges they faced during the creation of these maps, and propose improvements aimed at optimizing the use of these tools in higher education.

Materials/methods. The study involves 60 students divided into two modules, "Work Psychology" and "Andragogy." Organized into small groups, the participants designed concept maps throughout the semester, using course materials and recommended scientific articles. Data were collected at the end of the semester through a questionnaire that included Likert-scale items and open-ended questions. The results were analyzed using descriptive statistics and thematic analysis, respectively.

Results. CCMs proved to be effective in fostering creativity, enhancing critical thinking, and improving knowledge retention. However, certain limitations were identified, including cognitive overload related to organizing complex information and interpretive divergences within groups, which slowed down the collaborative process. Additionally, technical and organizational challenges, such as a lack of digital skills and coordination difficulties, were also noted. These limitations occasionally hindered the effectiveness of collaborative dynamics and the achievement of learning objectives.

Conclusion. CCMs are an innovative teaching-learning tool that promotes interactivity among learners. By overcoming identified challenges and implementing recommended strategies, these maps effectively achieve a variety of educational objectives.

1. Introduction

The integration of collaborative concept maps (henceforth abbreviated as CCMs) in higher education has garnered significant interest due to their potential to enhance students' learning processes. In an era where teaching approaches must adapt to the demands of a digital and collaborative world, these tools provide an opportunity to transform learning into an active and interactive experience. They foster the development of transversal skills, such as collaboration and critical thinking, while encouraging systematic engagement with academic content.

CCMs differ from traditional concept maps by emphasizing collaboration among learners, where knowledge is co-constructed through group interactions. This collaborative aspect positions CCMs as valuable tools in higher education, where active learning and teamwork are increasingly prioritized. Despite their growing popularity, questions remain about their effective implementation in diverse academic contexts.

While prior studies have established the benefits of concept maps in improving understanding, retention, and critical thinking (Cañas et al., 2023; Novak & Gowin, 1984), the specific dynamics of collaborative use, including their eventual limitations, have been less explored. This gap highlights the need for further investigation into how CCMs can be effectively utilized to maximize learning outcomes in higher education.

This research seeks to explore the role of CCMs in enhancing students' learning experiences by analyzing their benefits and the obstacles to their use, as perceived by students, and identifying practical strategies for their optimal implementation. By bridging gaps in existing literature, this study aims to provide actionable recommendations to support educators in leveraging CCMs to foster meaningful learning and skill development in university settings.

2. Literature Review

2.1. Nature of a Concept Map

Concept maps are widely recognized as effective tools for the organization and visualization of knowledge. They serve as visual aids that illustrate the relationships between concepts, allowing learners to better structure their understanding and navigate complex information (Ausubel, 2000; Novak & Cañas, 2008). Concept maps provide a comprehensive overview of a subject by graphically representing connections among ideas, fostering clarity and systematic thinking (Eppler, 2006).

At their core, concept maps consist of two primary elements: nodes, which symbolize specific concepts, and links, which indicate the relationships between these concepts. These links may be directional or non-directional and can include labels to define the nature of the relationships. This structure facilitates a clear and organized representation of interconnected ideas, enhancing learners' ability to grasp and retain knowledge (Cañas et al., 2023; Novak & Gowin, 1984).

The design and layout of concept maps are adaptable to different educational contexts and learning objectives. Formats such as hierarchical, network, spider web, radial, and tabular arrangements are commonly used. For instance, hierarchical maps progress from general to specific information, while spider web maps radiate from a central theme. Selecting an appropriate format—or combining formats—can maximize the utility of concept maps for diverse educational purposes (Hartsell, 2021).

In modern educational practices, concept maps can be created either manually or digitally, each approach offering distinct advantages and use cases. Manual concept maps, crafted with paper and markers, provide a hands-on experience that encourages reflection and creativity, making them particularly suitable for brainstorming sessions and environments with limited access to technology (Novak & Gowin, 1984).

https://doi.org/10.22521/edupij.2025.14.85 Published online by Universitepark Press

On the other hand, digital concept mapping tools enhance functionality through features such as real-time collaboration, integration of multimedia elements, and dynamic reorganization of ideas. Applications like CmapTools, MindMeister, Lucidchart, and XMind allow learners to create visually appealing and easily modifiable maps that can incorporate hyperlinks, videos, and images to deepen understanding (Farrokhnia et al., 2019; Molinari, 2017). These tools are especially valuable in collaborative or hybrid learning contexts, enabling geographically dispersed participants to co-construct knowledge effectively.

Additionally, some platforms, such as Miro and Concept board, offer advanced options like simultaneous editing and activity tracking, fostering a more interactive and engaging learning environment. By combining the tactile benefits of manual creation with the technological advancements of digital tools, educators can select the most appropriate medium to suit their objectives and learners' needs, thereby maximizing the pedagogical potential of concept maps.

While primarily employed in educational settings ranging from elementary education to advanced professional training, concept maps are versatile tools that transcend individual contexts. They promote meaningful learning by helping students integrate new knowledge into their existing cognitive frameworks. This structured approach to knowledge visualization makes concept maps particularly valuable for both individual study and collaborative learning environments (Hartsell, 2021; Novak, 2002).

2.2. Use of Concept Maps in Teaching and Learning

Concept maps are powerful pedagogical tools that offer a structured approach to organizing ideas, visualizing relationships, and promoting long-term knowledge retention. Novak and Cañas (2008) emphasize that concept maps enable the visualization of conceptual relationships, enhancing both the retention and organization of information. This process facilitates meaningful learning by integrating new ideas into existing cognitive frameworks, ensuring that knowledge is contextualized and interconnected rather than arbitrarily memorized (Horton et al., 1993).

Additionally, concept maps are highly effective tools for retrieval practice. Blunt and Karpicke (2014) demonstrate that the active recall required when creating a concept map strengthens memory pathways, significantly improving both knowledge retention and application. By combining the visualization of relationships with active cognitive engagement, concept maps provide a robust framework for enhancing learning outcomes (Blunt & Karpicke, 2014; Novak & Cañas, 2008).

Beyond enhancing retention, concept maps promote active learning by encouraging students to directly engage with the content through creating, modifying, and visualizing links between concepts (Schroeder et al., 2018; Thompson & Pugh-Bernard, 2020). Hartsell (2021) highlights their ability to boost student engagement by transforming passive learning experiences into dynamic, interactive processes. This engagement fosters a deeper understanding of complex subjects and helps students effectively structure their knowledge (Nesbit & Adesope, 2006). Research has also shown that concept maps are significantly more effective in improving learning capacities than passive strategies like highlighting or rereading due to their active and constructive nature (Woods & Beye, 2020).

Concept maps are also valuable assessment tools. They provide teachers with a clear visual representation of students' cognitive structures, enabling the evaluation of understanding before and after instruction (Horton et al., 1993). Moreover, they encourage self-assessment by helping learners identify gaps in their knowledge and take active steps to address them (Thompson & Pugh-Bernard, 2020).

Concept maps further enhance teaching quality by transforming abstract ideas into concrete visual representations, making complex information more accessible (Hay et al., 2008). This ability to simplify and clarify concepts is particularly beneficial in higher education, where learners often

https://doi.org/10.22521/edupij.2025.14.85 Published online by Universitepark Press

encounter abstract and interdisciplinary materials. Integrating concept maps into teaching strategies also fosters collaboration and creativity, further enriching the teaching-learning experience (Hartsell, 2021).

Concept maps are graphical representations that illustrate the relationships between concepts, enabling learners to visualize and structure their knowledge. Leung and Cheng (2018) highlight that concept maps serve as a direct means to analyze the structure of a student's knowledge, allowing for the measurement of declarative knowledge and the representation of unique learning experiences. This aligns with the findings of Wang et al. (2018), who assert that concept mapping supports understanding and communication of complex ideas, fostering effective cognitive processes by organizing knowledge into a schematic structure. The hierarchical nature of concept maps, as discussed by Demirci and Memiş (2021), further emphasizes their role in illustrating inter-conceptual relationships, which is crucial for cognitive organization.

The effectiveness of concept mapping as an educational strategy is well-documented. Alharbi's research (2024) indicates that concept mapping enhances comprehension and critical thinking, particularly in digital concepts, suggesting its value in promoting systemic thinking and long-term retention of information. Similarly, Dahal (2024) emphasizes the transformative potential of concept mapping in physics education, noting its ability to enhance student achievements across cognitive domains. This is corroborated by Chevan et al. (2023), who demonstrate that concept mapping can effectively explore and describe relationships in health informatics education, thereby guiding discussions and evolving understanding. Moreover, the application of concept maps extends beyond traditional subjects. For instance, Latif and Nor (2020) propose that concept mapping can replace conventional nursing processes, enhancing clinical experiences for nursing students. This is echoed by Yarmohammadi et al. (2023), who found that concept mapping improved learning outcomes and satisfaction among midwifery students, indicating its versatility across different fields of study. As highlighted by Chang et al. (2022), the integration of concept maps in technology-enhanced learning environments further illustrates their adaptability and effectiveness in K-12 education.

The pedagogical benefits of concept mapping are also supported by its ability to identify misconceptions and facilitate meaningful learning. Aşıksoy (2019) notes that concept mapping is instrumental in addressing misconceptions and enhancing concept learning, particularly in technology-enhanced educational settings. Furthermore, research by Mottian et al. (2022) indicates that concept maps can effectively represent complex concepts in nursing education, enhancing understanding and retention. Concept mapping is a multifaceted educational strategy that enhances knowledge organization, comprehension, and critical thinking across various disciplines. Its graphical representation of concepts and their interrelations not only aids in learning but also fosters deeper cognitive engagement. The diverse applications of concept mapping in fields ranging from health informatics to physics and nursing education underscore its significance as a versatile pedagogical tool.

2.3. Collaborative Concept Maps (CCMs)

CCMs extend the benefits of individual mapping by incorporating the dynamics of group interaction. Studies highlight their positive impact on knowledge co-construction and group dynamics, as they encourage teamwork, creativity, and critical discussion (Eppler, 2006; Morita et al., 2021; Novak & Cañas, 2008). Allowing multiple participants to contribute to a shared visual representation stimulates idea exchange, enhances social skills, and fosters creativity (Molinari, 2017). This collaborative process not only deepens individual understanding but also promotes collective intellectual growth as students challenge and refine each other's contributions (Thompson & Pugh-Bernard, 2020).

The integration of digital tools into collaborative concept mapping has further enhanced its accessibility and functionalities. Features such as real-time updates, instant feedback, and remote collaboration enable learners to more easily incorporate diverse perspectives, dynamically modify their work, and track the evolution of their ideas (Dillenbourg, 1999). These technological advancements provide an inclusive and interactive platform, particularly useful in online or hybrid learning environments.

The analysis of educational networks based on concept maps shows that these tools can predict learners' understanding by comparing their contributions to a collective network of comprehension. Network metrics applied to CCMs yield stronger correlations with learner performance than traditional metrics (Freedman et al., 2024). When used in online environments, CCMs facilitate group interaction, especially in concept-oriented tasks. However, they are less effective for design-oriented tasks (Wang et al., 2018).

An individual preparation phase prior to collaborative work improves the epistemic and social processes of knowledge co-construction. This fosters verification, clarification, and consensus-building oriented towards integration (Tan et al., 2021). Moreover, students with a high perception of collaboration demonstrate better conceptual understanding and more diverse behavioral sequences during collaborative concept mapping activities (Liu et al., 2021). However, they may encounter challenges in integrating their individual contributions into a group concept map. The "reciprocal kit-build" (RKB) approach helps externalize ideas and understand partners' perspectives, although practical limitations remain (Sadita et al., 2020).

In collaborative contexts, concept maps act as a bridge between individual learning and group engagement, combining the cognitive benefits of visualization with the social advantages of teamwork. Novak (2002) and Molinari (2017) emphasize how this dual functionality makes CCMs a versatile tool for fostering deeper understanding in various educational contexts. Their adaptability and potential for dynamic interaction make them particularly effective in addressing complex interdisciplinary challenges and promoting meaningful group discussions (Eppler, 2006).

One of the primary advantages of collaborative concept mapping is its ability to foster deeper understanding through peer interaction. The effectiveness of the Reciprocal Kit-Build (RKB) approach, which supports collaborative knowledge construction in subjects like linear algebra, demonstrating that structured collaborative activities can enhance learning outcomes significantly (Sadita et al., 2020). Similarly, Tan et al. (2021) emphasize the importance of individual preparation phases before collaborative mapping, allowing students to develop their mental representations before sharing them, thereby enhancing the collaborative process through peer scaffolding. This scaffolding is crucial as it enables learners to articulate their understanding and engage in meaningful discussions, leading to improved comprehension and retention of knowledge (Sadita et al., 2020).

The role of technology in facilitating collaborative concept mapping cannot be overstated. Shih and Chang (Shih & Chang, 2020) discuss how technology has transformed concept mapping from an individual to a collaborative activity, allowing for enhanced student engagement and motivation. Furthermore, Ouyang and Xu's (2021) study on different instructor participatory roles in online collaborative concept mapping illustrates how varied instructional scaffolding can influence the effectiveness of collaboration, thereby enhancing students' problem-solving and knowledge-construction skills. This aligns with findings from Farrokhnia et al. (2019) who assert that computer-supported collaborative concept mapping significantly contributes to conceptual understanding and knowledge co-construction. Moreover, the impact of collaborative concept mapping extends beyond mere knowledge acquisition; it also enhances critical thinking skills. CCMs can improve students' critical thinking abilities in science education, suggesting that the process of collaboratively constructing concept maps encourages deeper cognitive engagement with the material (Aziz &

Halim, 2019). This is further supported by the work of Zandvakili et al. (2019), who propose a model that integrates concept maps with critical thinking and collaboration, highlighting the interconnectedness of these educational practices.

In addition to cognitive benefits, collaborative concept mapping has been shown to positively affect students' attitudes towards learning. Engaging in collaborative mapping activities not only improved academic performance but also increased group motivation and individual responsibility for learning (Sadita et al., 2020). This sentiment is echoed in the work of Lailiyah and Yustisia (2022) who note that the collaborative nature of concept mapping fosters a sense of satisfaction and engagement among students in vocational education settings. Collaborative concept mapping serves as a multifaceted educational strategy that enhances knowledge construction, critical thinking, and student engagement. The integration of technology and structured collaborative approaches, such as the RKB method, further amplifies its effectiveness in various educational contexts. Future research should continue to explore the nuances of collaborative concept mapping, particularly in diverse learning environments and across different subject areas. The current study seeks answers to the following questions:

1. To what extent do CCMs impact student learning in higher education?
2. What are the main cognitive, technical, or organizational challenges faced by students when creating CCMs in an academic context?
3. What pedagogical and methodological interventions can be proposed to enhance the effectiveness and adoption of CCMs in higher education?

3. Methodology

3.1. Study design

This study employs a mixed-methods approach, combining quantitative and qualitative data to explore the use of collaborative concept maps (CCMs) in a master's program. The primary objective is to evaluate the impact of CCMs on learning, identify the challenges faced by students, and propose improvements to optimize their use.

3.2. Participants

The study was conducted with 60 students enrolled in the master's program "Professions in Education and Supervision" at the Higher Normal School of Casablanca, Morocco. The participants included 50 women and 10 men, divided into 37 first-year students and 23 second-year students.

3.3. Data collection tools

Data were collected using a single questionnaire structured into several sections, including Likert-scale (quantitative) and open-ended (qualitative) questions. Below is a detailed description of the questionnaire sections:

Perception of the effectiveness of Concept Maps

This section aimed to assess students' perceptions of the effectiveness of CCMs in their learning. It included 5-point Likert-scale questions (1 = Strongly Disagree, 5 = Strongly Agree) addressing the following aspects:

- Stimulation of creativity.
- Encouragement of reflection.
- Improvement of information retention.
- Facilitation of understanding complex scientific articles.

Intention to use Concept Maps in other subjects

This section evaluated whether students intended to use CCMs in other disciplines. It included:

- A closed-ended question measured on a 5-point Likert scale: "Do you intend to use concept maps in other subjects?"

- An open-ended question to explore the underlying reasons for their intentions: "Why do you think concept maps are (or are not) suitable for other subjects?"

Challenges encountered in creating CCMs

This section aimed to identify the challenges students faced when creating CCMs. It was entirely qualitative and included open-ended questions to gather detailed feedback on the obstacles encountered.

Suggestions for improvement

This section invited participants to propose improvements to optimize the use of CCMs. It was also qualitative and included open-ended questions to collect concrete suggestions.

3.4. Validity of data collection tools

A panel of 3 experts in pedagogy and research methods reviewed the questionnaire to assess its relevance and alignment with the study's objectives. The experts confirmed that the questions adequately covered the study's key dimensions (effectiveness of CCMs, challenges encountered, and suggestions for improvement).

3.5. Data collection procedure and analysis

The questionnaires were distributed to participants at the end of the semester after they had completed the creation and presentation of their CCMs.

- Quantitative responses were analyzed using descriptive statistics, i.e. percentages, means, standard deviations (Suwartono,2014).

- Qualitative responses were subjected to thematic content analysis, highlighting recurring trends and improvement proposals suggested by students.

3.6. Ethical considerations

The study was conducted in accordance with the ethical principles of educational research. Participants were informed in advance about the study's objectives and procedures, and their free and informed consent was obtained prior to data collection. Anonymity and confidentiality of responses were guaranteed, in compliance with ethical and regulatory standards.

The study adhered to the ethical guidelines of Hassan II University of Casablanca, ensuring the protection of participants' rights and the collected data. Since the research did not involve experimental interventions or sensitive data collection, formal approval by an ethics committee was not required. Nevertheless, all methodological and ethical precautions were taken to ensure scientific integrity and transparency in the study.

4. Results

4.1. Effectiveness of concept maps

The first part of the questionnaire aimed to gather students' perceptions of the effectiveness of concept maps in relation to learning (Figure 1).

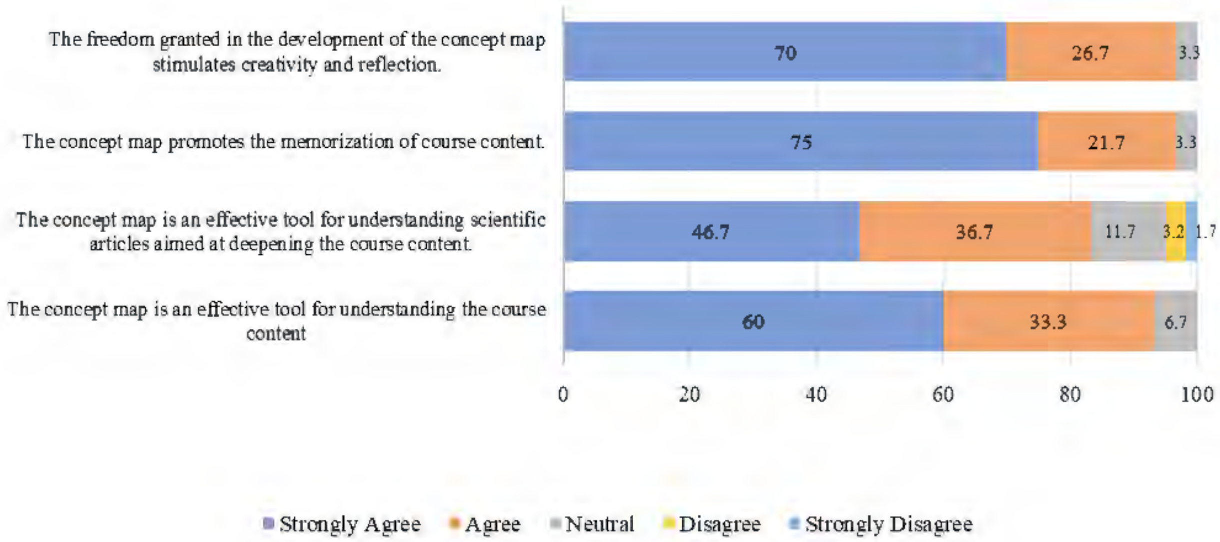

Figure 1. Students' perception of the effectiveness of concept maps in learning (%)

The graph reveals that concept maps are widely perceived as an effective tool for stimulating creativity, encouraging reflection, and enhancing memory retention. Over 70% of participants "strongly agree" with these statements, indicating that most students appreciate the flexibility and visual organization provided by this tool.

However, the effectiveness of concept maps in understanding complex scientific articles is less unanimously recognized, with 46.7% of participants "strongly agreeing." This suggests that concept maps are seen as useful for structuring ideas in simpler educational contexts, but they show limitations when dealing with more dense and technical content.

Thus, while concept maps are a powerful learning tool, they seem better suited for simpler or intermediate content and may require adjustments to be fully effective in more complex academic contexts.

4.2. Students' intention to use concept maps in other subjects

Regarding students' intention to use concept maps in other subjects, the responses appear to vary based on individual opinions and experiences. However, the general trend leans toward a positive attitude in favor of using concept maps across different subjects (Figure 2).

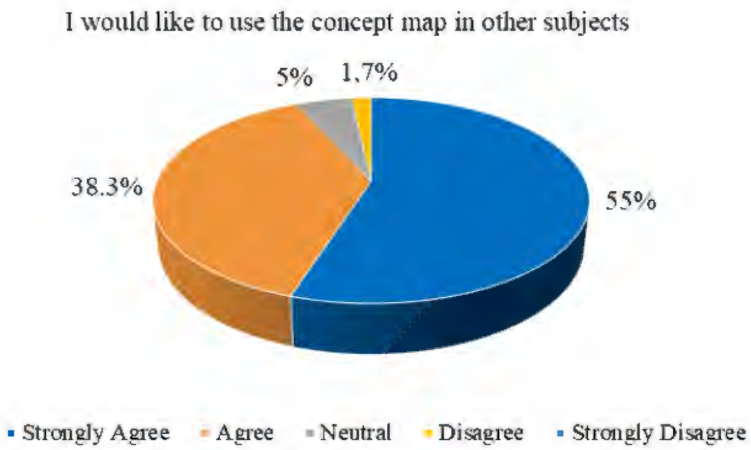

Figure 2. Students' intention to use Concept Maps in other subjects (%)

https://doi.org/10.22521/edupij.2025.14.85 Published online by Universitepark Press

The graph shows that 55% of participants "strongly agree" with the idea of using concept maps in other subjects, while 38.3% "agree" with this idea. However, qualitative responses provide a more nuanced view of this generally positive trend.

Conditional acceptance depending on the subject matter

Although the majority of respondents are in favor of using concept maps in other disciplines, some express reservations. Several participants highlight that the effectiveness of this tool depends on the nature of the subject. For instance, subjects requiring written syntheses or complex article analyses may not be well-suited for concept maps, as they demand more in-depth information processing. As one participant noted, "It depends on the nature of the subject; some require written summaries."

Variety of learning styles

Qualitative responses also reveal that some students feel that concept maps do not align with their learning style. While these participants are in the minority (as shown by the low percentage of negative responses in the graph), they prefer alternative visual learning methods, such as text-based formats. One comment illustrates this hesitation: "I prefer other methods of visual organization..."

Perceived limitations of Concept Maps

Some participants expressed doubts about the effectiveness of concept maps for deep learning. While the tool is seen as useful for summarizing main ideas, it may lack depth for more theoretical or complex subjects. One participant summarized this by stating, "It doesn't ensure deep learning, it just emphasizes the main ideas to remember..." This point underscores that concept maps are perceived as an effective tool for general idea structuring but may require supplementation to address more complex details.

4.3. Difficulties related to the creation of CCMs

Participants' responses revealed several challenges encountered during the creation of CCMs. These difficulties can be categorized into several key themes (see Table 1).

https://doi.org/10.22521/edupij.2025.14.85 Published online by Universitepark Press

Table 1. Summary of challenges encountered in the creation of CCMs

Theme	Details of the difficulties	Examples of participants' responses
Information overload	Difficulty in selecting the most relevant concepts due to the large amount of information to integrate, sometimes leading to cognitive overload.	*"It was hard to know which concepts to include, and it made the process longer and more confusing."* *"It felt overwhelming to sort through all the data..."*
Differences in understanding	Divergences in understanding the concepts among group members led to disagreements about what to include in the map, slowing down the process.	*"We had trouble agreeing on which concepts to include because everyone had a different perception..."* *"Each person had their own perspective, and it was difficult to find common ground..."* *"Our discussions took too much time because we couldn't agree on the key concepts."*
Time and organizational issues	Difficulty coordinating among group members, managing time, and distributing tasks, which delayed the creation of the map.	*"It was hard to find times when everyone was available, and coordinating tasks wasn't always easy."*
Technical skills and use of ICT	Difficulty using digital tools required for the creation of concept maps, especially for those with limited technical skills.	*"Some of us weren't comfortable with the digital tools, which made the process more complicated..."* *"I wasn't familiar with the software, so I had to ask for help frequently."* *"Learning how to use the tools slowed us down a lot..."*
Differences in design strategies	Diverging strategies among group members for designing the maps, causing tension and extended discussions about the best way to organize the information.	*"Our approaches were different, and it took a long time to find a compromise on how to structure the map..."* *"One person wanted a linear design, while others wanted a more creative layout, which led to conflicts..."*
Complexity of concepts to represent	Difficulty visually representing abstract and complex concepts, particularly those from scientific articles.	*"The concepts were too abstract, which made their representation in a concept map quite complex."* *"We struggled to simplify complex ideas without losing their meaning."*

4.4. Improvement suggestions

Participants' recommendations offer various ways to optimize the use of CCMs. These suggestions aim to improve the creation process, collaboration, training, and the integration of these tools into teaching.

Creation of the Concept Map

Participants proposed several improvements to make the creation process more efficient and accessible (see Table 2).

Table 2. Suggestions for improving the creation of CCMs

Theme	Details of suggestions	Examples of participants' responses
Simplification of maps	Reducing the complexity of the maps for better understanding.	*"We sometimes included too much information, making the maps difficult to understand. A simple approach would be more effective."*
Progressive creation	Adopting an iterative approach where maps are built step by step as new concepts are assimilated.	*"It would be more useful to build the maps progressively as we assimilate new concepts..."*
Use of appropriate software	Selecting digital tools that better support information organization and structuring.	*"Using simpler and more suitable software would make the map construction easier and allow for better information structuring."*
Use of colors, icons, and keywords	Incorporating graphic elements such as colors, icons, and keywords to facilitate visualization and distinction of concepts.	*"Colors and icons make the map more readable and help better organize ideas..."*

Collaboration and communication

To foster better collaboration, participants suggested the following solutions (see Table 3).

Table 3. Suggestions for improving collaboration and communication in Concept Map creation

Theme	Details of suggestions	Examples of participants' responses
Using maps as a collaborative tool	Promoting discussion and co-construction of knowledge using the maps as a medium for dialogue.	*"The maps should be a tool to promote discussions and ensure that everyone contributes to collective learning..."*
Individual work before collaboration	Encouraging individual reflection before group work to enhance contributions.	*"Starting with individual work on the maps and then merging them in groups would be a better approach..."*
Thoughtful selection of group members	Creating groups with a balanced mix of skills and engagement levels to ensure effective collaboration.	*"It's important to carefully choose group members so that everyone is engaged and contributes."*
Equal task distribution	Ensuring that tasks are evenly distributed among group members to foster collaboration and avoid conflicts.	*"If everyone has a clear role, it helps avoid conflicts and work more efficiently..."*
Encouraging interaction	Promoting discussions and debates to enrich the quality of the collaborative work and the maps themselves.	*"...Discussions around the maps helped us better understand the concepts by comparing our ideas..."*
Managing diverging opinions	Adopting a constructive approach to resolve disagreements or conflicts over what content should be included in the maps.	*"...We sometimes had disagreements, but constructive discussions allowed us to reach consensus on the concepts to include..."*

Training and guidance

According to participants, continuous training is essential to maximize the effectiveness of concept maps. They addressed the following points (see Table 4).

Table 4. Suggestions for improving training and guidance in Concept Map creation

Theme	Details of suggestions	Examples of participants' responses
Establishing the research framework	Clearly defining objectives before starting the concept map creation process to ensure relevance.	"*It would be helpful to define clear objectives from the start so we know what to include in the map*."
Guidance throughout the process	Providing regular guidance and support to assist participants at each stage of map creation.	"*We sometimes needed more regular guidance to help us through the creation of the maps*..."
Pre-training on digital tools	Ensuring that participants are proficient with the digital tools required for creating concept maps before starting the project.	"*Training on the software before starting would have allowed us to work more efficiently*..."
Guidance on essential points	Offering clear instructions on the key elements that should be included in the maps to ensure they are relevant and focused.	"*Knowing which concepts were essential to include would have made the map more relevant and less cluttered*..."
Offering digital resources	Recommending appropriate software or platforms that facilitate the creation of concept maps effectively.	"*Recommendations on effective digital tools would have been very helpful*."

5. Discussion

The results of this research demonstrate that CCMs are perceived as effective tools, particularly for stimulating creativity, encouraging reflection, and enhancing memory retention. These findings align with research highlighting CCMs' ability to foster cognitive engagement and reflective thinking, such as Novak and Gowin (1984) and Bordunos et al. (2024). However, their perceived effectiveness appears to decrease when applied to complex academic content, such as scientific articles, with only 46.7% of participants considering them fully suitable. This suggests that CCMs may be better adapted to simpler or intermediate content, where cognitive demands are less intense. Such perceptions echo Novak and Gowin's (1984) findings on the utility of concept maps in organizing and visualizing less dense information.

Interestingly, the perception expressed by some participants contrasts with the literature, which underscores the potential of CCMs to facilitate the comprehension of complex materials. Hartsell (2021) highlights their ability to transform passive learning experiences into dynamic and interactive processes, thereby fostering deeper engagement and understanding of intricate subjects. Furthermore, Nesbit and Adesope (2006) emphasize that concept maps are powerful tools for structuring dense information and supporting knowledge retention in challenging academic contexts. These discrepancies suggest that the perceived limitations of CCMs by participants could stem from factors unrelated to the tool itself, such as insufficient training, inadequate implementation strategies, or the lack of cognitive scaffolding during the mapping process.

While most participants expressed a positive intention to use CCMs in other subjects, some noted that their effectiveness depends heavily on the nature of the subject. For example, disciplines requiring detailed written syntheses or in-depth analysis were perceived as less suited to CCMs, with students favoring alternative visual or organizational tools. This perspective is consistent with Dillenbourg's (1999) argument for tailoring pedagogical tools to the specificities of each discipline and the diverse preferences of learners. These observations underline the importance of a flexible and context-sensitive approach when integrating CCMs across academic domains.

The research also identified several challenges in collaboratively creating CCMs. Information overload emerged as a significant issue, as students struggled to filter and organize relevant concepts, often leading to cognitive strain. Divergences in understanding and interpretation among group members further complicated the process, causing delays and occasional conflicts. These challenges align with the findings of Voropaev and Neumyvakin (2023), who observed similar barriers in collaborative tasks requiring self-regulation and effective coordination, particularly in groups with varied skill levels. Additionally, technical limitations were prominent, with many participants lacking proficiency in using digital tools effectively. Addressing these issues is critical, as Jung et al. (2019) have shown that prior training on digital platforms can alleviate technical difficulties and enhance collaborative learning outcomes.

Participants proposed several strategies to overcome these challenges and optimize the use of CCMs. Simplifying the structure of concept maps was frequently recommended as a way to reduce cognitive demands and make the tool more accessible, especially for less experienced users. A progressive creation process, where maps are incrementally developed as new concepts are introduced, was another common suggestion. This approach aligns with Calma and Cotronei-Baird's (2021) findings that phased structuring enhances cognitive engagement and facilitates better management of complex tasks. Similarly, Mende et al. (2021) reported that staged collaboration, beginning with individual preparation and culminating in group synthesis, improves the quality of outputs and minimizes interpersonal conflicts.

Proper training on digital tools was also emphasized as critical to the successful implementation of CCMs. Participants noted that targeted training would equip them with the skills needed to navigate digital platforms confidently, thereby improving their collaborative performance. Nesbit and Adesope (2006) corroborate this, highlighting the importance of technological proficiency in optimizing the use of CCMs in higher education. Furthermore, fostering group cohesion and clearly defining roles within teams were identified as essential for reducing tensions and enhancing collaboration. Effective facilitation was also highlighted as crucial, as facilitators can mediate conflicts, ensure equitable participation, and provide constructive feedback. Research by Ouyang and Xu (2021) and Zhang et al. (2023) supports the notion that structured workflows and strong group dynamics are fundamental to successful collaboration.

This study makes a significant contribution to the discourse on CCMs by providing a critical analysis of their pedagogical utility, identifying key challenges, and proposing practical solutions for their effective implementation in higher education. CCMs demonstrate great potential to bridge the gap between theoretical knowledge and practical application, promoting active learning, collaborative engagement, and deeper knowledge retention. However, their successful application requires addressing cognitive, technical, and social dimensions. Simplifying map structures, adopting phased creation processes, and providing robust training on digital tools are essential strategies to overcome the barriers identified in this research. By fostering social cohesion and leveraging facilitator support, educators can further optimize the use of CCMs in diverse academic contexts.

https://doi.org/10.22521/edupij.2025.14.85 Published online by Universitepark Press

6. Limitations of the study

This study makes significant contributions to understanding the use of collaborative concept maps (CCMs) in higher education, while acknowledging certain inherent limitations in its design. First, although the sample of 60 students is appropriate for an exploratory study, it remains relatively small and is drawn from a single master's program at a specific institution (École Normale Supérieure of Casablanca, Morocco). This limits the generalizability of the results to other educational contexts or disciplines. However, this specificity allowed for an in-depth analysis of students' perceptions and experiences within a well-defined framework, providing valuable insights for future research.

Second, the data were primarily collected through self-administered questionnaires, which may introduce response biases, such as the tendency to provide socially desirable answers. Nevertheless, the inclusion of open-ended questions enabled the collection of detailed and nuanced feedback, enriching the qualitative analysis and complementing the quantitative data. Finally, the study was conducted over a short period (one semester), offering a snapshot of students' experiences with CCMs. While this limits the understanding of long-term impact, this approach captured immediate perceptions and practical challenges faced by participants, providing a solid foundation for future longitudinal studies.

These limitations, while present, do not diminish the value of this research. On the contrary, they highlight promising avenues for future work, such as expanding the sample to other educational and cultural contexts or integrating more comprehensive mixed methods. By acknowledging these limitations, this study paves the way for broader and more contextualized investigations, while demonstrating the potential of CCMs as an innovative pedagogical tool in higher education.

7. Suggestions and practical implications

Improving the use of collaborative concept maps (CCMs) in higher education first requires strengthening training and support. An introduction to digital tools and appropriate guidance would help overcome technical difficulties and optimize their use. Moreover, better clarification of pedagogical expectations would reduce interpretative divergences and facilitate the integration of concept maps into learning practices.

Furthermore, optimizing the creation process involves a more effective structure and a progressive approach. Simplifying concept maps by limiting the volume of information to the essentials would enhance idea organization and reduce cognitive overload. The integration of relevant visual elements would improve readability and the structuring of concepts. Additionally, individual preparatory work before group collaboration would strengthen the relevance of discussions and the coherence of final outputs.

The integration of CCMs into teaching should be adapted to disciplinary specificities and pedagogical objectives. Their use would benefit from being complemented by other methods, particularly in disciplines requiring in-depth analysis. Moreover, self-assessment and peer-assessment strategies would help improve the quality of concept maps and enhance student engagement. These adjustments would allow for the full exploitation of CCMs as an interactive and collaborative learning tool.

8. Conclusion

This study provides valuable insights into the pedagogical integration of collaborative concept maps (CCMs) in higher education. By strengthening critical thinking, consolidating knowledge retention, and fostering cognitive engagement, CCMs emerge as an effective lever for active learning. However, their use presents limitations when applied to complex academic content, particularly those requiring in-depth analysis, due to challenges related to cognitive overload, interpretative divergences, and technical constraints.

To address these difficulties, targeted pedagogical adjustments are necessary, including structured guidance, the development of digital skills, and adopting more suitable collaborative strategies. Further research should explore differentiated implementation approaches tailored to disciplinary specificities and learning contexts, ensuring their optimal integration into higher education curricula.

By rethinking their deployment and mitigating the identified challenges, CCMs can become a flexible and adaptive pedagogical tool, conducive to knowledge co-construction and self-regulated learning. This study highlights their transformative potential while emphasizing the need for further investigations to fully harness their benefits within a framework of sustainable educational innovation.

Declarations

Author Contributions. All authors contributed to the preparation of the original manuscript. All authors have read and approved the publication of the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

Funding. This research received no external funding.

Ethical Approval. Ethical approval and consent to participate were not required

Data Availability Statement. The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Ab Latif, R., & Mat Nor, M. Z. (2020). Using the ADDIE Model to Develop a Rusnani Concept Mapping Guideline for Nursing Students. *Malaysian Journal of Medical Sciences*, *27*(6), 115–127. https://doi.org/10.21315/mjms2020.27.6.11

Alharbi, H. S. M. (2024). The effectiveness of the concept mapping strategy in developing digital concepts among students at Prince Sattam bin Abdulaziz University. *Journal of Educational and Social Research*, *14*(2), 273. https://doi.org/10.36941/jesr-2024-0042

Aşıksoy, G. (2019). Computer-Based Concept Mapping as a Method for Enhancing the Effectiveness of Concept Learning in Technology-Enhanced Learning. *Sustainability*, *11*(4), 1005. https://doi.org/10.3390/su11041005

Ausubel, D. P. (2000). *The acquisition and retention of knowledge: A cognitive view*. Springer Science and Business Media. https://doi.org/10.1007/978-94-015-9454-7

Aziz, F. A. A., & Halim, L. (2019). Impact of Concept Mapping on Students' Critical Thinking Skills in Science (Impak Pemetaan Konsep Terhadap Kemahiran Berfikir Kritis Dalam Sains). *Jurnal Pendidikan Malaysia*, *44*(01SI). https://doi.org/10.17576/jpen-2019-44.01si-07

Blunt, J. R., & Karpicke, J. D. (2014). Learning with retrieval-based concept mapping. *Journal of Educational Psychology*, *106*(3), 849–858. https://doi.org/10.1037/a0035934

Bordunos, A. K., Miletich, M. P., & Volkova, N. V. (2024). Mindful learning: Principles and prospect of use in higher education. *Psychological Science and Education*, *29*(4), 16–30. https://doi.org/10.17759/pse.2024290402

Calma, A., & Cotronei-Baird, V. (2021). Assessing critical thinking in business education: Key issues and practical solutions. *The International Journal of Management Education*, *19*(3). https://doi.org/10.1016/j.ijme.2021.100531

Cañas, A. J., Reiska, P., & Shvaikovsky, O. (2023). Improving learning and understanding through concept mapping. *Knowledge Management & E-Learning*, *15*(3), 369–380. https://doi.org/10.34105/j.kmel.2023.15.021

Chang, C.-C., Hwang, G.-J., & Tu, Y.-F. (2022). Concept Mapping in Technology-Supported K-12 Education: A Systematic Review of Selected SSCI Publications From 2001 to 2020. *Journal of Educational Computing Research*, *60*(7), 1637–1662. https://doi.org/10.1177/07356331211073798

Chevan, J., Pak, S. S., Wilkinson, S. G., & Toole, E. (2023). Building a Foundation for Health Informatics Content in Physical Therapy Education Through Concept Analysis and Concept Mapping. *Journal of Physical Therapy Education*, *37*(1), 24–30. https://doi.org/10.1097/JTE.0000000000000267

Dahal, B. K. (2024). Transforming Physics Education: Harnessing the Potential of Concept Mapping Across Cognitive Domains. *Pragyaratna प्रज्ञारत्न*, *6*(1), 42–51. https://doi.org/10.3126/pragyaratna.v6i1.64532

Demirci, T., & Memiş, E. K. (2021). Examining the Views of Preservice Science Teachers on Creating Concept Maps. *Science Education International*, *32*(3), 264–272. https://doi.org/10.33828/sei.v32.i3.10

Dillenbourg, P. (1999). *Collaborative learning: Cognitive and computational approaches* (Vol. 35, Issue 1). Computers and Education. https://doi.org/10.1016/S0360-1315(00)00011-7

Eppler, M. J. (2006). A comparison between concept maps, mind maps, conceptual diagrams, and visual metaphors as complementary tools for knowledge construction and sharing. *Information Visualization*, *5*(3), 202–210. https://doi.org/10.1057/palgrave.ivs.9500131

Farrokhnia, M., Pijeira-Díaz, H. J., Noroozi, O., & Hatami, J. (2019). Computer-Supported Collaborative Concept Mapping: The Effects of Different Instructional Designs on Conceptual Understanding and Knowledge Co-Construction. *Computers & Education*, *142*, 103640. https://doi.org/10.1016/j.compedu.2019.103640

Freedman, H., Young, N., Schaefer, D., Song, Q., van der Hoek, A., & Tomlinson, B. (2024). Construction and analysis of collaborative educational networks based on student concept maps. *Proceedings of the ACM on Human-Computer Interaction*, *8*(1), 1–22. https://doi.org/10.1145/3637313

Hartsell, T. (2021). Visualization of knowledge with concept maps in a teacher education course. *TechTrends*, *65*, 847–859. https://doi.org/10.1007/s11528-021-00647-z

Hay, D., Kinchin, I., & Lygo-Baker, S. (2008). Making learning visible: The role of concept mapping in higher education. *Studies in Higher Education*, *33*(3), 295–311. https://doi.org/10.1080/03075070802049251

Horton, P. B., McConney, A. A., Gallo, M., Woods, A. L., Senn, G. J., & Hamelin, D. (1993). An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education*, *77*(1), 95–111. https://doi.org/10.1002/sce.3730770107

Jung, J., Shin, Y., & Zumbach, J. (2019). The Effects of Pre-Training Types on Cognitive Load, Collaborative Knowledge Construction and Deep Learning in a Computer-Supported Collaborative Learning Environment. *Interactive Learning Environments*, *29*(7), 1163–1175. https://doi.org/10.1080/10494820.2019.1619592

Lailiyah, M., & Yustisia, K. K. (2022). Collaborative Concept Mapping: A Study of Group Work Satisfaction in Vocational Higher Education. *Journal of Vocational Education Studies*, *5*(2), 312–

321. https://doi.org/10.12928/joves.v5i2.6181

Leung, C. H., & Cheng, S. C. L. (2018). The Effective Application of Concept Mapping in Marketing Education. *Asian Journal of Empirical Research*, *8*(1), 1–12. https://doi.org/10.18488/journal.1007/2018.7.1/1007.1.1.12

Liu, S., Kang, L., Liu, Z., Fang, J., Yang, Z., & Sun, J. (2021). Computer-supported collaborative concept mapping: the impact of students' perceptions of collaboration on their knowledge understanding and behavioral patterns. *Interactive Learning Environment*, *31*(6), 3340–3359. https://doi.org/10.1080/10494820.2021.1927115

Mende, S., Proske, A., & Narciss, S. (2021). Individual preparation for collaborative learning: Systematic review and synthesis. *Educational Psychologist*, *56*(1), 29–53. https://doi.org/10.1080/00461520.2020.1828086

Molinari, G. (2017). From learners' concept maps of their similar or complementary prior knowledge to collaborative concept map: Dual eye-tracking and concept map analyses. *Psychologie Française*, *62*(3), 293–311. https://doi.org/10.1016/j.psfr.2015.11.001

Morita, J., Ohmoto, Y., & Hayashi, Y. (2021). *Integrating Knowledge in Collaborative Concept Mapping: Cases in an Online Class Setting* (pp. 99–106). https://doi.org/10.1007/978-3-030-80421-3_12

Mottian, S. D., Roets, L., & Maboe, K. A. (2022). Interpretation of the concept 'nursing': Utilisation in nursing education and practice. *Curationis*, *45*(1). https://doi.org/10.4102/curationis.v45i1.2351

Nesbit, J. C., & Adesope, O. O. (2006). Apprendre avec des cartes conceptuelles et de connaissances: une méta-analyse. *Review of Educational Research*, *76*(3), 413–448. https://doi.org/10.3102/00346543076003413

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education*, *86*(4), 548–571. https://doi.org/10.1002/sce.10032

Novak, J. D., & Cañas, A. J. (2008). *The theory underlying concept maps and how to construct them*. http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge University Press. https://doi.org/10.1017/CBO9781139173469

Ouyang, F., & Xu, W. (2021). The Effects of Three Instructor Participatory Roles on a Small Group's Collaborative Concept Mapping. *Journal of Educational Computing Research*, *60*(4), 930–959. https://doi.org/10.1177/07356331211057283

Sadita, L., Hirashima, T., Hayashi, Y., Wunnasri, W., Pailai, J., Junus, K., & Santoso, H. B. (2020). Collaborative Concept Mapping With Reciprocal Kit-Build: A Practical Use in Linear Algebra Course. *Research and Practice in Technology Enhanced Learning*, *15*(1). https://doi.org/10.1186/s41039-020-00136-6

Schroeder, P., Anggraeni, K., & Weber, U. (2018). The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology*, *23*(1), 77–95. https://doi.org/10.1111/jiec.12732

Shih, Y. A., & Chang, B. (2020). Empirical Study on the Effects of Social Network–supported Group Concept Mapping. *Research and Practice in Technology Enhanced Learning*, *15*(1). https://doi.org/10.1186/s41039-020-00143-7

Suwartono, T. (2014). *Dasar dasar metodologi penelitian*. Yogjakarta: Andi Publisher

Tan, E., Weerd, J. G. d., & Stoyanov, S. (2021). Supporting Interdisciplinary Collaborative Concept Mapping With Individual Preparation Phase. *Educational Technology Research and Development*, *69*(2), 607–626. https://doi.org/10.1007/s11423-021-09963-w

Thompson, S. B., & Pugh-Bernard, A. (2020). Concept maps as a dynamic tool for teaching scientific thinking. *Journal of Immunology*, *204*(1). https://doi.org/10.4049/jimmunol.204.Supp.222.23

Voropaev, M. V, & Neumyvakin, V. S. (2023). Pedagogical support for development of learning activity self-regulation in high school students. *Psychological-Educational Studies*, *15*(3), 80–95. https://doi.org/10.17759/psyedu.2023150306

Wang, M., Wu, B., Kirschner, P. A., & Michael Spector, J. (2018). Using cognitive mapping to foster deeper learning with complex problems in a computer-based environment. *Computers in Human Behavior*, *87*, 450–458. https://doi.org/10.1016/j.chb.2018.01.024

Woods, A., & Beye, A. (2020). Teaching undergraduate students to create and use concept maps to improve their learning. *FASEB Journal*, *34*(S1). https://doi.org/10.1096/fasebj.2020.34.s1.06313

Yarmohammadi, A., Mostafazadeh, F., & Shahbazzadegan, S. (2023). Comparison lecture and concept map methods on the level of learning and satisfaction in puerperal sepsis education of midwifery students: a quasi-experimental study. *BMC Medical Education*, *23*(1), 251. https://doi.org/10.1186/s12909-023-04247-8

Zandvakili, E., Washington, E. D., Gordon, E. W., Wells, C. S., & Mangaliso, M. P. (2019). Teaching Patterns of Critical Thinking: The 3CA Model—Concept Maps, Critical Thinking, Collaboration, and Assessment. *Sage Open*, *9*(4). https://doi.org/10.1177/2158244019885142

Zhang, W., Yan, W., & Jan, Y. (2023). Teaching Strategy Research on Project-based Collaborative Learning. *Proceedings of the 2023 8th International Conference on Distance Education and Learning*, 133–138. https://doi.org/10.1145/3606094.3606104

About the Contributor(s)

Fatima Zahra Lotfi, PhD in Educational Sciences, Assistant Professor, Higher Normal School (ENS), Hassan II University, Casablanca, Morocco.
Email: fz.lotfi@enscasa.ma
ORCID ID: https://orcid.org/0009-0008-7738-7932

Tono Suwartono, PhD in Language Education, Professor of English Language Teaching, Universitas Muhammadiyah Purwokerto, Purwokerto, Central Java, Indonesia.
Email: suwartono@ump.ac.id
ORCID ID: https://orcid.org/0000-0002-9615-2257

Brahim Maziane, PhD in Didactics and Educational Sciences, Assistant Professor of Didactics and Educational Sciences, Higher Normal School (ENS), Hassan II University, Casablanca, Morocco.
Email: mazianebrahim@gmail.com

Sri Nurhayati, PhD in Community Education, Associate Professor, IKIP Siliwangi, Cimahi, West Java, Indonesia.
Email: srinurhayati@ikipsiliwangi.ac.id
ORCID ID: https://orcid.org/0000-0002-2273-9143

Youssef Laajan, PhD student in Didactics of Arabic Language, Multidisciplinary Laboratory in Educational Sciences and Training Engineering, Higher Normal School (ENS), Hassan II University, Casablanca, Morocco.
Email: laajan.youssef@gmail.com
ORCID ID: https://orcid.org/0000-0003-0693-5053

Brahim Nachit, PhD in Didactics of Mathematics, Professor of Didactics of Mathematics, Higher Normal School (ENS), Hassan II University, Casablanca, Morocco.
Email: nachitbrahim@yahoo.fr