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Artículos científicos

Una perspectiva sistémica en el proceso de enseñanza-aprendizaje de las matemáticas en el nivel educativo superior

A Systemic Perspective in the Teaching-Learning Process of Mathematics at the Higher-Level Education

Uma perspectiva sistêmica no processo de ensino-aprendizagem de matemática no nível superior

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Resumen

El trabajo colaborativo representa una base de mejora para el proceso de enseñanza-aprendizaje de las matemáticas en el nivel educativo superior y las Comunidades Profesionales de Aprendizaje (CPA) constituyen una herramienta útil para tal propósito. En esta investigación se tuvo como objetivo aplicar los postulados de la Metodología de Sistemas Suaves (SSM) y CPA a fin de establecer las bases para la construcción de una metodología sistémica que promueva cambios en la práctica docente. Se efectuó un taller dirigido a profesores en donde se analizaron técnicas de colaboración entre pares y el desarrollo de materiales didácticos digitales para mejorar su práctica docente. Las entrevistas y observaciones se interpretaron mediante tres esquemas de codificación: *1)* para comprender las respuestas de los participantes a lo largo del taller, *2)* para examinar las propuestas de enseñanza que implementan con sus estudiantes y *3)* para capturar oportunidades de aprendizaje en las CPA. Con base en el planteamiento teórico adoptado y los resultados obtenidos, se identificaron varios elementos de la SSM y CPA que abonan al mejoramiento de la práctica docente y a la calidad del aprendizaje de las matemáticas de nivel superior: desde aceptar la existencia del problema e interpretarlo en una forma ordenada hasta describir las definiciones raíz del sistema, así como sus interrelaciones.

Palabras clave: Comunidades Profesionales de Aprendizaje, metodología sistémica, práctica docente.

Abstract

Collaborative work represents a basis for improvement in the teaching-learning process of mathematics at the higher educational level and Professional Learning Communities (PLC) constitute a useful tool for this purpose. The purpose of this research was to apply the postulates of the Soft Systems Methodology (SSM) and PLC were applied to establish the bases for the construction of a systemic methodology that promotes changes in teaching practice. A workshop was held for teachers where peer collaboration techniques and the development of digital teaching materials were analyzed to improve their teaching practice. The interviews and observations were interpreted using three coding schemes: *1)* to understand the answers of the participants throughout the workshop, *2)* to examine the teaching proposals that they implement with their students and *3)* to capture learning opportunities in the PLC interviews. Based on the theoretical approach adopted and the

results obtained, several elements of the SSM and PLC were identified that contribute to the improvement of teaching practice and the quality of higher-level mathematics learning: from accepting the existence of the problem and interpreting it in an orderly manner to describing the root definitions of the system, as well as its interrelationships.

Keywords: Professional Learning Communities, systemic methodology, teacher practice.

Resumo

O trabalho colaborativo representa uma base de melhoria para o processo de ensino-aprendizagem da matemática no ensino superior e as Comunidades de Aprendizagem Profissional (CAP) constituem uma ferramenta útil para esse fim. O objetivo desta pesquisa foi aplicar os postulados da Metodologia Soft Systems (MSS) e CAP a fim de estabelecer as bases para a construção de uma metodologia sistêmica que promova mudanças na prática docente. Realizou-se um workshop para professores onde foram analisadas técnicas de colaboração entre pares e o desenvolvimento de materiais pedagógicos digitais para melhorar a sua prática pedagógica. As entrevistas e observações foram interpretadas usando três esquemas de codificação: 1) para entender as respostas dos participantes ao longo da oficina, 2) para examinar as propostas de ensino que implementam com seus alunos e 3) para capturar oportunidades de aprendizagem no CAP Com base na abordagem teórica adotada e nos resultados obtidos, foram identificados vários elementos do MSS e do CAP que contribuem para a melhoria da prática pedagógica e para a qualidade da aprendizagem da matemática de nível superior: desde aceitar a existência do problema e interpretá-lo de forma ordenada maneira de descrever as definições de raiz do sistema, bem como suas inter-relações.

Palavras-chave: Comunidades Profissionais de Aprendizagem, metodologia sistêmica, prática docente.

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Introduction

Countries that perform well on science and mathematics assessments are those that provide clear, consistent and coherent support systems for teachers (Fulton & Britton, 2011). To a large extent, this happens because good teachers work in every school in these nations, who exercise their profession with leadership and have the support to create a teaching-learning culture among their colleagues and students.

The theoretical approaches developed around the Professional Learning Communities (PLC) (Little, 2002) define these as a group of people who share and critically question their teaching practice in a continuous, reflective, collaborative, inclusive, learning-oriented and that promote the professional growth of all involved (Stoll, Bolam, McMahon, Wallace & Thomas, 2006). Collaborative work among colleagues has had excellent results in various educational systems and areas of knowledge, including mathematics (Horn, 2010; Vescio, Ross, & Adams, 2008). The development of PLCs at the elementary, middle, and high school levels of education has been extensively studied and important results have been achieved (Dooner, Mandzuk, & Clifton, 2008; Ell & Major, 2019; Fulton & Britton, 2011; Horn, 2010; Huijboom, Van Meeuwen, Rusman, & Vermeulen, 2021; King, 2014; Liu, Lu, & Yin, 2022; McLaughlin & Talbert, 2007; Schneider & Kipp, 2015; Vescio et al., 2008). However, the study and development of PLCs with higher level mathematics teachers is a subject that has not been dealt with much. Therefore, it is relevant to contribute to this field of study from the Systemic Paradigm, in order to promote teaching and learning environments that improve both the academic performance of students and teaching practice.

In academic meetings with professors who teach mathematics classes, problems that are faced in the classroom are commonly talked about and discussed, such as the low performance of the students, the lack of interest in learning and the dropout rate during and at the end of the term. semester. Based on the above, we ask ourselves the following question: what elements, relationships and characteristics should a PLC of higher-level mathematics teachers have, in such a way that they allow improving the academic performance of university students who study mathematics subjects?

According to Dogan, Pringle and Mesa (2016), Dooner et al. (2008), Fulton and Britton (2011), Horn (2010), McLaughlin and Talbert (2007), Popp and Goldman (2016), and Schneider and Kipp (2015), establishing a PLC has the potential to manage respect, trust and collaborative work among teachers, which translates into more efficient work in the classroom. The fact that the teachers' meetings have a clear purpose related to specific topics

of the discipline becomes a crucial axis so that the community does not only meet to agree and discuss any topic. To avoid redundant situations, it is extremely important to establish clear objectives and make explicit the strategies that will be implemented to achieve them. The fact that teachers have the opportunity to reflect and question their work in the classroom implies a paradigm shift regarding the belief in how to teach mathematics (Salas, 2012).

Since the problem to be studied involves, individuals making a great effort to organize themselves, it is necessary to reach agreements to positively influence the learning process of their students; that is why a systemic perspective is suggested for its approach. This perspective is developed considering the postulates of the Soft Systems Methodology (SSM) (Checkland, 2001) to propose a dynamic construct of PLC. According to Ramírez, Cardoso and Tejeida (2020), SSM is a System Science methodology that has been widely used and tested when solving complex problems that afflict organizations in various sectors of the population.

From the above, the objective of this research arises, which is to apply the postulates of the SSM and the PLC in order to establish the bases for the construction of a systemic methodology that promotes changes in teaching practice and thereby contributes to the improvement of the process. teaching-learning of higher-level mathematics. In this research we want to promote new forms of collaborative work, through theoretical foundations that allow us to lay the foundations to generate a systemic methodology that serves as a starting point to develop and implement PLC with higher-level mathematics teachers, and with it promote the improvement of the academic performance of university students.

Theoretical framework

The PLC model has had a great boom at the basic and upper secondary levels and has evolved in its implementation; however, the path has not been easy. According to DuFour (2004), the intentions are good, it begins with excellent enthusiasm, however, there is usually a fundamental confusion in the execution of the theoretical concepts involved, since it is believed that just having meetings of the teaching union will be enough, coupled with an inevitable adoption of problems associated with curricular reforms inherent to the educational system. Therefore, it is necessary to take into consideration the following bases to build a PLC: 1) ensure that students learn, 2) build a culture of collaboration and 3) focus on results and objectives. These three ideas require a systematic process in which teachers work together to analyze and improve their teaching practice, and where meaningful and

collaborative learning is promoted among their students through strategies that adapt to the reality of the classroom.

In the case of building a culture of teacher collaboration, Little (2002) proposes to focus on the representation of practice, collaborative work aimed at increasing the quality of learning and the norms of interaction and organization. In the case of representation of practice, Dogan et al. (2016) refer to the fact that in the conventional educational environment, science teachers are required to have in-depth knowledge about the development of specific learning practices, consistent with how their students learn, so the change in teaching practice must be seen driven by the incorporation of instructional techniques, the integration of new materials, improvements in study plans and programs, and improvements in the teaching process. In addition to these characteristics, these authors add two other factors: knowledge of the disciplinary content, which refers to a degree of specialization of teachers, and knowledge of pedagogical strategies, which facilitates student learning.

Collaborative work is conceptualized as a process in which all the people involved interact in such a way that they can differentiate, contrast and discuss points of view proposed in the group, which translates into the construction of knowledge. Regarding the norms of interaction and organization, Popp and Goldman (2016) found five types of discourse that strengthen joint work in PLCs: 1) interrogative, where the ideas of team members are made explicit, qualified, and expanded; cluster; 2) purposeful, in which proposals are necessary to build collective knowledge; 3) articulation of ideas, where examples of teaching and learning strategies are provided; 4) negotiation, where agreements are established with the purpose of resolving possible conflicts that may arise, and, finally, 5) where the reasoning is explained, this leads to the scrutiny and analysis of ideas to reach a consensus on complicated issues.

School leaders have a strong influence on the development and success of PLCs, so it is important to consider the steering factors: leadership, collective autonomy and ease of group dynamics, analyzed in Huijboom et al. (2021).

As can be seen, there are several factors that must be considered for the creation of PLC from the pedagogical-didactic point of view, and to achieve the purpose of this research and strengthen our theoretical approach, we use as scaffolding some of the knowledge of the body of knowledge of Systems Science. Within its body of knowledge, there are concepts and theories, a paradigm or research method that uses its own metamethodologies, models and methodologies for its treatise.

Precursor of Systems Science, the General Systems Theory opens a gap in the path of proposing solutions to complex situations to which human beings have tried to find an order (von Bertalanffy, 2018). At present, the day to day is organized through institutions, which, for the most part, show complex organization processes that require structured and well-defined mechanisms. Systems Science focuses on discovering and interpreting the dynamics of the relationships and conditions between the actors and entities of a system, as well as the principles and isomorphies that can be discerned and applied to it at any level of nesting to achieve its purpose in homeostatic balance with its context.

For van Gigch (2016), "a system is a collection or set of related elements" (p. 17); Of course, its elements can be varied, depending on what is being studied, but there will always be a purpose of the system. To understand and interpret a system, Systems Science has its paradigm, approach or thought. Pham and Jaaron (2018) argue that Systems Thinking is normally seen as a solid and favorable current when it comes to offering complementary strengths to the traditional currents of the disciplines.

Systemic Thinking offers a comprehensive vision when addressing complex problems that are characterized by having a wide variety of actors and interrelationships that constitute subsystems and are part of a total system. The use of this thought is becoming more and more recurrent in the field of educational research (Hurst, 2020; Kordova, Frank & Nissel, 2018; Molderez & Ceulemans, 2018; Nyemba, Carter, Mbohwa & Chinguwa, 2019; Parra, 2022; Paschalidou, Salta and Koulougliotis, 2022; Pham and Jaaron, 2017). In our research, the system is structured by interrelated concepts, objects and subjects with a purpose and the exchange of information in a very specific environment, the school. The problems that emerge from the systems are the responsibility of the administrators, planners or analysts, among other figures, who have to differentiate between the improvement of a system or the design of one. Improvement transforms or changes a system in such a way that it behaves in a standard or normal way. In the case of design, this is a creative process that studies, interprets and questions the assumptions from which the system has been made. However, the difficulties lie not only in the complexity of the study phenomena, but in all the entities involved (von Bertalanffy, 2018).

A system is made up of various parts. Therefore, if we know the total number of fragments and the relationship between them, it is said that the behavior of the problem is derivable from the behavior of the parts. “It seems that the primary thing is the behavior resulting from the interaction within the system; Secondarily, there is the determination of

the elements to actions that only depend on them, which leads to summative behavior" (von Bertalanffy, 2018, p. 71).

In order to study and select, in a well-founded way, the application of a systemic methodology in a given problem, metamethodologies have been developed in Systems Science. One of them is the Total Systems Intervention Metamethodology, which, through matrices, helps to identify the relationship of the participants with decision-making and the type of system in which the problem emerges (Jackson, 2003). In the Context-Problem Matrix, systems are categorized into simple and complex (table 1). A simple system is characterized by having a reduced number of individuals, as well as a small number of interactions between them; For these reasons, these types of systems are somewhat closed to their environment, and are usually static. In the case of the complex system, there is a considerable number of elements and the interrelationships are vast; In general, these types of systems actively interact with their environment and tend to evolve. Regarding the relationships established by the participants, these are classified into three categories: unitary, where all those involved agree with the objectives, share interests and their beliefs and values are compatible; therefore, in decision-making, all individuals participate; pluralistic, the participants have different values and beliefs, they have different interests and objectives, however, there are agreements that lead them to achieve their objectives; coercive, this type of relationship is characterized by little common interest among the participants, there are conflicts and the only consensus that can be reached is through the use of force and the domination of one or several groups over others.

Table 1. Problem-Context Matrix

		Participants		
		Unitary	Pluralist	Coercive
System	Simple	Simple unitary	Simple pluralist	Simple coercive
	Complex	Complex unitary	Complex pluralist	Complex coercive

Source: Jackson (2003)

The Context-Problem Matrix, generated by Jackson (2003), is complemented by the Systems Methodology System (SMS), which includes six types of methodologies and models

categories according to the type of system and the characterization of the participants involved in it. the problem identified (table 2).

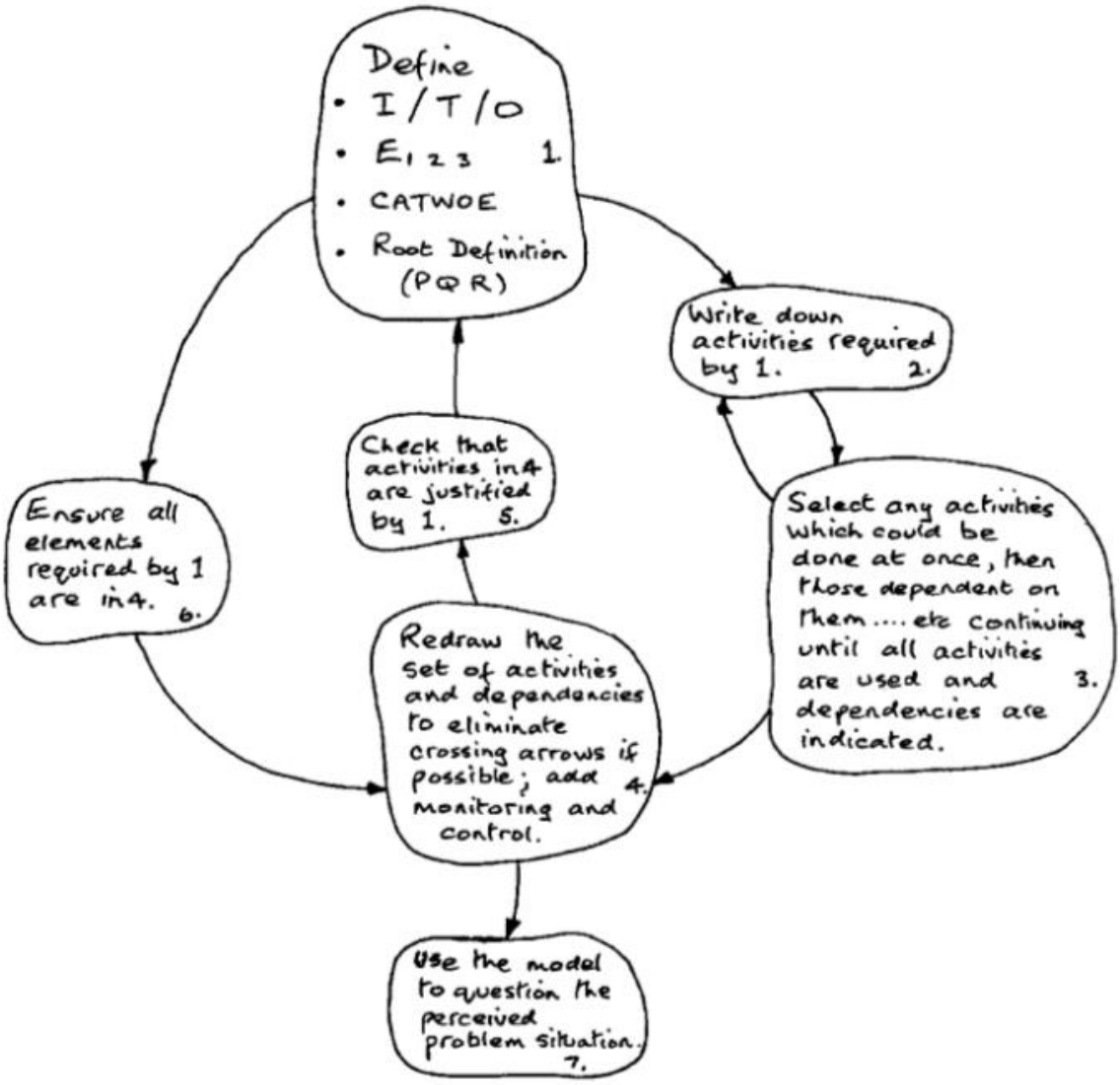
Table 2. Systems Methodology System

		Participants		
		Unitary	Pluralist	Coercive
System	Simple	Hard systems thinking	Soft systems	Emancipatory Systems
	Complex	System dynamics Complex theory Organizational cybernetics		Posmodern Systems

Source: Jackson (2003)

Another important tool for systems with a high social content in Systems Science, such as PLCs, is the SSM, developed by Checkland (2001). The SSM is a flexible methodology based on phenomenology and hermeneutics, it contains stages that are divided into the abstract world and the real world. The stages maintain a logical sequence, but they do not necessarily have to be developed in their entirety and in sequential order; rather, this will depend on the experience of the systems researcher, the nature of the system under study, and what is intended to be achieved for it (figure 1).

Figure 1. Soft Systems Methodology



Source: Checkland (2000; p. S32)

In the first two stages, the problem to be studied is defined, beginning by accepting the existence of the problem, and then interpreting it in a structured, organized way, which includes the activities and interrelationships of the elements that make it up. In the third stage, the root definitions of the relevant systems are described; In this description, the following approach must be made explicit: "a necessary system that allows carrying out an action x through y, which involves transformation processes, and thus reach the objective z". The construction of these root definitions is based on six factors: client (C), actors (A), transformations (T), worldview (W), owner (O) and environment (E), whose initials in English make up the acronym CATWOE. In the fourth stage, conceptual models are elaborated that represent the activities that will be carried out in the system; Therefore, there will be as many models as there are root definitions. Due to the nature of our proposal, in the

fourth stage we will start from the concept of a formal system, where the use of a general model will describe the human activity used to verify that the built models are not fundamentally deficient. In the fifth stage, the conceptual models are compared with reality, that is, the differences between what is described in the conceptual models and what actually happens in the system emerge. In the sixth stage, changes are proposed based on the differences detected in the previous stage. Said changes must be evaluated and approved by the actors of the system, in such a way that the viability of said changes is guaranteed. In the seventh stage, the proposed changes are implemented, designed to achieve the objective initially set.

Method

As mentioned, this research adopts a systemic perspective and uses the Systemic Paradigm, therefore, to base its treaty, the Total Systems Intervention Metamethodology was used, which was described previously.

Due to the characteristics of the population involved and the relationships and interactions that are projected from collaborative work, in this research a complex-pluralist system is visualized. Having this information, the SMS matrix is used, which presents useful systems approaches, depending on the type of system characterized by the context-problem matrix.

By locating the complex pluralistic system that is being addressed, in the SMS it is identified that the category "Soft systems" is the pertinent one, which is why the SSM was ideal for this investigation.

Derived from the above, the use of the SSM is based, since it allows us to give structure to something that does not have it, that is, it places the problem in such a way that its internal and external elements are identified and become relevant in the system (Ramírez et al., 2020). In addition to the informed selection provided by the total systems intervention metamethodology, the SSM has been used in problem solving in educational research (Cezarino, Liboni, Oliveira, & Caldana, 2016; Davis, Dent, & Wharff, 2015; Luong, Huynh and Kim, 2022; Shahabi, Azar, Radfar and Asadifard, 2020), which provides solid foundations for its application in the teaching-learning system of mathematics at the higher education level.

For the conformation of the investigative procedure, a methodological approach based on the synergy and complementarity of the theory of the PLC with the SSM was considered. Table 3 shows the integration of the PLC with the SSM.

Table 3. Proposed methodological approach

		Profesional Learning Communities			
		Ensure student´s learning	**Culture of teaching collaboration**	**Focus on goals and results**	
Soft Systems Methodology	**Unstructed problem**	Low academic performance is not perceived as a consequence of teaching practice.	The teaching community meets only deal with labor issues.	Professors works in isolation, attending to the objectives of the curriculum individually.	All the actors in the teaching and learning process are conceived as somewhat unconnected to school work, which is why the existence of a problem in this environment is not explicit or evident.
	Expressed problem	The need to improve the academic performance of students becomes evident.	Professors begin to bring to the table problems associated with their teaching practice and that influence the way they teach their classes.	The curriculum is present. The teaching staff makes explicit the objectives of each learning unit and proposals begin to emerge on how to achieve them.	Those involved in the teaching and learning process make aware and evident the existence of various problems that affect their development within the educational field.
	Root definitions	**C: Students** **A:** Teachers and school authorities. **T:** The goal is to transform the teaching and learning strategies implemented in the classroom.	**C: Professors** **A:** Teachers and school authorities. **T:** The aim is to transform the teaching practice through collaborative work and professional growth.	**C:** Students **A:** Teachers, school authorities and current Educational Model. **T:** It is intended to achieve the objectives set out in the curriculum.	For each of the stages it will be necessary to define our CATWOE factors. What is presented is only the generality of the System.

		W: Improvement of the academic performance of the students. **O:** PLC. **E:** School and extracurricular environment.	**W:** Improved professional service from teachers and opportunities for professional growth. **O:** PLC. **E:** School and extracurricular environment.	**W:** Improving the academic performance of students, professional growth of teachers and adequate school infrastructure. **O:** PLC. **E:** School and extracurricular environment.	
	Conceptual Models (CM)	They will describe what the System needs to do at each stage in an ideal way. How each activity of the actors should be connected and related to each other in a logical way. These models will show what must happen to achieve the objectives outlined in the previous point.			They are established from the Root Definitions.
	Comparison of CM with reality	Each MC must explain the purpose, operation, decision-making process, components that interact and the resources available to later compare the results with reality; whether the objectives were achieved or not. The members of the PLC will have the opportunity to analyze in depth their actions within the classroom.			For each stage of the PLC, the results of the proposals issued must be analyzed in such a way that it allows identifying areas of success or opportunity.
	Desing changes	Based on the results obtained from the previous stages, changes will be proposed if necessary. Note that the members of the PLC must analyze in depth the successes and errors of each of the proposals implemented in the teaching and learning process.			The restructuring of proposals will not be a trivial activity, which is why, if necessary, the Community must take extreme care in redesigning and re-implementing the suggested changes in the CM.
	Implementation of the changes	In the event that any change has been suggested and designed, it must be implemented in common agreement with all the members of the PLC, and then contrast it again with reality, and if any adjustment is required again, make it.			

Source: By the authors based on Salas, Morales, Tejeida y Moreno (2021)

It is important to highlight that this methodological proposal encompasses the problem that we want to study; however, the work carried out so far has only allowed us to interpret the first three stages in detail and we are in the process of analyzing the following phases.

As part of the activities of this research, a workshop was held for higher-level mathematics teachers interested in acquiring new collaboration techniques among peers and who are willing to develop digital teaching materials to improve their teaching practice. Due to the dynamics of the 2019 coronavirus disease (covid-19) pandemic, all the activities were carried out in a virtual modality through which they worked synchronously and asynchronously with the teachers. There were three crucial phases for the development of the collaborative and individual work of the teachers: 1) diagnosis, to get to know the participating population; 2) elaboration of learning situations through the use of digital didactic resources, and 3) conclusion, where the final results and agreements of the community were presented.

To generate the contrasting of the conceptual models with reality, in the synchronous sessions some of the principles of the model of integrity were followed (Beer, 1994). This model is oriented towards the generation of consensus and the articulation of interests where communication processes are organized, especially socio-technical systems, through five stages: 1) opening, in which the work plan is presented and participants are invited actively participate around it; 2) work agenda, each participant is motivated to use their imagination, creativity, knowledge and experiences, in such a way that solutions to the problems raised are generated; 3) assignment of working groups, is the vital stage of the integrity process where each participant chooses topics to be discussed in the sessions; 4) work on specific topics, each topic to be discussed must have teachers who are in favor of and against the topic to be studied, in such a way that consensus is generated, which will be called the syntegristic postulate; finally, 5) the conclusions stage, is the final presentation of the agreements reached in the meetings (Beer, 1994).

Based on the above, the research instruments (annex) were generated and interpreted through three coding schemes: 1) to understand the responses of the participants throughout the workshop, 2) to examine the teaching proposals that they implement with their students and 3) to capture learning opportunities in PLCs. These schemes were developed under a

process of iterative refinement between the analysis and synthesis of the teachers' teaching and the elements described in the meetings.

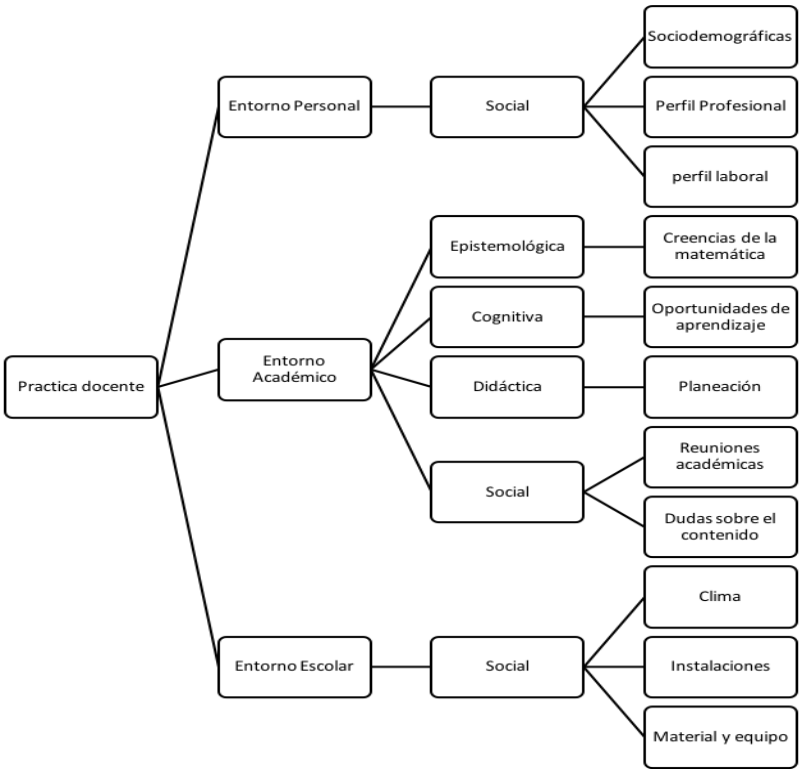
Results

Phase 1: Unstructured problem

As indicated in Table 3, in this phase the existence of a problem in the school environment is not explicit or evident, where the actors in the teaching-learning process work in isolation, attending to the objectives of the curriculum individually.

In order to know and describe the teaching population participating in the training action, a context questionnaire was applied at this stage, which made it possible to detect class teaching techniques, collaboration habits among peers, and the approval and failure rates of their students. To study and understand teaching practice, we consider the classification proposed by Salas (2012), which covers three environments: personal, academic, and school. These environments will allow detecting the actions that govern the teaching practice inside and outside the classroom, as shown in figure 2.

Figure 2. *Teaching practice*



Source: Salas (2012)

Personal environment

Studying the characteristics of the teacher provides specific information about their position as an education professional; In addition, it warns of possible fields of improvement and refinement. For this reason, it is essential for this research to investigate the context in which the teacher operates.

The workshop had the participation of 13 teachers, of whom 23% were women and 77% men. All had undergraduate studies, 62% did so in mathematics and 38% in engineering. In addition to this degree, 77% of the participants had master's studies, of which 40% specialized in the area of mathematics, 40% in education and 20% in engineering or others. Finally, only one of the participants has doctoral studies in the area of mathematics.

The average years of service as participating teachers was 16 years; 38% of the participants had between 21 and 30 years of service in front of the group. Most teachers know the institutional educational model of their workplace and take it into account when planning their classes and activities.

All participating teachers are in constant updating, that is, they take training and updating courses at least once a year, which refers to a good interest on their part in maintaining constant training.

Academic environment

The teaching practice, in general, is reflected by the actions that are implemented in the classroom, however, the teacher's work is not limited to the classroom. For the teacher, it is unavoidable to use resources that do not necessarily belong to the educational field. These means help him to plan the activities that he will carry out in front of his students, and thus anticipate the consequences of these activities to, finally, verify if the proposed objectives are being achieved or not.

Therefore, it is extremely important to inquire about the actions that the teacher exercises to plan his classes, manage the educational resources he uses, establish how to proceed when he has doubts about a specific topic, determine whether or not to record the progress of your class and how it validates what you are teaching.

The range of learning units that teachers teach and have taught is quite robust: algebra, geometry, trigonometry, differential calculus, integral calculus, vector calculus, probability, statistics, numerical methods, differential equations, as well as complex variables. From this we can assume a high degree of specialization in mathematics among teachers. In addition,

it is important to point out that these learning units are focused on a student background that is mostly engineering.

Teachers' beliefs about mathematics permeate the way in which teachers prepare, apply and evaluate the activities they carry out around the teaching-learning process of the units they teach (Ernest, 1989; Salas, 2012).

On the one hand, 77% of the participating teachers report that mathematics is:

> A field of continuous creation and invention, which is why its results are open to constant review depending on the sociocultural and scientific context. Its core is made up of conceptual structures, which allow the intertwining of concepts and topics, as well as specific mathematical procedures and general strategies.

On the other hand, 23% of the participants report that mathematics is:

> A nucleus made up of the results of a utilitarian nature, whose veracity and existence are not subject to discussion; These results are understood as a group of rules and tools, without a specific theoretical or practical link. The objective of mathematical knowledge is the development of other sciences and techniques.

Regarding how mathematics should be taught, most teachers agree that there should be a good communication channel with students, that is, that the contents are presented in a clear, simple and precise way, without neglecting the rigor that the course requires. In addition, it is important to incorporate technological elements and digital tools, going from the simple to the complex. According to the opinion of those involved, the student is required to assume an active and participatory role that allows them to build their own knowledge with the help of the teacher, this in order to achieve the established learning objectives.

Since we want to know the dynamics of work among peers, several questions were established to interpret the collaborative work between teachers, of which about 50% meet each semester to address issues such as student academic performance and design of strategies to improve it; however, it will be important to delve into this topic in the sessions that will be held with the participants.

For the preparation of classes, the participating teachers make use of books specialized in mathematics, and on few occasions they use specialized magazines. Regarding the use of technology, they rely on specialized software such as Mathematica, Matlab and Geogebra.

Due to the pandemic situation, most teachers have used the Classroom platform to carry out their school activities.

Already in the sessions with their students, teachers always explain the topic to be studied, address exercises contextualized to a real situation and frequently ask students to establish strategies to solve exercises. They always answer questions and encourage their students to ask if they have them. In addition to the above, they also report that, regularly, they verify that the student has understood the topics covered. On this last point, evaluation plays an important role in the teaching-learning process. Next, the answers of the teachers regarding this item are interpreted.

Diverse opinions are held regarding what the evaluation is, however, most of the teachers refer that "it is a continuous process that allows verifying if the student has learned and assimilated the topics seen" and that its main function is "to demonstrate the areas of opportunity for each student. Most of the teachers apply the evaluation proposal of the current study program that they teach and make adjustments based on group performance. The evaluation tools most used by teachers are: open and closed exams, evidence portfolios, individual and group tasks, as well as the approach of problems formulated by teachers.

School environment

Investigating issues concerning the school environment will allow us to know the social atmosphere in which the teacher carries out his work activities. To interpret teaching practice in detail, it is necessary to recognize what perceptions teachers have regarding their work area. It should be noted that the school environment is permeated by different variables that directly or indirectly affect all the actors in the educational system, and that this exerts an influence on how an academic unit operates.

In general, the participating teachers report a good relationship with their students, colleagues and managers, from whom they frequently allow comments or contributions about their practice in the classroom. They also comment that the furniture in the facilities is good and that the facilities are kept hygienic. The library service is adequate and they have individual work spaces in good condition; The only thing that could be considered an area of opportunity is internet access, since they report that it is of low quality.

Phase 2: expressed problem

The synchronous sessions with the teachers made it possible to make evident to the community the need to improve the academic performance of the students. The teachers put on the table problems associated with their teaching practice and that influence the way in which they teach their classes; Such is the case of isolated, individualized work. One of the participants commented:

> Most of us here have a basic math background and from that perspective we were taught to work alone, I think that's a big influence on our classes and how we relate to other math teachers. For this reason, these types of spaces are very important, where we can work with other colleagues in proposing teaching strategies, see what works for me and what works for others.

The student's performance in his own academic training was also interpreted, specifically the following points of view were taken:

> I believe that students should have an active participation in the construction of their mathematical learning, exposing the topics and solving the problems that their fellow speakers pose to the rest of the group. It hasn't worked for me, but I think that's how it should be.

Also: "You must know how to listen to understand and contribute to autonomous learning, without losing the role of teacher." And finally: "An active role, open dialogue with the teacher."

The interaction between the participants was essential to establish learning situations in which the objectives of the topic to be studied, analyzed and synthesized were clear, the didactic sequence to be implemented, as well as the desired results. For this, each teacher made the choice of digital teaching resources, established teaching strategies and selected forms of evaluation.

All teachers provided learning situations for different topics in mathematics, such as linear functions, optimization of functions, division of polynomials, elements of analytic geometry, and differential equations. As digital teaching resources, for the most part, educational videos and blogs were implemented. It is important to point out that these learning situations are yet to be implemented with students, for this reason we still do not have data about their effectiveness in the classroom; however, the collaborative work carried out by the participating teachers was very beneficial, and has undoubtedly contributed to fostering a culture of collaboration among peers.

Phase 3: root definitions

Let us remember that a root definition breaks down the main objective of the system, that is, to achieve a specific objective, certain transformation processes are required to reach the goal. Considering the elements interpreted and integrated in table 3, the six CATWOE factors and the results of the sessions with the teachers, we found that to guarantee that the student learns, the actors of the system (teachers and school authorities) must be aware that the improvement of the academic performance of clients (students) is priority; For this, it will be necessary to have the academic and infrastructure resources that allow them to transform their teaching proposals. It is up to the actors of the system (school authorities) to promote a culture of teacher collaboration through the creation of spaces in which clients (teachers) can reflect, question and improve their teaching practice through collaborative work. In order to contribute to the process of improving results and meeting the objectives, we believe it is necessary for the actors (teachers and school authorities) of the system to attend to the learning needs of the clients (students) through the implementation of learning situations that are made in community.

Discussion

Based on the theoretical approach adopted in this research and the results obtained, we have been able to identify several elements of the SSM and PLC that contribute to the improvement of teaching practice. The study of the first three phases of the SSM proposed by Checkland (2001) allowed us to give a systemic structure to what teachers already do in the classroom: from accepting the existence of the problem and interpreting it in an orderly way to describing the root definitions of the problem. system and their interrelationships. As Little (2002), Ell and Major (2019) and Alhanachi, de Meijer, and Severiens (2021) refer, it is important to guide collaborative work between teachers towards improving the quality of learning. From the interactions with the participants, we observe that they express common problems when teaching mathematics, and that the work they carry out individually for class planning, preparation of didactic material, as well as the establishment of learning situations, has better results if they socialize these proposals with their peers. From the work sessions and the results of the context questionnaire, it can be seen that teachers are in the best disposition to improve their teaching practice; however, it is extremely important to try to explore the different types of discourse proposed by Popp and Goldman (2016).), since they

help to adequately establish the norms of interaction and organization in the PLC, and thereby reduce conflict situations, especially those referring to political issues and decision-making by school authorities, also reported in Alhanachi et al. to the. (2021).

Based on what was reported by Ell and Major (2019), the moment the participants begin to interact is when certain difficulties associated with leadership and trust among peers are reflected. It is also in the work sessions that we face these situations, that is, at the beginning the teachers were a little closed to participate or evaluate the proposals of their classmates, however, these attitudes changed little by little in each consecutive session.

Various investigations (Alhanachi et al., 2021; Holmlund, Deuel, Slavit, & Kennedy, 2010; King, 2014; Liu, Lu, & Yin, 2022) continue to emphasize providing facilities to PLC participants so that it is fruitful. , in which we also agree. According to the results of the applied context questionnaire and the work sessions, teachers are interested in improving their teaching practice and make use of the resources that their institution provides them, so feeling accompanied and supported in the process is a motivating factor. to improve their academic and work environment.

According to Huijboom et al. (2021), the importance of a facilitator, the implementation of research, as well as the ability to engage in dialogue are three factors that are considered important for collective learning in a PLC. In our case, the figure of a facilitator was crucial to carry out the work sessions with the teachers, as well as presenting and synthesizing the first two phases of the SSM, identifying the unexpressed problem and later making it visible to the community. However, two important points to consider are the incorporation of research as professional growth of the participants, as well as establishing techniques to improve communication and reach fruitful facets of dialogue and with the least risk of conflict.

Conclusions

The inclusion of the Systemic Paradigm through the SSM in the proposal of the PLC in university education has allowed us to establish the theoretical bases to propose a methodology that has permeated the work of the university professor of mathematics; Indeed, reflection on teaching practice has been promoted as a trigger for students' academic success.

The way of teaching work has been changing progressively, yes, but in a stable way, in order not to create conflict between the participants. Change agents must gain the trust of

the recipients so that all those involved can perform their task, for which they must share a system of values and expectations that ensure consent and approval of the proposals to be implemented. The creation of our PLC has been little by little and with much effort from all the participants; So far, we have carried out various activities in which the great interest of teachers in improving the way in which they teach mathematics classes is present.

The interpretation of the texts studied in this research shows that the degree or level of reflection reached by the members of the PLC is essential to propose significant changes, and thereby achieve a renewal of teaching and student behavior in the classroom. Venturing into the creation and operation of a PLC is not an easy job, it requires commitment from the educational authorities, teachers and students, in such a way that a culture of cooperation and organization is generated that encourages collegiate work. and peer learning.

Likewise, the development of a PLC is effective in promoting the quality of teaching, so all the actors in the system must be aware that the responsibility for the success of the students is shared and that it does not only depend on the performance of the teacher. Through the development and implementation of this type of methodologies we can do a lot to teach our students to become exceptional professionals.

Future lines of research

The development of PLCs supports student learning, generates professional growth, and contributes to a continuous and sustainable education system (Schneider and Kipp, 2015; Stoll et al., 2006; Vescio et al., 2008). However, building a PLC is a complex process and requires a deep understanding of the dynamics that exist within it, as well as the challenges associated with collaborative work and shared responsibilities (Fulton & Britton, 2011; Schneider & Kipp, 2015); Stoll et al., 2006). Therefore, continuing to contribute to this theoretical current from the context of higher education is one of our main interests.

In addition to the above, we consider it pertinent to fully integrate the postulates and principles of the team integrity model proposed by Beer (1994) to the methodological approach proposed in the part of contrasting the conceptual models with reality, with a view to facilitating the organization of processes. communication and manage complexity in sociotechnical systems such as the one studied. This will allow building a better dynamic in the sessions with the team of teachers that make up the PLCs. In addition, as reported by Hernández and Castillo (2017), self-assessment of performance positively influences the

workplace, which is why it is interesting to add the element of self-assessment of teaching practice in the PLC work sessions.

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References

Alhanachi, S., de Meijer, L. A. and Severiens, S. E. (2021). Improving culturally responsive teaching through professional learning communities: A qualitative study in Dutch pre-vocational schools. *International Journal of Educational Research, 105*, 1-11. Retrieved from https://doi.org/10.1016/j.ijer.2020.101698.

Beer, S. (1994). *Beyond Dispute: The Invention of Team Syntegrity.* England: John Willey y Sons.

von Bertalanffy, L. (2018). *Teoría general de los sistemas: fundamentos, desarrollo, aplicaciones.* México: Fondo de Cultura Económica.

Cezarino, L. O., Liboni, L. B., Oliveira, M. F. and Caldana, A. C. F. (2016). Soft Systems Methodology and Interdisciplinarity in Management Education. *Systems Research and Behavioral Science*, *33*(2), 278-288. Retrieved from https://doi.org/10.1002/sres.2383.

Checkland, P. (2000). Soft systems methodology: a thirty year retrospective. *Systems Research and Behavioral Science*, 17(S1), S11-S58.

Checkland, P. (2001). *Systems Thinking, Systems Practice*. Chichester, United Kingdom: Wiley.

Davis, A. P., Dent, E. B. and Wharff, D. M. (2015). A Conceptual Model of Systems Thinking Leadership in Community Colleges. *Systemic Practice and Action Research*, *28*(4), 333-353. Retrieved from https://doi.org/10.1007/s11213-015-9340-9.

Dogan, S., Pringle, R. and Mesa, J. (2016). The impacts of professional learning communities on science teachers' knowledge, practice and student learning: a review. *Professional Development in Education*, *42*(4), 569-588. Retrieved from https://doi.org/10.1080/19415257.2015.1065899.

Dooner, A.-M., Mandzuk, D. and Clifton, R. A. (2008). Stages of collaboration and the realities of professional learning communities. *Teaching and Teacher Education*, *24*(2), 564-574. Retrieved from https://doi.org/10.1016/j.tate.2007.09.009.

DuFour, R. (2004). What Is a "Professional Learning Community?". *Educational Leadership, 61*(8), 6-11.

Ell, F. and Major, K. (2019). Using activity theory to understand professional learning in a networked professional learning community. *Teaching and Teacher Education, 84*, 106-117. Retrieved from https://doi.org/10.1016/j.tate.2019.05.010.

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. En P. Ernest, Mathematics teaching: The state of the art (págs. 249-254). Londres: The Falmer Press.

Evert, K., y Cooper Stein, K. (2022). Teachers' networked learning communities: Does collective participation matter? *Teaching and Teacher Education: Leadership and Professional Development*, 1-11. https://doi.org/10.1016/j.tatelp.2022.100009

Fulton, K. and Britton, T. (2011). STEM Teachers in Professional Learning Communities. (Executive summary). National Commission on Teaching and America's Future, Washington.

Hernández, G. del J., y Castillo, S. E. (2017). Adquisición de las competencias específicas, mediante una docencia centrada en comunidades profesionales de aprendizaje. *RIDE. Revista Iberoamericana para la Investigación y el Desarrollo Educativo*, *8*(15), 155-181. Recuperado de https://doi.org/10.23913/ride.v8i15.295.

Holmlund, T., Deuel, A., Slavit, D. and Kennedy, A. (2010). Leading Deep Conversations in Collaborative Inquiry Groups. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83*(5), 175-179.

Horn, I. S. (2010). Teaching Replays, Teaching Rehearsals, and Re-Visions of Practice: Learning from Colleagues in a Mathematics Teacher Community. *Teachers College Record, 112*(1), 225-259.

Huijboom, F., Van Meeuwen, P., Rusman, E., y Vermeulen, M. (2021). Professional learning communities (PLCs) as learning environments for teachers: An in-depth examination of the development of seven PLCs and influencing factors. *Learning, Culture and Social Interaction*, *34*, 1-14. Retrieved from https://doi.org/10.1016/j.lcsi.2021.100566.

Hurst, G. A. (2020). Systems thinking approaches for international green chemistry education. *Current Opinion in Green and Sustainable Chemistry*, *21*, 93-97. Retrieved from https://doi.org/10.1016/j.cogsc.2020.02.004.

Jackson, M. C. (2003). *Systems Thinking: Creative Holism for Managers*. Chichester, England: John Wiley y Sons.

King, F. (2014). Evaluating the impact of teacher professional development: an evidence-based framework. *Professional Development in Education*, *40*(1), 89-111. Retrieved from https://doi.org/10.1080/19415257.2013.823099.

Kordova, S., Frank, M. and Nissel, A. (2018). Systems thinking education: seeing the Forest through the trees. *Systems*, *6*(3), 29. Retrieved from https://doi.org/10.3390/systems6030029 .

Little, J. W. (2002). Locating learning in teachers´ communities of practice: Opening up problems of analysis in records of everyday work. *Teacher and Teaching Education*, *18*(8), 917-946. Retrieved from https://doi.org/10.1016/S0742-051X(02)00052-5.

Liu, S., Lu, J. and Yin, H. (2022). Can professional learning communities promote teacher innovation? A multilevel moderated mediation analysis. *Teaching and Teacher Education*, *109*, 1-11. Retrieved from https://doi.org/10.1016/j.tate.2021.103571.

Luong, T.-T., Huynh, V.-N. and Kim, E. (2022). A Hybrid Use of Soft Systems Methodology for Developing a Framework of Evidence-Based Teaching for Hospitality and Tourism Instructors in Vietnam. *Systemic Practice and Action Research*, 1-34. Retrieved from https://doi.org/10.1007/s11213-022-09609-9.

McLaughlin, M. W. and Talbert, J. E. (2007). Building professional communities in high schools: Challenges and promises practices. In Stoll, L. and Louis, K. S., *Professional Learning Communities: Divergence, Depth and Dilemmas* (pp. 151-165). Berkshire, England: Open University Press.

Molderez, I. and Ceulemans, K. (2018). The power of art to foster systems thinking, one of the key competencies of education for sustainable development. *Journal of Cleaner Production*, *186*, 758-770. Retrieved from https://doi.org/10.1016/j.jclepro.2018.03.120.

Nyemba, W. R., Carter, K. F., Mbohwa, C. and Chinguwa, S. (2019). A systems thinking approach to collaborations for capacity building and sustainability in engineering education. *Procedia Manufacturing*, *33*, 732-739. Retrieved from https://doi.org/10.1016/j.promfg.2019.04.092.

Parra, J. D. (2022). Decentralisation and school-based management in Colombia: An exploration (using systems thinking) of the Full-Day Schooling programme. *International Journal of Educational Development, 91*. Retrieved from https://doi.org/10.1016/j.ijedudev.2022.102579.

Paschalidou, K., Salta, K. and Koulougliotis, D. (2022). Exploring the connections between systems thinking and green chemistry in the context of chemistry education: A scoping review. *Sustainable Chemistry and Pharmacy, 29*. Retrieved from https://doi.org/10.1016/j.scp.2022.100788.

Pham, D. T. and Jaaron, A. A. M. (2018). Design for Mass Customisation in Higher Education: A Systems-Thinking Approach. *Systemic Practice and Action Research, 31*, 293-310. Retrieved from https://doi.org/10.1007/s11213-017-9426-7.

Popp, J. and Goldman, S. (2016). Knowledge building in teacher professional learning communities: Focus of meeting matters. *Teaching and Teacher Education, 59*, 347-359. Retrieved from https://doi.org/10.1016/j.tate.2016.06.007.

Ramírez, A., Cardoso, P. and Tejeida, R. (2020). A Methodological Proposal for the Complementarity of the SSM and the VSM for the Analysis of Viability in Organizations. *Systemic Practice and Action Research, 34,* 331-357. Retrieved from https://doi.org/10.1007/s11213-020-09536-7.

Ramos Gonçalves, D., y Vieira da Silva, M. (2019). Formación de profesores e identidad profesional: la contribución del trabajo colaborativo en educación. *Profesorado, 23*(2), 359-376. https://doi.org/10.30827/profesorado.v23i2.9691

Salas, E. (2012). *Un estudio de las creencias e implicaciones de evaluación educativa en matemáticas de secundaria.* (Tesis de maestría). Instituto Politécnico Nacional, Ciudad de México.

Salas, E., Morales, O., Tejeida, R. y Moreno, J. J. (2021). Hacia el diseño de una metodología sistémica para generar comunidades profesionales de aprendizaje con docentes universitarios de matemáticas. *Acta Latinoamericana de Matemática Educativa 34*(1), 103-112.

Schneider, A. and Kipp, K. H. (2015). Professional growth through collaboration between kindergarten and elementary school teachers. *Teaching and Teacher Education, 52*, 37-46. Retrieved from https://doi.org/10.1016/j.tate.2015.08.006.

Shahabi, A., Azar, A., Radfar, R. and Asadifard, R. A. (2020). Combining Soft Systems Methodology with Interpretive Structural Modeling and System Dynamics for

Network Orchestration: Case Study of the Formal Science and Technology Collaborative Networks in Iran. *Systemic Practice and Action Research*, *33*(4), 453-478. Retrieved from https://doi.org/10.1007/s11213-019-09490-z.

Stoll, L., Bolam, R., McMahon, A., Wallace, M. and Thomas, S. (2006). Professional Learning Communities: A Review of the Literature. *Journal of Educational Change*, *7*, 221-258. Retrieved from https://doi.org/10.1007/s10833-006-0001-8.

van Gigch, J. (2016). *Teoría general de sistemas.* México: Trillas.

Vescio, V., Ross, D. and Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education*, *24*(1), 80-91. Retrieved from https://doi.org/10.1016/j.tate.2007.01.004.

Appendix

Context questionnaire

1) Choose your gender:
- *a)* Male
- *b)* Female

2) Did you have a bachelor's degree or engineering degree?
- *a)* Yes
  - i. In which area?
- *b)* No

3) Have you completed a master´s degree?
- *a)* Yes
  - i. In which area?
- *b)* No

4) Have you completed doctoral degree?
- *a)* Yes
  - i. In which area?
- *b)* No

5) Which is your school of assignment?

6) How many yes of service do you have in the National Polytechnic Institute (IPN)?

7) Do you know the current IPN Institutional Educational Model (MEI)?

8) Do you take workshops focused on teaching?
- *a)* How often?
  - i. Every semester
  - ii. Every year
  - iii. When a course of my interest is offered

9) What mathematics subjects have you taught?

10) Do you consider mathematics has to be a science whose characteristics are:

a) A field of continuous creation and invention, so their results are open to constant revision depending on the socio-cultural and scientific context. Its core is made up of conceptual structures, which allow the interweaving of concepts and topics, as well as specific mathematical procedures and general strategies.

b) A static, pre-existing body of knowledge, endowed with a logical structure, which gives it an objective, absolute and universal character. The objective pursued by the creation of mathematical knowledge is its development; that even when one is aware of its possible applications, it develops independently of them.

c) They have a nucleus made up of results of a utilitarian nature, whose veracity and existence are not subject to discussion; these results are understood as a group of rules and tools, without a specific theoretical or practical linkage. The objective of mathematical knowledge is the development of other sciences and techniques.

11) From your perspective, how should mathematics be taught?

12) What do you think should be the role of the student in the classroom?

13) How often do you meet with your co-workers (math professors) to discuss?

Table 4. Frequency of meeting with peers

	Every two weeks	Every month	Every semester	Never
Design of learning situations to apply with your students.				
Exchange books, magazines, videos, etc., to help plan your mathematics lessons.				
Academic performance of your students and how to improve it.				

Source: Own elaboration

14) Do you use the syllabus of the subjects you teach to structure your classes?

15) How often do you use the following educational resources to prepare your classes?

Table 5. Frequency of use of educational resources

	Always	Most of the time	Rarely	Never
Specialized books				
Specialized journals				
Wiki				
Blogs				
YouTube				
Virtual learning environments • Classroom • Moodle • MOOC				
Computer programs (Matlab, Mathematica, etc)				

Source: Own elaboration

16) How often do you do the following actions when you have doubts about a content or topic to be addressed in the classroom?

Table 6. Actions taken when professors have doubts about a content or topic to be addressed in the classroom.

	Always	Most of the time	Rarely	Never
Search for information on the Internet				
Consult specialized books				
Ask your coworkers				
Omits the subject				

Source: Own elaboration

17) During your math class, how often do you do the following activities?

Table 7. Frecuencia de actividades realizadas en el salón de clase

	Always	Most of the time	Rarely	Never
Explains the subject				
Explains exercises that apply the subject matter to everyday situations.				
Pass the students to the blackboard.				
Ask your students to come up with strategies for solving exercises in class.				
Attends to questions.				
Encourages students to ask questions if they do not understand.				
Verify that all students have understood the topic.				

Source: Own elaboration

18) For you, what is assessment?

19) What do you think is the main function of the assessment?

20) What type of assessment do you implement?

21) Do you explicitly let your students know how you will evaluate them during the course?

a) Yes

b) No

22) How often do you use the following instruments to assess your students' academic performance?

Table 8. Frequency of implementation of evaluation instruments

	Always	Most of the time	Rarely	Never
Oral test				
Open test				
Multiple choice test				
Evidence portfolios				
Observation logbook				
Checklist				
Rubrics				
Self-assessment				
Co-assessment				

Source: Own elaboration

23) How often do you ask your students the following?

Table 9. Activities requested from students

	Every class	Every week	Every month	Every semester	Never
Personal assigments					
Grupal assigments					
Essays					
Research projects					
Solve problems formulated by you or by other authors					

Source: Own elaboration

24) If a student is underperforming academically, what do you usually do? (More than one option is possible)

- *a)* Talks to students
- *b)* Leaves aditional assigments
- *c)* Dedicates aditional time
- *d)* Does not usually do anything special

25) If a student has a high academic performance, what do you usually do? (More than one option is possible)

- *a)* Integrates him/her to help his/her peers
- *b)* Leaves aditional assigments
- *c)* Dedicates aditional time
- *d)* Does not usually do anything special

26) What recognition do you give your students when they achieve good results?

27) How often do you ask for feedback or input on your teaching practice?

Table 10. Feedback on their teaching practice

	Most often	Often	Rarely	Never
Students				
Colleagues				
Educational Staf				

Source: Own elaboration

28) How would you rate the support of the following aspects of the school environment for your teaching practice?

Table 11. School environment aspects

	Excellent	Good	Regular	Bad
School rules and dicipline				
The school's pedagogical proposal				
Students relationship				
Collagues relationship				
Relationship with the academy presidents				
Relationship with the authorities of your academic unit				

Source: Own elaboration

29) Regarding the infrastructure of your work center, how would you rate the following?

Table 12. Work center infrastructure

	Excellent	Good	Regular	Bad
Classroom furnishings				
General cleaning of the school				
Library				
Computer classrooms				
Internet access				
Offices				

Source: Own elaboration

Synchronous virtual sessions with teachers (Syntegrity Model)

In this research we need to form and consolidate a CPA that is interested in comprehensively understanding the problems of academic achievement and performance of their students, so that the synchronous virtual work sessions generate proposals that lay the groundwork for achieving the goal of creating the 12 postulates. For this reason, the following work agenda was established with the participating teachers:

Table 13. Work agenda

Session	Activity
1	Welcome, framing and presentation of the results of the context instrument.
2	Analysis of the teacher's role in the academic training of students.
3	Analysis of the student's role in his or her own academic training.
4	Analysis of the role of academic unit authorities on pass/fail rates in mathematics.
5	Proposal of interaction among participants to establish didactic planning.
6	Development of activities to be implemented in the classroom
7	Choice of digital educational resources
8	Establish teaching strategies
9	Selection of assessment strategies
10	Strategies for implementation of classroom activities
11	Analysis of the results of each participant
12	Strategies to improve the results obtained
13	Conclusions

Source: Own elaboration