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Visualising for Better Understanding: The Contribution of Mind Maps to Teaching Didactics to Adult Learners

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Abstract: In an educational context marked by growing challenges in adult teaching, pedagogical pressures often hinder understanding and knowledge retention, as is the case at the Ecole Normale Supérieure, where students often encounter difficulties in organising ideas, stimulating reflection, and connecting concepts effectively, resulting in insufficient preparation of learners. Given this observation, it is essential to use innovative teaching methods that make learning

more interactive, structured, and accessible. That said, mind maps, also known as heuristic maps, allow information to be represented in a tree-like, hierarchical manner to reinforce understanding.

The study we propose is part of an experimental approach conducted with learners training at the ENS. A section of the course on the module “Classroom management tools and techniques” was used as a basis for analysis, first presented traditionally and then using a mind map constructed collectively. A comparison of the two groups' outputs enabled evaluation of the impact of this visual approach.

Keywords: Mind Map, Innovative Teaching, Knowledge Visualisation, Adult Learners, Training.

Introduction

As education continuously and rapidly evolves, the pedagogy of teaching methods to adult learners presents a growing range of challenges, especially in initial training situations, particularly when young adults (22 to 25 years old) enrolled in programs for a bachelor of French at the École Normale Supérieure (ENS), continue to struggle with organizing complex ideas, activating critical thought, and meaningfully linking theory to practice. Educational challenges have increased because of increasing pressures related to classrooms with learners who have heterogeneous rhythms of learning or who come from varied cultures and text/backgrounds, in addition to information overload, all of which have resulted in a lack of knowledge retention and knowledge production for future educators (c.f. modules related to classroom management). It is therefore appropriate to examine new approaches to pedagogical content to achieve learning that is increasingly interactive, organised, and accessible, with cognitive elements that also mimic tree-like memory (Brookfield, 2015).

Research Problem

Mind maps or heuristic maps are a promising solution, as they use visual representations to show information in a hierarchical, tree-like form (using branches, colours, and images to stimulate visualisation, memorisation, and connections between ideas) as opposed to more conventional linear approaches such as lists and slides shown sequentially and linearly (Davies, 2011).

The main question of this study is how mind maps affect understanding and interaction in teaching for adult learners in a context where traditional approaches have not been able to mitigate cognitive and motivational barriers. More specifically, do visual representations, such as mind maps, assist with the limitations shown at ENS, such as how to prioritise concepts (as demonstrated in the analysis of the learner-teacher interactions), or enable an inclusive reflection of varied teaching practices (for teaching in primary, middle school, and high school)? This is part of a larger theoretical framework that informs work on visual and cooperative learning, which emphasises the need to model interactive learning processes to develop lasting professional skill sets in adult learners.

Research Focus

The main objective of this research is to empirically demonstrate that mind maps facilitate a more profound understanding and greater participation than a traditional approach, as measured by qualitative indicators such as the organisation of ideas, depth of reflection, and interactive engagement. Secondary objectives include a comparative analysis of learners' work and recommendations for integrating these tools into educational training.

To guide this investigation, we formulate the following hypotheses:

- Mind maps will significantly improve the level of engagement and interaction management among adult learners by promoting active contributions and an inclusive climate, unlike the traditional linear format, which generates passive participation.

- They enhance the quality of idea organisation and depth of reflection by enabling intuitive heuristic structuring and nuanced connections between theory and practice (e.g., links between conflict management and motivation techniques).

- Overall, these tools will boost autonomy and reflective adjustments, leading to more transformative professionalisation for future French teachers, with implications for knowledge retention and reduced motivational gaps.

This study adopts a comparative experimental approach conducted with 25 ENS students, based on a module dedicated to "classroom management" presented first in a traditional manner, then via a collaborative mind map. The data, collected via standardised observation grids and analysed qualitatively, will validate these hypotheses and open new perspectives on innovative teaching methods.

Literature review

Challenges in teaching adult learners

The educational literature extensively describes issues of teaching adult learners in the initial training context (i.e., teaching French). Knowles (1980), in his andragogical model, identifies that adults are motivated by immediate professional needs, which can create cognitive barriers such as information overload and the organisational complexity of complex concepts, leading to poor retention of knowledge and limited reflection (Brookfield, 1986). At the École Normale Supérieure and other settings, these challenges are made more difficult by contextual factors, including learner diversity and professionalisation, which are discussed in research on teacher education (Darling-Hammond, 2006; Zeichner, 2010).

Mind maps as a visual alternative.

Mind maps, or heuristic or cognitive maps, which visually show ideas around the central core based on the associative pathway of thought in ideas with associations of ideas and keywords, are a very effective visual alternative to traditional linear approaches (which often have a highly

hierarchical and abstract way of presentation that is not always suitable for every learner). Buzan (1974) conceptualised mind maps as tree-shaped heuristic tools (or heuristic maps), drawing inspiration from the brain's neural structures to facilitate logical thinking, creativity, and imaginative associations within a neuroscientific framework. The mind mapping process is based upon cognitive principles, such as Paivio's (1971) dual verbal-visual coding theory, which enhances the process of memorising and connecting concepts via hierarchical branches represented through colours, symbols, and images to reveal global and holistic understandings of the learning process, as well as for synthesising information for more organised and structured learning.

Research in educational psychology supports their usefulness and meanings as a form of note taking, in meetings or collaborative work to help students organize and create, and specifically to increase creativity and alleviate cognitive anxiety in adults, which can be accomplished by utilizing practical considerations that include seven considerations in the design and implementation of their usage (Farrand et al., 2002; Antoni et al., 2010), as well as for interactive learning or increased creative initiative in learners – for instance, in Business Model teaching and learning. In addition, they are powerful tools for enabling visual representation of ideas for students with organisational difficulties, structuring, visualising, and controlling the content of a subject/topic for better understanding and presage sequencing for memory encoding – definitely not a fad.

Methodology

Comparative experimental approach to the use of mind maps in teaching

The methodology of this research adopts a comparative experimental approach to assess the impact of mind maps on students' understanding and interaction during teacher training. It is part of a research process that initiates structured reasoning. Inspired by cooperative teaching principles and professional training tools, this methodology aims to compare two methods of teaching duplicate content using systematic observations and quantitative evaluation. The steps have been planned to include implementing the intervention, taking into account key aspects such as data collection using a grid and its analysis.

This experimental study is designed as an intervention aligned with the principles of theoretical teaching in specialised programs, namely the teaching of a module entitled “classroom management tools and techniques” to students preparing for a bachelor's degree in French. It is based on a comparative design (traditional course vs. course designed with artificial intelligence tools) with two groups (control and experimental), integrating innovative teaching methods to model learning processes.

The main objective is to demonstrate how mind maps facilitate understanding and interaction compared to a traditional approach, by measuring indicators such as the organisation of ideas and retention of concepts. The research is conducted in an authentic training context, with a total duration of two sessions (one per modality) to minimise temporal biases.

Participants

The sample includes 25 final-year students at the Higher School of teachers, aged 22-25 on average, who are training to become French teachers. These adult learners, enrolled in an initial teacher training program, are selected for their homogeneity in academic level and prior exposure to teaching tools. The group is randomly divided into two subgroups of 12-13 students each: a control group that receives traditional instruction and an experimental group that uses mind maps. Informed consent is obtained, and anonymity is ensured, in accordance with ethical standards in academic research.

Procedure

The procedure follows a rigorous plan of intervention stages, divided into two phases for the "Classroom Management Tools and Techniques" module (each phase lasting 1.5 hours, one week apart).

- **Phase 1:** Traditional teaching (control group).

The course is delivered traditionally, using a linear presentation with slides, oral explanations, and written notes. Topics covered include strategies for managing classroom interactions, conflict resolution, and techniques for motivating students. Students are encouraged to take notes and ask questions, simulating a standard theoretical teaching format. Immediately afterwards, an observation grid is used to assess their interaction.

- **Phase 2:** Teaching via mind maps (experimental group).

The content is similar, but instead of a topical outline, it is now organised using a collaborative mind map utilising napkin.ai. The teacher creates the foundational mind map:

A central theme ("Classroom Management") has branches (e.g., "Interactive Strategies", "Motivational Tools") with keywords, illustrations, and colour-coding. The students are involved in the process of creating the mind map collectively by adding branches and concepts based on their reflections and keywords from the introduced content. This process promotes active modelling and problematization of concepts through methods of scientific inquiry. The observation grid is used similarly, following the session.

Both phases use course sheets to guide students, focusing on the main concepts covered in the chapter.

Assessment tools

A standardised observation grid, based on pedagogical frameworks used in vocational education, is employed to measure participation and understanding. The observation involves measuring the following criteria on a 5-point Likert-type scale: level of participation (questions posed, engagement), quality of organisation of ideas (clarity of notes and diagrams), depth of

reflection (connections between concepts), and perceived retention (a short quiz immediately after the session).

The observation grid is administered to the teacher and a second blind observer each time a grid is employed to maintain data reliability. Brief semi-structured interviews (5-10 min) were also conducted with students to provide qualitative insight into their perceived difficulty in understanding.

Module content: “Classroom management tools and techniques”

- This module aims to equip future French teachers with the tools to manage a classroom effectively, taking into account a variety of educational contexts (primary, middle school, high school). It emphasises the “opportunity to learn” as a key benefit for professionals, providing concise content to develop classroom management skills.

- By the end of the module, students will be able to: (1) Identify classroom management tools; (2) Analyse learner-teacher interactions; (3) Apply techniques to promote engagement; (4) Reflect on inclusive practices.

- 2 sessions, each lasting an hour and a half, for 25 adult students in initial training, with a reflective approach to support their professional development.

Section 1: Fundamentals of classroom management (50 min)

Definition and challenges: Classroom management encompasses strategies for creating an environment conducive to learning by managing interactions and conflicts. Discussion of contextual pressures (student diversity, inclusion) and the importance of reflective practice.

Example: Using educational tags to insert text or links to multimedia resources, such as videos of real-life cases.

Section 2: Practical tools (50 min)

- Digital and collaborative tools: collectively create management scenarios or shared folders to make files available (e.g., lesson plan templates).
- Motivation techniques: Practical exercises to allow students to simulate interventions, such as role-plays on conflict resolution.
- Inclusive resources: Integrate practices to enrich content, taking into account specific needs (e.g., for non-native French-speaking students).

Section 3: Interaction and assessment techniques (50 min)

- Intervention methods: Discuss ways to review post-activity and project-inclusive activities.
- Practice analysis: Describe and explain teaching and learning sessions, focusing on interactions (e.g., peer-to-peer exchanges) for heuristic understanding.
- Assessment: Use quizzes or feedback to measure engagement and boost motivation through interactive elements.

Section 4: Summary and areas for improvement (30 min)

- Group discussion on challenges (managing diverse groups) and suggestions for personal contributions, such as getting involved in class projects.

Objective: Facilitate learning by presenting key information concisely to improve overall performance.

Implementation in the experimental phases

- **Phase 1** (Traditional): Content is presented via a linear presentation (slides, explanatory speech), with individual note-taking.

An observation grid evaluates interaction (number of questions, level of engagement) to identify limitations in retention and connections between concepts.

- **Phase 2** (Mind map): The duplicate content is restructured into a collaborative mind map (central theme: "Classroom Management"; branches: "Tools," "Techniques," "Interactions").

Students add visual elements, promoting hierarchical organisation and increased interaction. The grid measures improvement in understanding and participation, demonstrating that mind maps facilitate active, lasting visualisation.

The course is organised into thematic sections, with interactive activities to encourage engagement. It is based on five essential components: resource management, clear expectations, positive relationships, student attention, and discipline management.

Concrete examples, such as role-plays in French, are included to anchor the content in their future teaching practice.

Course presentation (15 minutes)

- Classroom management is the set of thoughtful and simultaneous actions implemented by the teacher to establish, maintain, and restore a climate conducive to learning, by limiting disruptive behaviours and optimising the use of time. It encompasses the planning of teaching situations, classroom organisation, and control during the action, while distinguishing between minor (one-off) problems and major (course-impeding) problems.

- Why classroom management: It is essential for placing students in optimal learning conditions, promoting motivation, and preventing misbehaviour. In the context of future French teachers, it helps to manage student diversity (learning speeds, cultures) and to vary situations (lectures, interactive, groups).

- Activity: Plenary discussion on personal challenges in classroom management (e.g., managing interactions in French class).

- Preparation before class (20 minutes)

- Teaching plan: Distinguish between essential and secondary content, ensure consistency between learning objectives, assessment, and methods, and take into account the profile of the students (class size, abilities). Plan for balanced sessions by estimating the time allocated.

- Logistics: Arrange the physical space in the classroom (table layout to encourage interaction) and prepare materials (e.g., digital resources for French lessons).

- Concrete example: For a French class, plan a role-play on resolving verbal conflicts, incorporating ICT tools such as collaborative wikis to vary the groupings of students.

- Activity: Students sketch out a simple plan for a French lesson, identifying clear expectations and the necessary resources.

Conduct during class (40 minutes)

- Management of the teaching space
 - Explain the purpose of the class, capture the students' attention (e.g., with a motivating question about a literary text), and announce the requirements for maintaining discipline.
- During the session: Manage time with clear guidelines, vary methods (e.g., individual or group work to analyse a French poem), and intervene discreetly in cases of indiscipline by promoting positive relationships (Pygmalion effect: adopt optimistic assumptions).
- End of session: Summarise, allow time for assimilation, and answer questions.
- Benevolent authority and communication: Adopt a professional attitude, free yourself from the teaching habitus (based on investigation and decision-making), and master verbal/nonverbal communication (e.g., avoid "words that kill" when correcting French). Encourage criticism and discussion to develop students' analytical and summarising skills.
- Behaviour management: Use preventive interventions (creating a conducive environment) and corrective interventions (managing deviations) to promote engagement and prevent indiscipline.
- Activity: Role-play in small groups on a situation of indiscipline in a French class (e.g., whispering during a reading), applying 10 essential strategies such as varying situations and observing time wasters.
- Adjustment after class (20 minutes)
- Reflection phase: Analyse the teaching process to regulate actions, identifying what worked and what did not (e.g., if control of the class was lost, adjust the plan accordingly).
- Precautions: Develop skills continuously, with discernment and humility; spark students' curiosity by presenting "juicy bait" to stimulate their desire to learn.
- Activity: Students complete a self-assessment grid of their management skills, inspired by models for assessing attention and engagement.

Summary and evaluation (25 minutes)

- Summary: Connect the tools to future French teaching practice, emphasising how effective management promotes a favourable climate and student success.
- Evaluation: Quick quiz on key concepts and student feedback to gauge understanding.

- Additional resources: Recommend readings such as “Vers une gestion éducative de la classe” by Archambault and Chouinard, or tools for inclusive management (e.g., for students with difficulties).

This content provides comprehensive training that aligns with fundamentals such as the teacher's impact on learning and the principles of proactive management. In the traditional phase, present it linearly; with the mind map, restructure it around a central diagram to boost interaction and understanding, as demonstrated by approaches that vary the methods used to achieve the objectives.

Observation grids for assessing interaction and understanding in classroom management.

It allows the observation and quantification of interactions among 25 students in two phases: traditional teaching (linear, with individual grades) and teaching via mind maps (collaborative, with a tree-like visualisation). The objective is to demonstrate, through comparison, how mind maps facilitate understanding and interaction by measuring indicators such as engagement level and output quality, aligned with classroom management principles that distinguish thoughtful actions to maintain a climate conducive to learning.

The grid is structured around observable criteria. It is applied immediately after each phase by the teacher and an independent observer (another teacher), as recommended in classroom observation systems that incorporate coding and analysis of dynamic environments.

- Adapted criteria: Based on a comprehensive grid for analysing classroom management, including observables such as setting, engagement, and adjustments, to identify what is working or needs adjustment.

- Comparison: Calculate the total scores for each phase; mind maps should reveal increased interaction (e.g., more questions asked, better hierarchical organisation), thereby confirming their impact on motivation and understanding, as in person-centred approaches where collaborative tools facilitate discipline.

Table 1

Observation analysis grid based on the traditional course

Criterion	Description	Qualitative notes (examples of observations)
Commitment level	Evaluates the number of questions asked and passive contributions (e.g., attentive listening without collaborative visual tools) to measure attention in a linear format, which is key to capturing attention and reducing disruptions in the classroom.	Students ask 2-3 questions; moderate engagement without peer-to-peer interactions.

Quality of the organization of ideas	Observe the clarity of individual linear notes and the structuring of concepts (e.g., sequential list of management tools), noting the limitations of a non-visual approach to prioritizing information, as in grids that facilitate the analysis of practices.	Rigid textual notes, with few links between concepts such as conflict management.
Depth of reflection	Measures the links established between theory and practice through notes or oral responses (e.g., analysis of techniques without diagrams) to assess critical thinking in an explicit traditional context.	Superficial reflections, focused on linear memorization without deeper connections.
Interaction management	Observe minimalist exchanges (e.g., one-way questions and answers) and the atmosphere in a traditional setting to analyze positive relationships without collaborative tools.	Interactions limited to 2-3 exchanges; positive but passive atmosphere.
Autonomy and adjustments	Measures the initiative to adapt individual grades and post-course adjustments, noting the absence of collaborative elements for an analysis of specific needs.	Low autonomy; adjustments based on textual notes without collective iterations.

Presentation of the course for the experimental group

We present the course outlined on the napkai.ai website.

Figure 1

Transformative Classroom Management

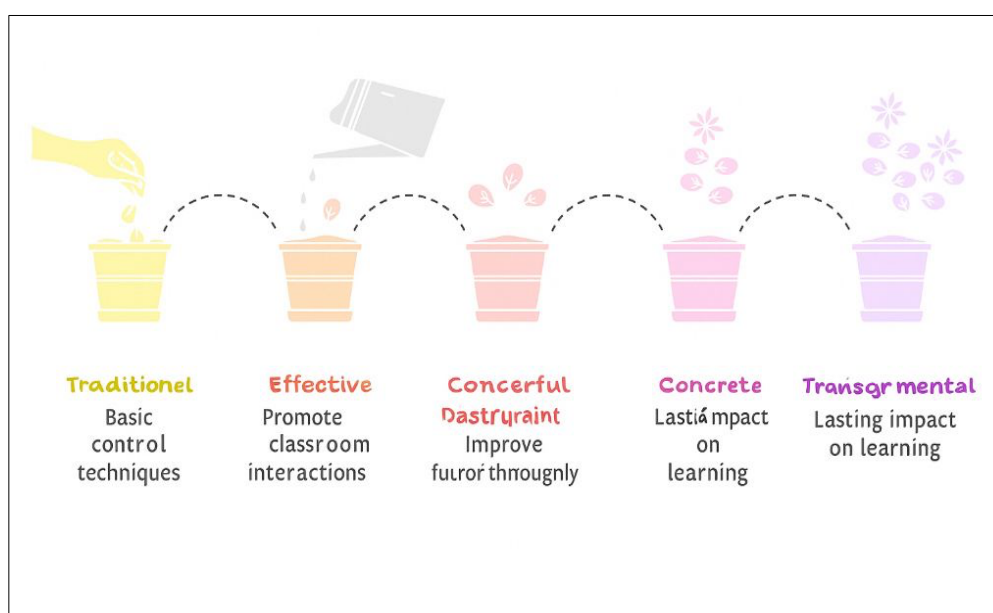


Figure 2

Foundations of Transformative Classroom Management

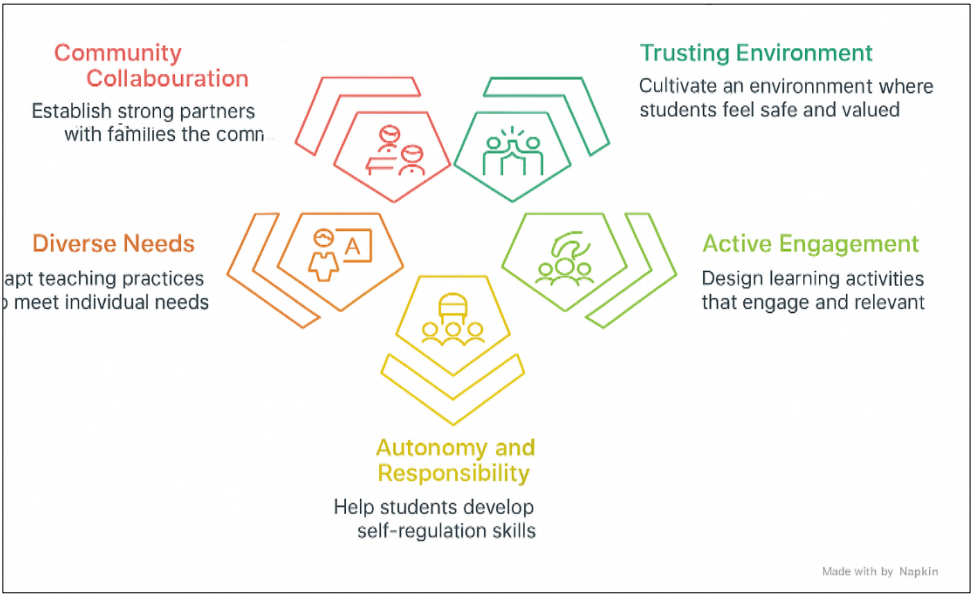


Figure 3

Classroom Interaction Analysis

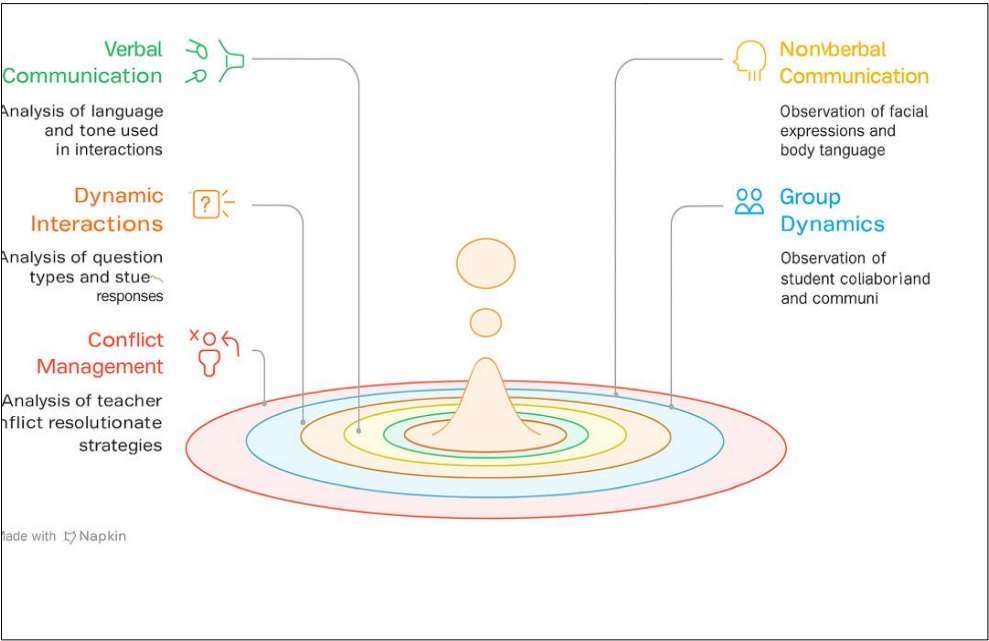
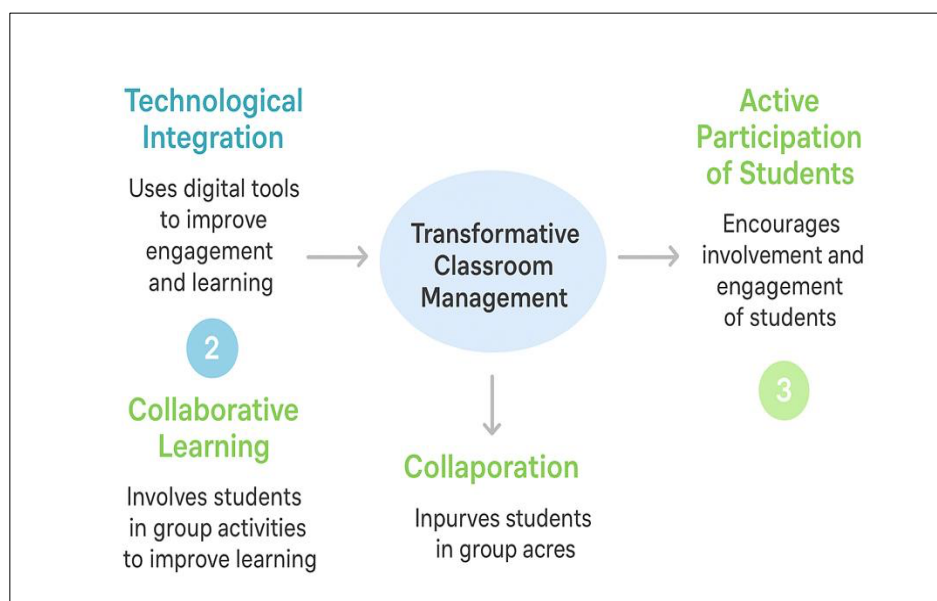


Figure 4

Transformative Teaching Practices



Analysis of the observation grid for the control group

Students engaged in 2-3 questions constructed around a question related to minor vs. major issues (Chapter 1: Managing The Classroom)—although engagement level was moderate and passive, leaning into listening vs. engaging, thus reflecting signs of limited internal motivation in a traditional explicit approach used to demonstrate evidence (as in response analysis grids) (Haney, 2019).

Student notes were clear but rigid, listing sequentially, in outline fashion pedagogical preparations and planning (and logistical); visual representation was absent (e.g., linking content to benevolent authority, linking benevolent authority to behavior management); and while the analysis illustrated a practical approach to linear organization for the final synthesis of pedagogical preparation—moving from less generic to a final or, more definitive synthesis of preparation—it was similarly limited throughout the synthesis regarding hierarchical categorization. This trait aligns with tools for analysis and emphasises organisation and planning in a pedagogical context (Haney, 2019).

In the section for reflections to adjust course expectations, the reflections were shallow and limited to verbal exchanges on management skills (which consisted of self-reflection on interventions for stepped remediation) that did little to engage students with one another on the topic of inclusion. This suggests that critical thinking was limited by the linear manner in which course expectations were provided for reflections, as reflected in the grid analyses, which demonstrated discrepancies in learning (the difference between the desired modality and the enacted modality).

Exchanges during the interactions were limited to 2-3 exchanges per section (role-plays in small groups during the lesson), resulting in a warm, but rather one-dimensional, tone and an atmosphere of collegial engagement. There was friendliness; however, it did not stimulate collaboration or require stimuli for a collaborative experience; this reinforces that you may have

enough engagement in the direction, but a passive, pedagogically effective use of others' talking for your own productivity. This is again similar to the expectations in guides for analysing the relational issues at play in a language class.

Students demonstrated little autonomy in adjusting their post-class notes, relied on lists presented in textual format, and did not iterate graphically. Analysis of their behaviours uncovered that the adjustments were limited by a lack of linear flexibility (i.e., an observation needed to determine whether an adjustment was warranted), often in ways similar to the methodology articulated to co-construct assessment tools.

When overall analysis of a traditional session showed moderate engagement and understanding, the strengths would clearly indicate linear clarity (during analysis and synthesis), while the weaknesses would have reflected a lack of deliberative, deep reflection and autonomy. Comparisons of traditional teaching methods have often demonstrated the contrary. This will serve as another comparative basis for analysis when the mind map phase of teachers in the study begins. The mind map provides students with varied talking spaces to discuss observations they may or may not expect, which supports theoretical principles of observation and is likely to foster more engagement than in the previous phase (even if it is not the conclusion once all analyses unfold).

Table 1

Analysis grid for the observation phase for the “teaching via mind maps” phase

Criterion	Description	Qualitative rating (during observation)	Comparison between traditional classes and classes using mind maps
Level of commitment	Evaluate the number of questions asked and active contributions (collaborative additions to the mind map on branches such as “motivation techniques”) to measure accumulated attention in a visual and interactive format, which is key to capturing attention and reducing disruptions in the classroom.	Students ask 8-10 questions; high engagement with peer-to-peer interactions during collective branch building on ‘conflict management’.	A significant improvement over the traditional approach, where engagement is moderate and passive; this demonstrates how mind maps encourage dynamic participation, aligned with collaborative practices that motivate adult learners.
Organization of ideas	Observe the clarity of collective tree diagrams and the structuring of concepts (visual hierarchy of management tools using colors and images),	Clear diagrams with visual links between ‘educational planning’ and ‘space management’; intuitive	Better structuring: the contribution of mind maps to overcoming non-visual limitations, making concepts more

	noting the advantages of a heuristic approach to linking information, as opposed to linear lists.	hierarchical organization facilitating an overview.	accessible and interconnected.
Depth of reflection	Measure the links established between theory and practice using mind mapping (ramifications on the analysis of interactions with collective reflections), to develop critical thinking in a visual and collaborative context.	In-depth reflections, with nuanced connections between 'benevolent authority' and the 'Pygmalion effect'; stimulating debates on practical applications.	Accumulated depth (more complex connections) compared to the superficial reflections of the traditional approach; mind maps stimulate critical analysis, as in methods that encourage heuristic problematization for better understanding.
Interaction management	Observe collaborative exchanges (e.g., mutual additions to the map on "conflict resolution" and integrated role-playing), and the positive atmosphere fostered by the visual tool.	Rich interactions with 10-12 peer-to-peer exchanges; dynamic and inclusive atmosphere, encouraging positive relationships.	Increased interactions (vs. minimalist in the traditional sense; this highlights how mind maps promise a favorable climate by aligning with principles of proactive and collaborative management.
Autonomy and adjustments	Measure the initiative to collectively adapt the mind map and post-course adjustments (e.g., iterations on branches such as "post-course precautions"), noting collaborative elements for a specific needs analysis.	High autonomy; iterative group adjustments, with personalized additions based on feedback to refine inclusive techniques.	Greater autonomy (collective initiatives vs. weak individual ones); mind maps facilitate dynamic adjustments, reinforcing the autonomy of learners in training, unlike the rigid textual approach.

Analysis of the observation analysis grid for the experimental group (use of mind mapping)

This grid examines the 12-13 students in the experimental group during the two sessions (total duration: 3 hours, one week apart), where the content is restructured around a collaborative mind map (central theme: "Classroom management"; main branches: "Preparation," "Conduct," "Adjustment," "Synthesis," with branches for objectives such as analyzing interactions and applying inclusive techniques). Observations focus on active interaction (e.g., collective additions of keywords/images for various educational contexts, such as primary/secondary), promoting more profound reflection on moral and civic issues related to classroom management.

The observation analysis grid for the experimental group, using collaborative mind maps during two sessions on the "Classroom Management Tools and Techniques" module, defines five criteria aligned with specific objectives (identifying tools, analyzing learner-teacher interactions,

applying techniques for engagement, and reflecting on inclusive practices), demonstrated a significant impact of mind maps on interactive and reflective learning among 12-13 students in teacher training; For example, the level of engagement is illustrated by 9-12 questions and active role-plays on topics such as “Behavior during class,” boosting motivation and reducing disruptions. At the same time, the quality of the organisation of ideas provides a clear hierarchical structure with visual links (e.g., branches on “Preparation” to distinguish between essential and secondary elements). The depth of reflection encourages nuanced debates on the Pygmalion effect and inclusive practices, interaction management enriches peer-to-peer exchanges for a positive atmosphere, and autonomy and adjustments encourage collective iterations for needs analysis, confirming that mind maps transform classroom management into a proactive and engaging practice, with implications for the training of future French teachers in various contexts, specifically in terms of gains in motivation and critical thinking, aligned with scientific pedagogical principles for concise and transformative content. However, multimedia adjustments could enrich abstract concepts.

Table 2

Summary comparison table

Criterion	Classical Group Observations (linear teaching)	Experimental Group Observations (collaborative mind maps)	Comparison and Qualitative Insights
Level of commitment	Moderate engagement, limited to attentive listening and a few sporadic questions, with little peer-to-peer interaction and passive participation in discussions on topics such as student motivation	High engagement, marked by numerous questions and active contributions (e.g., collaborative role-playing on driving during the course, stimulating debates on the “possibility of learning” in various contexts).	Significant improvement in the experimental group, where mind maps boost motivation and reduce disruption through dynamic participation, contrasting with the passive nature of the traditional approach; this aligns with the goal of applying inclusive techniques to create an engaging environment.
Organization of ideas	Rigid organization using linear notes, with limited sequential structuring and few clear links between concepts (e.g., simple lists on preparation before class, without visual hierarchy).	Clear and intuitive organization via tree diagrams, with hierarchical visual links (e.g., dependent branches adjusted after the course to the needs analysis, facilitating an overview of the tools).	Better structure in the experimental group, overcoming the non-visual limitations of the traditional approach for a concise and scientific design, promoting tool identification and transformative management.
Depth of reflection	Superficial reflections, focused on linear memorization without nuanced connections (e.g., basic analyses of	Nuanced and critical reflections, with in-depth connections between theory and practice (e.g., discussions on the	Depth accumulated in the experimental group, stimulating heuristic problematization and critical reflection on moral issues, well beyond the surface of the

	contextual issues such as student diversity, without in-depth discussion).	Pygmalion effect in the synthesis, linking to inclusive practices for non-native students).	classic, in support of the objective of reflection on inclusive practices
Interaction management	Minimalist, one-way interactions, with a positive but passive atmosphere (e.g., limited discussions about behavior management, without immediate feedback).	Rich and collaborative interactions, creating a dynamic and inclusive environment (e.g., peer-to-peer exchanges on assessment techniques, promoting positive relationships and preventive interventions).	Significant enrichment in the experimental group, promoting an environment conducive to learning through visual tools, contrasting with the minimalism of the classic approach and aligned with the analysis of learner-teacher interactions.
Autonomy and adjustments	Low autonomy, with individual adjustments coordinated based on rigid textual notes and few initiatives to adapt to specific needs (e.g., limited post-class regulation without collective iterations).	High autonomy, with iterative group adjustments (e.g., personalized adaptations to continuously develop skills, such as sparking curiosity in various contexts).	Gaining initiative and flexibility in the experimental group, encouraging reflective professionalization and dynamic adjustments, as opposed to the rigidity of the traditional approach, in order to offer transformative tools.

This comparative table analyses how mind maps transform didactic teaching into an interactive and inclusive process, going beyond the limitations of the traditional linear format. For example, it discusses the pedagogical implications based on recognised principles (such as needs analysis and goal-setting for engaging learning), emphasising that visual tools boost engagement and critical thinking in adult learners, and promoting proactive classroom management across various educational contexts (primary/secondary). Address related qualitative strengths (e.g., enriched interactions and increased autonomy) to argue for their integration into initial training for French teachers, while noting areas for improvement, such as the addition of multimedia for abstract concepts. This reinforces the experimental study's hypothesis, inviting future research on the long-term impact, aligned with approaches that value the social construction of meaning and the reduction of motivation gaps.

It reveals marked qualitative contrasts between the traditional linear approach and the use of collaborative mind maps, highlighting the effectiveness of visual tools in transforming learning into an interactive and reflective process aligned with the objectives of the "Classroom Management Tools and Techniques" module. In the traditional group, observations highlight overall rigidity, with passive engagement, limited sequential organisation, superficial reflections, unidirectional interactions, and restricted autonomy, which hinder in-depth analysis of learner-teacher interactions and reflection on inclusive practices, as observed in sections such as pre-class preparation, where the links between concepts remain basic and not very adaptable. In contrast, the experimental group demonstrates an enriched dynamic, characterised by active engagement through role-playing and debates, intuitive heuristic structuring that promotes visual connections (e.g., dependent

ramifications, synthesis with adjustment for a transformative overview), nuanced critical depth on issues such as student diversity, rich interactions promoting an inclusive climate, and iterative autonomy encouraging personalised adjustments.

Analytically, These qualitative differences illustrate how mind maps overcome the limitations of the traditional format by boosting motivation, facilitating proactive behavior management (e.g., preventive interventions in driving during class), and supporting reflective professionalization, particularly in identifying and applying tools in various educational contexts (primary/secondary), which supports the initial experimental hypothesis that mind maps create an accumulated "opportunity to learn" by integrating scientific pedagogical principles for concise and engaging content. However, multimedia adjustments may be necessary for abstract concepts such as the Pygmalion effect, inviting wider adoption in didactic training while offering the need for longitudinal studies to assess the sustainability of gains.

Conclusion

In summary, this comparative experimental study on the contribution of mind maps to teaching didactics to adult learners confirms that these visual and collaborative tools represent a significant pedagogical innovation for overcoming the challenges observed at the École Normale Supérieure, such as difficulties in organising ideas, stimulating reflection, and linking concepts in a module such as "Classroom Management Tools and Techniques." Through a rigorous methodology involving 25 students divided into control (traditional linear teaching) and experimental (collaborative mind maps) groups, the analyses of the summary observation grids reveal marked qualitative contrasts: while the traditional approach generates moderate engagement, rigid organization, superficial reflection, minimalist interactions, and limited autonomy, mind maps maintain active engagement through role-playing and debates, intuitive heuristic structuring with visual links, in-depth nuanced criticism on inclusive issues, rich exchanges for a dynamic climate, and iterative autonomy encouraging personalized adjustments.

These results, aligned with the specific objectives of the module (identifying management tools, analyzing learner-teacher interactions, applying techniques for engagement, and reflecting on inclusive practices), demonstrate that mind maps transform learning into an interactive and transformative process, boosting motivation, provoking disruption, and promoting reflective professionalization among future French teachers in various educational contexts (primary, middle school, high school).

Theoretically, this reinforces established pedagogical principles for engaging and scientific learning, highlighting how tree-like visualisation mimics cognitive structures to improve retention and build "learning potential." Practically, these results recommend the systematic integration of mind maps into teacher training, particularly through software such as MindMeister, to alleviate pedagogical pressures and improve the preparation of adult learners. Nevertheless, limitations remain, such as potential visual overload with abstract concepts, residual learning bias despite spacing between sessions, and the limited sample size at higher school levels, which calls for cautious generalisation.

In the future, longitudinal research could evaluate the sustainability of these gains in authentic teaching contexts or explore multimedia hybridisations to enrich the tools, thus opening new avenues for innovative and inclusive teaching. Ultimately, by visualising for better understanding, mind maps do more than just structure knowledge; they open horizons for more interactive and fulfilling adult education.

Suggestions for Future Research

Future research could expand on these findings by exploring how mind mapping contributes to long-term knowledge retention and professional autonomy in teacher training. While this study focused on a small sample of adult learners in the context of classroom management at the École Normale Supérieure, subsequent studies could apply similar experimental frameworks to other disciplines or teacher education programs, to assess the transferability of the results. It would also be valuable to investigate the impact of digital or AI-assisted mind-mapping tools, particularly in hybrid or online environments, where interactivity and visualisation may mitigate cognitive overload. Longitudinal designs could help determine whether the observed gains in engagement, reflection, and autonomy persist over time and translate into real classroom practice once these learners become active teachers. Future studies could also consider comparative cultural analyses to examine how visual pedagogies support inclusive practices in multilingual or multicultural contexts. Such work would contribute to a broader understanding of how heuristic mapping can transform traditional pedagogical approaches into more interactive, student-centred, and reflective learning models.

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Conflict of Interest

None.

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