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Şcoala Doctorală de Studii Inginereşti

Intelligent Tools to make Teaching and Learning Models more efficient for Generation ”Z” Students

PhD Thesis – Summary

for obtaining the scientific title of Doctor at
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in the field of Engineering and Management

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Chapter 1, titled ”**Introduction**” presents the relevance of the research topic, which lies in the fact that recent studies have highlighted the need to adapt educational strategies to address the learning styles and specific needs of Generation Z members. These individuals are accustomed to daily technology use and quick access to information. [1] Based on this relevance, the purpose and objectives of the thesis were defined. The aim of this thesis is to ***identify methods to optimize teaching and learning models for Generation Z students,*** achievable through the following five specific objectives:

- *Evaluating the dynamics of Generations "X," "Y," and "Z" within workgroups;*
- *Conducting a critical analysis of learning models in the specialized literature;*
- *Configuring a teaching and learning model;*
- *Implementing tests to survey learning preferences and validating them through intelligent tools;*
- *Identifying methods to optimize teaching and learning models for Generation Z students based on responses obtained through intelligent systems.*

The chapter concludes with the structure and presentation of the thesis.

Chapter 2, titled **”Evaluation of the dynamics of Generations X, Y, and Z within workgroups”** It meets the thesis's first specific objective, developing along two directions. The first direction explores the scope of the concept of a group and its attributes through a comprehensive theoretical framework. A group is defined as a social construct formed by two or more people working together to achieve a common goal. [2] Within a group, processes take place that can be defining for its long-term success and resilience. [3] In this regard, group characteristics were analyzed, determining that the efficiency and cohesion of a group can be influenced by the interaction, interdependence, and similarity of its members. [4]

The second direction identifies the active generations within current workgroups based on preferences, which underlie the establishment of group identity, as well as the means of persuasion and motivation for members of such a social construct. To optimize communication and cohesion within groups that include members from multiple generations (X, Y, Z), the research aims to find proactive interaction pathways between generations.

Members of Generation X, born during a period marked by stability and traditionalism, value loyalty, respect hierarchy, and are committed to their work. They prefer stability, are reserved toward technology—though they do not reject it—and adapt more slowly to rapid changes. [5]

On the other hand, Generation Y members, or Millennials, are more open to technology and oriented toward immediate rewards (financial or social recognition). [6] They prefer teamwork, seeking constant feedback, ask for recognition of their work, and emphasize the balance between personal and professional life. [7]

Generation Z members, having grown up in the digital age, are highly skilled in using technology and have a pragmatic mindset. Their pragmatism leads them to combine technological efficiency with personal life. They are accustomed to offering quick solutions and demand flexibility in their work schedule. In groups, they emphasize innovation and are less attached to traditional hierarchies and structures, which can create tension with Generation X and Y members. [8]

Currently, the concept of a group and its attributes, as presented through the bibliographic framework, is expressed differently among these three generations. The preferences of Generation X, Y, and Z members cannot fully align, lacking shared similarities and characteristics. Thus, communication among these generations has become quite convoluted due to differences in perception and expression, as motivations, methods, and tools vary generally, and in particular, the necessity for similarity—key to group cohesion—is unmet.

To enhance communication and cohesion within groups containing members from multiple generations (X, Y, and Z), it is proposed to find proactive interaction pathways between the different generations, bridging understanding and communication gaps that manifest as obstacles in the learning and training process.

In this regard, it is essential to find and conceptualize ways for Generation Z members to relate to other active generations.

Chapter 3, titled ”**Learning models**”, meets the second specific objective of the thesis by defining the scope of the research and through a critical analysis of six learning models from the specialized literature. This delimitation is necessary due to the heterogeneity of generations within current groups, both in workplaces and educational institutions. Consequently, the thesis is limited to identifying Generation Z's perceptual styles in learning engineering disciplines and generating compatible teaching solutions for this generation.

Based on the research scope, six learning models from the specialized bibliography were identified and presented in detail in a critical analysis of their advantages and limitations.

Model 1**,** based on the predominant mode of perception adapted from Aisami's concept [9], has the main advantage of providing insights into suitable teaching and learning strategies for seven types of perception: verbal/linguistic, visual/spatial, auditory/aural, physical/kinesthetic, logical/mathematical, solitary/intrapersonal, and social/interpersonal. The primary limitation of this model is that it does not suggest how to establish the learning style for a particular student.

Model 2**,** based on enhancing learning capacity through the influence of the external environment adapted from Deshmukh and colleagues [10], has the main advantage of enabling the systematic grouping of the study group into three categories: visually inclined individuals, auditory-oriented individuals, and kinesthetic learners. The main limitation of this model is that it does not account for all learning styles, such as the classic (read-write) style, which remains a preference among students.

Model 3**,** based on the preferred assimilation style adapted from El-Sabagh's concept [11], has the main advantage of introducing four operational sensory types: visual, auditory/aural, read-write, and kinesthetic/tactile, covering all learning perceptions. It is limited in that it specifies only one type of assimilation/learning from a single category for each student, excluding the possibility that some students might prefer multiple modes of knowledge assimilation.

Model 4, for structuring distance courses in line with learning styles, adapted from Faisal and colleagues [12], has the main advantage of providing directions for personalized, student-centered learning by classifying materials according to predominant learning types. The main limitation of this model is that it does not account for all learning styles, such as the classic (read-write) style, which still represents a preference among students.

Model 5, based on the predominant personality type adapted from Radwan’s concept [13], has the main advantage of linking the 16 personality types (MBTI) with the preferred learning style. It is limited because it proposes subject types based solely on the personality test and not on a preferences test.

Model 6, which involves grouping learning styles, adapted from Fussel's concept [14], has the main advantage of allowing classification of learning styles according to affiliation groups: cognitive, observational, conditional, and a combination of these three. It is limited in that it proposes subject types based solely on the mode of perception and not on a preferences test.

The most significant limitations are in Models 1, 4, and 5, and the thesis research aims to identify certain intelligent methods and techniques to overcome these limitations.

Chapter 4, titled ”**Research Methodology – The Temple of Teaching and Learning Dedicated to Generation Z*”*** meets the third specific objective of the thesis by presenting the research methodology and conceptualizing two tests. The research methodology is structured in three stages, carried out through the three pillars of the *Temple of Teaching and Learning dedicated to Generation Z* (Fig. 4.1), as follows:

Pilar I: The theoretical stages of the research methodology;

Pilar II: The use of intelligent tools for implementing the theoretical stages of the methodology;

Pilar III: Connecting Pillar II with the results of Test 2 to generate teaching solutions.

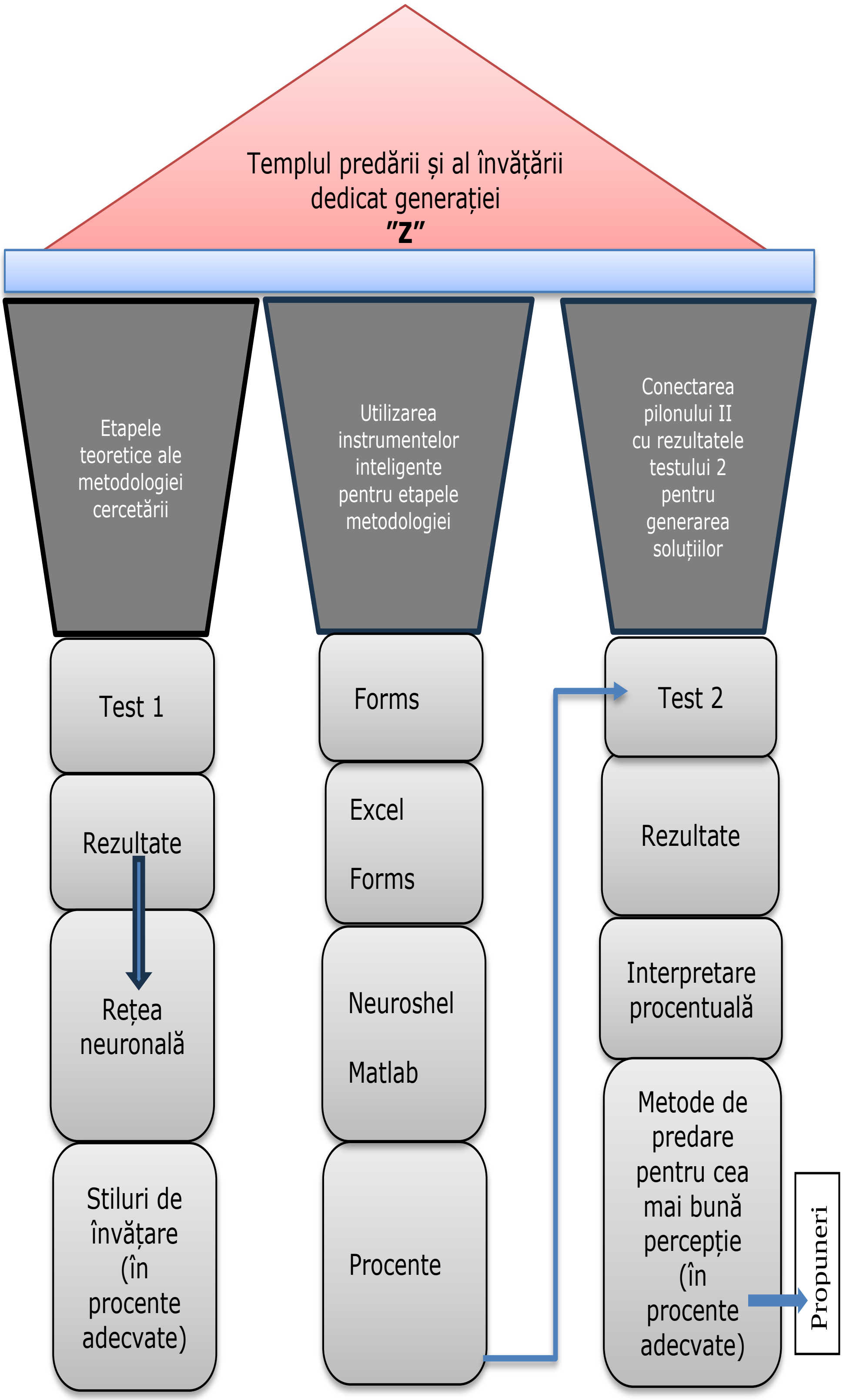

Fig. 4.1 *Temple of Teaching and Learning dedicated to Generation Z*

Two tests are conceptualized to identify individual learning styles, specifically the modes of perception and assimilation of engineering subjects through combined learning styles. The tests configured in this chapter consider the psychological aspects of a tested person, allowing responses to consider the diversity of the social context and the individual's adaptation to this diversity.

Test 1 analyzes the individual perception and learning preferences of Generation Z engineering students, who are accustomed to a variety of communication channels, often different from the preferences of professors who belong to other generations (X and Y). These differences create a need for implementing a teaching and learning system adapted to the individual or collective preferences of Generation Z students.

Test 1 focuses on the four perception and learning styles—classic (read-write), auditory, visual, and kinesthetic—with 10 questions proposed for each style, totaling 40 questions. In developing the system for evaluating and analyzing perception and learning styles, the test was structured and conducted in multiple phases. Initially, necessary items were selected and collected from the bibliographic reference framework. This preliminary stage aimed to establish a useful database for subsequent question formulation within the test. Based on item selection, questions were formulated and designed to accurately capture the characteristics of preferred learning styles. *Test 1* identifies learning styles in general through the configured questions, psychologically drawing on a wide range of life approaches (such as focusing, deciphering a map on a trip, etc.).

Through *Test 1*, the percentages of perception and learning styles can be revealed, but only in a general sense. To optimize the teaching-learning methods for engineering subjects, it is necessary to identify how the percentages provided by *Test 1* should be allocated across the different phases of teaching and learning (teaching/learning theory; teaching/learning diagrams and algorithms, etc.). Thus, the goal is to clarify the allocation of these percentages (when the auditory or classic style or other learning styles or combinations are preferred). Consequently, the research methodology proposes in the applied part (Pillar III) of the Temple of Teaching and Learning dedicated to Generation Z the use of *Test 2*, where students are tested to verify various processes, they approach in perception and learning (how they perceive information during teaching, how they prefer to assimilate it, how they prefer to experience it).

Test 2 is built upon *Test 1* and contains 14 questions to specifically identify the structuring of engineering course modules using the four teaching-learning styles for theoretical, algorithmic, design aspects, as well as learning/assimilation methods during exam sessions, etc. In this regard, the conceptualization, development, and bibliographic research conducted for *Test 1* is extremely useful for *Test 2*, as they share common foundations, supplementing and complementing each other to a significant degree.

Chapter 5, titled "**Implementation of the proposed model using intelligent tools**" achieves the last two specific objectives of the thesis and, implicitly, its declared purpose. In the first part of the chapter, the two tests are implemented using the Microsoft Forms platform.

Following the generation of *Test 1* and data collection, the percentages of learning styles are identified and interpreted. The data collected from the Excel sheet generated by *Test 1* are subsequently used to configure and train two artificial neural networks (ANNs), one in *NeuroShell* and the other in *MatLab*. The purpose of configuring and training the ANNs is to obtain an intelligent system capable of quickly testing a limited number of students, members of a study group, and providing a real-time prediction of preferred teaching-learning styles. By training the two ANNs, favorable results were obtained in evaluating learning preferences (an R-Square coefficient of 0.9972 for data trained in *NeuroShell* and a coefficient of 0.9021 for data trained in *MatLab*), ensuring data consistency and strong predictive performance.

Test 2 was implemented to identify how a student might perceive an engineering subject and, additionally, how the student might learn the course notes for the exam.

Connecting ANN responses with the responses from *Test 2* provides insights for adapting the teaching of engineering course modules. The ANNs were configured to quickly predict the percentage of perception and learning styles for an individual, a group, or a class of students. The data were consistent, as similar results emerged in both programs (they trained at the same speed, with equally strong parameters and similar predictions). The chart in Fig. 5.16 compares the data obtained using *Test 1* with the ANN outputs (targets) from *MatLab*, illustrating data stability and the ANN's strong predictive capacity, which provides almost identical data to those calculated from the *Test 1* outputs.

Test 2 indicates the allocation of style percentages and identifies actions where the classic style is useful (in our case, for introductory material, theory in general, and learning stages) and which parts prefer the kinesthetic style (in the experiential phase). *Test 2* clarifies the percentages obtained from the ANN. The two intelligent systems based on ANN have subsequently become predictive tools for learning styles among Generation Z students.

From the data analysis conducted, it was observed that all the primary learning styles are preferred (auditory, classic, visual, and kinesthetic) and combinations thereof emerged.

In designing models to adapt engineering course modules, concentration-enhancing techniques were integrated, based on the *"7 Habits of Highly Effective People,"* which include Covey's *"4 Ways of Renewal"* or *"Sharpen the Saw"* method [15]. Specifically, for the *"4 Ways of Renewal,"* actions are proposed that can be integrated throughout the learning/teaching process. For physical renewal, it is recommended to balance time spent with digital technology with equal time in nature or physical activities—a relay-based workshop; for social/emotional renewal, balancing individual study periods with similar workshop times is proposed; for spiritual renewal, stress from difficult course modules should be offset by breathing exercises or relaxing background music; and for mental renewal, stress from challenging course modules should be balanced with logic-based exercises.

The final solutions integrate all 7 habits, with course module adaptation initiated by Habit 2 (establishing the end goal of each course module), setting priorities with Habit 3 (time management), and the proposed solutions in the thesis are based on proactivity, communication rules, a win-win model, and empathy (see Fig. 5.24).

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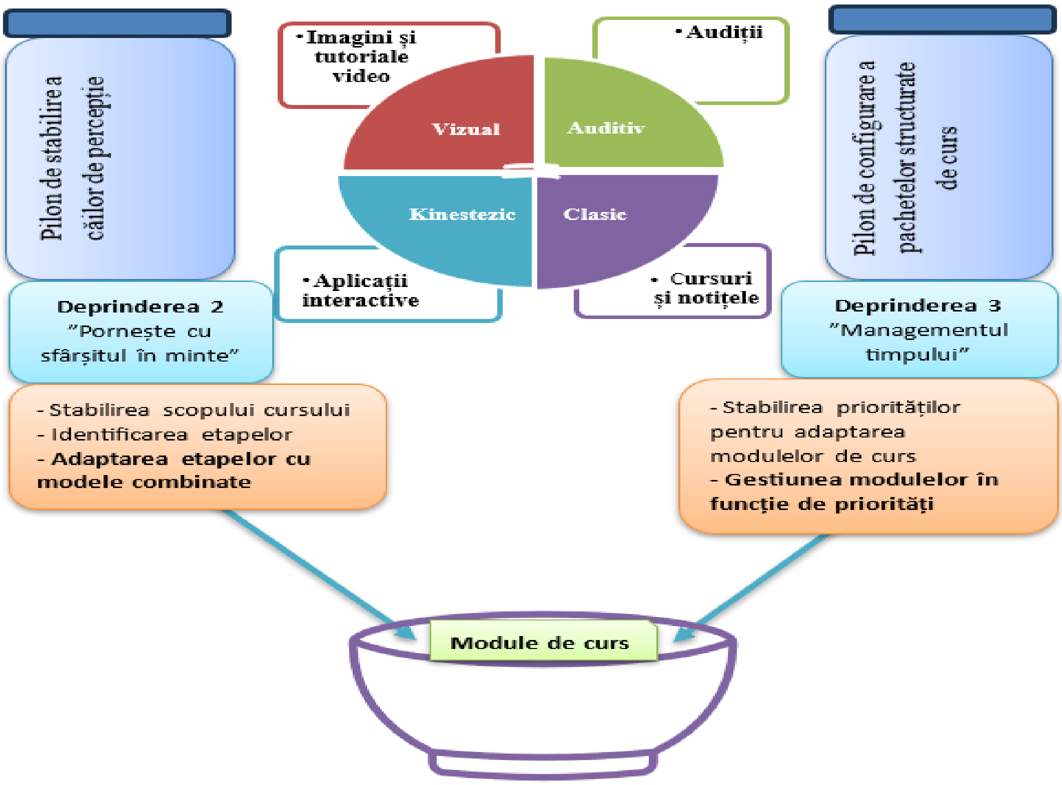

Fig. 5. 24 Proposal for restructuring course modules

The results of the two *ANNs* can be combined with the analyses in Excel generated by *Test 2*, providing teachers with essential information for adapting engineering courses dedicated to Generation Z.

The proposed model optimizes the teaching and learning process based on each course participant's individual styles, also generating methods for fostering study group cohesion. The model proposed in Fig. 5.24, *Proposal for Restructuring Course Modules*, integrates communication skills, adapting the stages of course content delivery with the combined learning styles preferred by Generation Z students.

To demonstrate the functionality and applicability of the results from the *ANNs*, connected with the derived combinations of learning and teaching styles (Fig. 5.23) as identified through *Test 2*, the following parameters are considered: the time required for knowledge transfer and the quality of knowledge transfer.

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CLA	AUD	VIS	KIN	TOTAL	CL%	AUD%	VIZ%	KINES%			
Cla	AUD	VIS	KIN	total	Cla	Aud	Vis	Kin	Max	Sel	Pattern
6	7	7	7	27	22.22%	25.93%	25.93%	25.93%	25.93%	Aud+Vis+Kin	Aud+Viz+Kin
3	9	8	8	28	10.71%	32.14%	28.57%	28.57%	32.14%	Aud	Aud+Kin
4	8	6	8	26	15.38%	30.77%	23.08%	30.77%	30.77%	Aud+Kin	Aud+Viz
2	6	4	6	18	11.11%	33.33%	22.22%	33.33%	33.33%	Aud+Kin	Cla+Viz+Kin
8	9	5	9	31	25.81%	29.03%	16.13%	29.03%	29.03%	Aud+Kin	Cla+Aud
7	**8**	5	7	27	25.93%	29.63%	18.52%	25.93%	29.63%	Aud	Cla+Aud+Kin
5	6	4	**10**	25	20.00%	24.00%	16.00%	40.00%	40.00%	Kin	Cla+Aud+Viz+Kin
2	3	6	4	15	13.33%	20.00%	40.00%	26.67%	40.00%	Viz	Cla+Kin
8	8	5	9	30	26.67%	26.67%	16.67%	30.00%	30.00%	Kin	Cla+Viz
7	**10**	6	8	31	22.58%	32.26%	19.35%	25.81%	32.26%	Aud	Viz+Kin
4	4	5	4	17	23.53%	23.53%	29.41%	23.53%	29.41%	Vis	Cla
7	5	6	**9**	27	25.93%	18.52%	22.22%	33.33%	33.33%	Kin	Aud
7	7	7	7	28	25.00%	25.00%	25.00%	25.00%	25.00%	Cla+Aud+Vis+Kin	Vis
7	9	8	9	33	21.21%	27.27%	24.24%	27.27%	27.27%	Aud+Kin	Kin

Fig. 5.23 Preferred learning styles

In demonstrating the functionality of the proposed system, the engineering course titled **Intelligent Systems in Electrical Engineering (SIE)**, taught at the bachelor's level in the **Engineering and Management** field, fourth year of study, is considered. In the first part of the course, introductory notions are taught, including definitions; intelligent systems and expert systems, specifying application domains and block systems for understanding specific concepts; mathematical logic, covering all logical connectors, propositional logic, and deduction rules. This continues with *Knowledge Base Representation* through several methods, each configured as a course module, as follows: **Method 1:** First-order predicate representation; **Method 2:** Semantic networks.

Although the resulting percentage for classic and visual teaching is quite low (approximately 30%), it still represents nearly one-third of the teaching method for this subject. In demonstrating the model's functionality, it is considered appropriate for this percentage allocation to apply to introductory theoretical parts that do not present a high degree of perception difficulty.

Course modules (introductory theory, glossary of terms, definitions, etc.) will be taught in a classic, auditory, and visual manner, using the traditional lecture method, supported by PowerPoint course materials and resources uploaded to digital learning platforms (Virtual Campus, faculty website). In the specific case of the engineering course *SIE*, the introductory part is configured in a classic and visual manner. For knowledge base representation, it becomes necessary to adapt the teaching method by introducing auditory and kinesthetic modules. The auditory and kinesthetic modules represent over 70% of the teaching method. For this reason, in demonstrating the proposed model's functionality, solutions have been sought to merge the classic method with specific auditory and kinesthetic methods. The following are original solutions for reconfiguring the teaching method through the proposed course module adaptations.

The goal of the first adapted course module is the knowledge transfer for the **First-Order Predicate Representation** method. Introductory notions, including the glossary of terms and course evolution stages, are presented in the classic manner (PowerPoint slides and materials posted on specific platforms). The **First-Order Predicate Representation** method is based on the propositional function of first-order predicates. Thus, the knowledge piece is expressed in natural language, decomposed into elementary statements called assertions, represented with the first-order predicate, placing each assertion's predicate before a parenthesis. Inside the parenthesis, the object of predication is listed first, followed by the rest of the nominal group. To streamline the teaching process, a new application is proposed, to be resolved interactively with all present students.

The solutions proposed in the thesis verify the efficiency of knowledge transfer from teacher to student in real time. In this regard, immediately after presenting the theory and application, two auditory and kinesthetic methods were proposed and experimented with, as follows: **The Socratic Method [SM]** (original adaptation); **The Multi-Level Learning Method [MLM]** (original configuration).

In the first stage, *SM* is applied, which develops critical thinking and understanding of complex concepts. Through successive questions, the teacher verifies students' understanding of the taught algorithm: starting with an inductive and reflexive dialogue, students are logically guided through propositional analysis to identify assertions within the knowledge piece (Examples of questions: "What are the predicates within the knowledge piece?"; "What is the first assertion?"). However, this method also has certain limitations, namely: without the participation of all students in the course, this method loses effectiveness; some students fear public speaking and therefore do not engage.

In the proposed solution, addressing these limitations is considered, and for this purpose, the application of the following original method is proposed: **Multi-Level Learning [MLL].** Through the Socratic dialogue, predicates and assertions have been identified, and the next step is to represent and generalize the knowledge piece itself. This process can be achieved through **MLL** (original method), which is conducted under the following conditions:

- students who did not participate in the Socratic dialogue likely have gaps in understanding. Therefore, only a few students fully understood the explanations and will complete the knowledge piece representation in a relatively short time;
- the professor continuously monitors activity in the classroom, and when students who have understood and completed the task are identified, the professor validates their work and invites them to act as junior consultants (assistants);
- in the next stage, the professor divides the students into study groups and begins giving explanations directly to these groups, this time with the help of the junior consultants. This way, the professor can focus on explaining to a smaller group of students at a time, focusing solely on their understanding (empathy is applied), while junior consultants provide necessary explanations to other groups;
- once other students have completed the task and understood it, they are also designated as junior consultants, and the process continues until all students have understood and successfully completed the knowledge piece representation.

I. The verification of the ***SM*** and ***MLL*** methods was conducted with a group of students specializing in Engineering and Management, who studied the course “Intelligent Systems in Electrical Engineering”. Twenty-two students attended the class. The course focused on teaching the knowledge representation method using “First-Order Predicates”. The class began at 12:00 and was conducted in three stages, as follows::

1. In the first stage, the theory and an application were taught in a classic and visual manner (lecture using PowerPoint slides and written explanations on the board). As the application was presented, the theory was revisited in an applied manner. This stage lasted **40** minutes. Students were informed that two more stages based on creative methods would follow, and they were advised to focus on the theoretical part and its applicability.

2. In the second stage, which lasted **5** minutes, a new application was introduced using a new PowerPoint slide. The ***SM*** method was applied. All students were involved and were each quickly asked a question related to solving the new proposed application. For the questions asked through the ***SM*** method, only **36.4%** of the students (**8** students) answered correctly.

3. In the third stage, the ***MLL*** **Method** was applied. **The *MLL* Method** began at 12:45. Each student was required to solve the proposed application individually. The first students to solve the application correctly were part of the group of 8 students who had correctly engaged in the ***SM*** **Method**. The ***MLL*** **Method** progressed as follows:

- At 12:55, 2 students (9%) successfully completed the application, and after discussing with the professor, they were designated as “junior consultants.” They then assisted classmates who requested help, providing explanations. The success of this method is based on the fact that Generation Z students received explanations from “junior consultants” who are also Generation Z students.
- At 1:00 PM, another 2 students (9%) correctly completed the application and, after discussing with the professor, also became “junior consultants.”.
- Over the next 5 minutes, the “junior consultants” assisted another 4 students (18.18% of the total students), meaning that a total of 8 students (over 36%) became “junior consultants”.
- By 1:10 PM, all 22 students had completed their tasks, and the workshop, based on the ***MLL*** **Method**, concluded.

The grade-based assessment of the 22 students was as follows:

- 8 students (36.4%) ("junior consultants") received a grade of 10.
- 4 students (18.18%) received a grade of 9.
- 5 students (22.72%) received a grade of 8.
- 5 students (22.72%) received a grade of 7

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The validation of the SM and MLL methods was confirmed by the fact that knowledge transfer was achieved for all students present, with the lowest grade being 7.

The second course module addresses the representation of the knowledge piece through the semantic network. The basic elements, used as introductory items for representing the knowledge piece by mapping the connections between the concepts that comprise it, are taught through lecture and supported by PowerPoint slides and materials posted on platforms commonly used by students for educational purposes. Specifically explained are concepts or nodes, represented by entities within the knowledge domain, links, arcs, or relationships, etc. The solution proposed within this module also verifies the efficiency of knowledge transfer in real time. In this regard, immediately after presenting the theory and application, the ***Collective Notebook Creation (CNC)*** **Method** (an original method) was proposed, involving both **visua**l and **kinesthetic** participation.

The implementation of the ***Collective Notebook*** **method**, with the professor as the guide/facilitator of the entire process, is carried out as follows:

1. In the first part of the course, the theoretical content and its applicability are presented using the classic and visual method (lecture, PowerPoint slides, written explanations on the board)..
2. In the second part of the course, the ***Collective Notebook Creation (CNC)*** **Method** is applied. The **CNC** solution should configure a semantic network for a piece of knowledge, aligned with the professor's theoretical explanations, using a creative combination of kinesthetic, auditory, and visual styles..

- First step: Teams of 3-4 students are formed.
- Second step: Each student takes a sheet of paper and attempts to configure the semantic network for the proposed piece of knowledge (5 minutes of work time).
- Third step: After 5 minutes, the papers are exchanged from right to left, with each student passing their paper to the colleague on their left. Each student analyzes what the colleague to their right has done and then completes or corrects it according to their own thinking. The purpose of the exchange is creative, allowing students to adjust each other's problem-solving approaches without criticism.
- Fourth step: After another 5 minutes, the papers are exchanged again from right to left, and the process repeats until each student receives their original paper back.
- Fifth step: Once all exchanges are completed, the consensus-building procedure begins to establish the final representation.

Verification of the ***CNC Method*** was conducted with a group of students specializing in *Engineering and Management,* who studied the course titled *"Intelligent Systems in Electrical Engineering."* A total of 32 students attended the course. The lecture focused on teaching the method of *knowledge representation using semantic networks.* The course began at 12:00 PM and was structured into three stages, as follows:

1. In the first stage, the theory was presented and illustrated with an application. This stage

lasted **20** minutes. The students were informed that two more stages would follow, based on a creative method, and were advised to focus on the theoretical part and its applicability.

2. In the second stage, which lasted **10** minutes, two expression options were presented, using logical representations of the semantic network's meaning from the application demonstrated by the professor.

3. In the third stage, the ***CNC Method*** was applied. The ***CNC Method*** began at 12:30 PM. Students were required to configure a semantic network for a piece of knowledge similar to the one demonstrated.

First step: teams are configured (8 teams of 4 students each).

Second step: each student takes a sheet of paper on which they try to configure the semantic network for the piece of knowledge (work time: 5 minutes).

Third step: after 5 minutes, the sheets were passed from right to left, with each student handing their own sheet to the colleague on the left. Each student analyzed what their colleague on the right had done and added or corrected it according to their own thinking. The purpose of the exchange is a creative one, allowing students to adjust each other's problem-solving approach without criticizing one another.

Fourth step: after another 5 minutes, the sheets were again passed from right to left, and the process was repeated until each student received back their original sheet.

Fifth step: After all exchanges were completed, a consensus-reaching procedure began for the final representation. The goal of these procedures is to apply communication techniques among Generation Z members, both for problem-solving and for reaching consensus. Within each group, students discussed and explained their ideas to one another, selecting the option they deemed best. It was observed that the students communicated very effectively, in line with Generation Z's communication style.

At 12:55 PM, the first group correctly completed the application, and by 1:15 PM, all 8 teams had finished the application.

Validation of the ***CNC Method*** was confirmed by the fact that knowledge transfer was achieved for all students present.

The proposed methods ***SM***, ***MLL***, and ***CNC*** are very useful for reconfiguring the teaching approach of study subjects for Generation Z. These methods were validated by the fact that knowledge transfer was successfully achieved for all students present at the time of their implementation.

Chapter 6, titled ***"Conclusions,Personal Contributions, Research Perspectives, and Research Limitations"*** present the final conclusions of the research within this thesis, the author’s personal contributions,future research directions, and the limitations of the research from the author’s perspective.

The validation of the contributions was achieved through the publication of six scientific papers as follows: two scientific papers published in Web of Science journals (Q4), one paper presented at an International Conference, currently in the process of publication in a Web of Science journal, and two papers presented at International Conferences, published in the conference proceedings.

This work has investigated a current topic for the contemporary educational environment—namely, the identification of learning techniques and methods suited for Generation Z students. The research topic emerges from understanding how Generation Z students, who are deeply connected to the digital environment, assimilate and perceive information differently, leading to the following conclusions:

- Currently, the concept of a group and its attributes are expressed differently across the three generational types (X, Y, Z).

- The preferences of members of the three generations (”X”, ”Y”, and ”Z”) cannot align in unison, as they lack commonalities and shared characteristics. Members of Generation X are proponents of traditionalism and morality, while members of Generation Y are not satisfied with moral incentives alone, preferring personal development combined with material rewards. Generation Z members, in addition to being highly pragmatic, are also interested in achieving a perfect balance between personal and professional life.
- Communication among the involved social actors has become quite complex due to differences in perception and expression among members of the three generations.
- It is necessary to find or conceptualize a way of relating, in general, for students and industry employees who currently belong to Generation Z, as well as managerial methods for group cohesion, regardless of intergenerational connections.
- The individual learning preferences of today's students, who are members of Generation Z and accustomed to a multitude of communication channels, often differ from the teaching preferences of professors, who belong to Generation X and Generation Y.
- These differences lead to *the need for implementing a teaching and learning system that is also adapted to the individual or collective preferences of those involved*.
- In conclusion, the tests configured within this chapter take into account the psychological aspects of the individual being tested, so that the responses can reflect the diversity of the social context and the individual's adaptation to this diversity.
- The proposed model, through the ***Teaching and Learning Temple*** methodology dedicated to Generation Z, connects the results of the two ANN analyses with the data from the ”Excel” application generated by *Test 2*, providing teachers with the necessary information to adapt engineering courses for Generation Z. The model optimizes the teaching and learning process according to the individual styles of each course participant and also generates methods for fostering cohesion within the study group.
- The model proposed in Fig. 5.24***, Proposal for Restructuring Course Modules,*** optimizes the teaching and learning process according to the individual styles of each course participant, also generating methods for study group cohesion. The model integrates communication skills, adapting the stages of course material delivery with combined models of learning styles preferred by Generation Z students..
- The proposed solutions ***SM, MLL,*** and ***CNC*** are very useful for reconfiguring the teaching approach of study subjects for Generation Z, validated by the fact that knowledge transfer was successfully achieved for all students present at the time of their implementation.

Personal Contributions:

Theoretical Contributions

	Page
- *Analysis and synthesis of the bibliographic references on the concept of a group and its attributes, in connection with Generations X, Y, and Z*	*19*
- *Identification of the major differences among the three generations X, Y, and Z, and possible ways to help bridge and reduce the gaps between these generations*	*56*
- *The original conclusion regarding interaction, interdependence, and identity status (see Fig. 2.1), wherein identity status is based on the dynamics of interaction and the strength of interdependence, but also requires a shared vision to support them*	*59*

- *Critical analysis of the six learning models and identification of major advantages and disadvantages* *77*
- *Systematization of the identified limitations in the analyzed learning models, with the aim of developing suitable learning and teaching methods for Generation Z* *78*

Methodological Applicative Contributions:

Page

- *Configuration of the research methodology through the model called the 'Teaching and Learning Temple dedicated to Generation Z”* *81*
- *Conceptualization of Test 1 for identifying preferred learning styles* *83*
- *Development of Test 2 for identifying combined methods of perception and assimilation of engineering subjects* *95*

Experimental Applicative Contributions:

Page

- *Generation of Test 1 using ”Microsoft Forms”* *98*
- *Identification and interpretation of the percentages processed in the Excel application, generated by Test 1* *99*
- *Configuration and training of the ANN in ”NeuroShell"* *101*
- *Configuration and training of the ANN in ”MatLab"* *106*
- *Generation of Test 2 using ”Microsoft Forms"* *117*
- *Identification and interpretation of the percentages processed in the ”Excel” application, generated by Test 2* *119*
- *Adapting the four renewal pathways included in the teaching/learning process of engineering disciplines: Proposal for restructuring engineering course modules to suit Generation Z's perception* *120*
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Future Perspectives:

Considering the results of this doctoral thesis, the applicability of the developed models could be extended to other educational fields to better adapt to the diverse needs of future generations.

Additionally, the increased implementation of Artificial Intelligence within the educational process could reveal new opportunities for continuous adaptation and personalization of the learning process through methods that directly perceive a person’s focus during learning, such as gaze perception, gesture analysis, or dedicated tests based on knowledge bases.

Model Limitations:

The model cannot generate course module adaptations for all types of engineering subjects. Some subjects use laboratory instruments or software and hardware programs for which the proposed solutions are not suitable.

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