MLS - EDUCATIONAL RESEARCH
http://mlsjournals.com/Educational-Research-Journal
ISSN: 2603-5820

How to cite this article:

Vilchez Guizado, J. (2017). Digital Empowerment and Development of Mathematical Competences in the Training of the Teacher of Mathematics. *MLS Educational Research, 3*(1), 59-78 Doi: 10.29314/mlser.v3i1.130

DIGITAL EMPOWERMENT AND DEVELOPMENT OF MATHEMATICAL COMPETENCES IN THE TRAINING OF THE TEACHER OF MATHEMATICS

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Abstract. The present work was oriented to reveal the level of digital empowerment and the development of mathematical competences in the initial formation of the mathematics teacher at the Hermilio Valdizán University. The objective of the study was to evaluate the implications of the use of digital resources: mathematical software and interactive pages in the teaching-learning process of the topics of mathematics and the development of reasoning, problem solving and argumentation skills, communication and argumentation. The research was framed in the qualitative methodology based on the techniques of participant observation, in-depth interview and evaluation rubric. The data collected through the interview was subjected to a process of codification, categorization and construction of semantic networks with the help of the Atlas.ti, while the data from the observation process and the rubric are presented and interpreted statistically in (frequencies and percentages). From the most significant findings it can be seen that most of the teachers in initial training have a considerable digital empowerment, expressed in the use of free software, collaboration resources, social networks and interactive pages for the solution of mathematical problems in algebraic form and graph. On the other hand, more than 85% state that their mathematical competences were developed optimally with the use of technology. It is concluded that digital empowerment is fundamental for the learning of mathematics and the development of reasoning skills, problem solving, modeling and mathematical communication during the initial training of the mathematics teacher.

Keywords: Digital Empowerment, mathematical competence, initial teacher training.

EMPODERAMIENTO DIGITAL Y DESARROLLO DE COMPETENCIAS MATEMÁTICAS EN LA FORMACIÓN DEL DOCENTE DE MATEMÁTICA

Resumen. El presente trabajo estuvo orientado a develar el nivel de empoderamiento digital y el desarrollo de competencias matemáticas en la formación inicial del docente de matemática en la Universidad Hermilio Valdizán. El objetivo del estudio fue evaluar las implicaciones del uso de recursos digitales: software matemático y páginas interactivas en el proceso de enseñanza-aprendizaje de los tópicos de la matemática y el desarrollo de las competencias de razonamiento, planteamiento y resolución de problemas, comunicación y argumentación. La investigación estuvo enmarcada en la metodología cualitativa sustentada en las técnicas de observación participante, entrevista en profundidad y rúbrica de

evaluación. Los datos recolectados a través de la entrevista fueron sometidos a un proceso de codificación, categorización y construcción de redes semánticas con ayuda del Atlas.ti, mientras que los datos provenientes del proceso de observación y de la rúbrica se presentan e interpretan estadísticamente en (frecuencias y porcentajes). De los hallazgos más significativos se puede extraer que la mayoría de los docentes en formación inicial tienen un empoderamiento digital considerable, expresado en el uso de software libre, recursos de colaboración, redes sociales y páginas interactivas para la resolución de problemas matemáticos en forma algebraica y gráfica. Por otro lado, más del 85% manifiestan que sus competencias matemáticas fueron desarrolladas de forma óptima con uso de la tecnología. Se concluye que el empoderamiento digital, es fundamental para el aprendizaje de las matemáticas y el desarrollo de las competencias de razonamiento, resolución de problemas, modelación y comunicación matemática durante la formación inicial del docente de matemática.

Palabras clave: Empoderamiento digital, competencia matemática, formación inicial docente.

Introduction

In recent years, the strategic objectives of education have been to improve the quality of education through the diversification of contents and teaching methods, as well as through strategies aimed at promoting experimentation, innovation, dissemination and sharing of information and good practices, forming learning communities and stimulating fluid dialogue on policies to be followed as well as activities to be carried out (UNESCO, 2004). This statement is reinforced by the implementation of digital technologies as a didactic resource aimed at training focused on student learning, within a constructive and interactive environment of didactic processes.

Nowadays, education systems at their different levels and modalities revolve around the use of information and communication technologies (ICTs) to provide students with the tools and knowledge of the era of globalization and knowledge, where the development of mathematical competencies becomes essential: associating real situations with mathematical expressions, use of didactic resources, heuristic and metacognitive strategies, as well as the explanation, justification and verification of concepts and theories, fundamental inputs for knowledge building in a quality educational process. The teaching-learning process receives a significant impact from ICT compared to conventional teaching-learning methods. It also predicts the transformation of the educational process and the way in which teachers and students access knowledge and information (Spanish, 2010).

Therefore, the current educational praxis focuses on the integral formation of students in the different areas of the curriculum being studied, particularly in the area of mathematics, through the development of knowledge, skills and attitudes oriented to innovation and lasting transformation, in line with scientific and technological progress. Under this premise, the use of ICT and the process of learning mathematics cannot be separated. Thus, the use of digital technology as a didactic-pedagogical resource dynamizes the teaching-learning process. These resources, when used appropriately, help teachers to capture students' attention, to motivate, to develop examples, to encourage creativity and to assign tasks. They also support students through interactive activities to solve numerical, algebraic and graphic problems in an autonomous and collaborative way. Interaction in all learning environments allows innovation to help students develop their skills, so that they respond equitably to current and future educational needs; thus consolidating the link between professional training and educational praxis.

The potential of digital resources in teaching and learning processes is one of the current challenges that mathematics education faces; since from these new technological tools benefits are glimpsed offered by calculators, computers, software, Internet, etc., due to the fact that they can store, process and transmit information, thus constituting a fundamental resource for problem solving. However, such didactic processes and their learning are not without difficulties. Among them stand out those associated with representational nature and those linked to a conceptual complexity over those related processes (Hitt, 2003).

Nowadays, the use of digital resources in the teaching and learning process at higher education level is an absolute necessity, since they allow to perform functions that range from information access and exchange, to the creation of simulated environments that facilitate the realization of practices of easy control and preparation by teachers. Moreover, their flexible and open nature means that they can be used in different contexts and learning situations, from information transmission to phenomena simulation or exercises realization, knowledge evaluation or tutoring.

Making a diagnosis regarding the use of digital technology in the teaching-learning process during the subject development and the integration of ICT into the curriculum, in the professional education career of the Universidad Hermilio Valdizán de Huánuco, the following was found. The use of digital technology in the development of academic activities, as a didactic medium and resource, is sporadic and static. In addition, in most cases, teachers use the technological resource only as a visual aid, without encouraging dynamism or interaction in student learning, which leads to a deficient learning, filled with flaws and inconsistencies, mainly due to not knowing how to use digital technology as a didactic resource. As an alternative to the deficiency detected in the use of ICTs by teachers and students during the didactic process, there is an urgent need to promote digital empowerment in educational subjects as a catalyst for the teaching-learning process of the different topics, making ICTs real resources to express meaningful, effective and efficient learning in students.

This is why the proposed innovation is pertinent, since through the project, it was possible to optimize the process of learning mathematics, making use of some digital tools (mathematical software, interactive pages and social networks), as well as integrating them into the current curriculum as transversal content to all curricular areas. This way the student assimilates the benefits of technological resources for learning mathematical concepts and procedures, thus making them a student of the global world in which they live.

The research process consisted of revealing teachers' knowledge and attitudes in initial training regarding the use of digital tools as a means and resource for capacity building in the management of technology resources and as a catalyst for the development of mathematical competencies in higher education students, having the following as a guiding question of the process: What is the influence of the digital empowerment of teachers in initial training on the development of their mathematical skills? The study objective is to identify, describe and analyze the influence of digital empowerment on the development of mathematical competencies in the initial training of teachers in the specialty of mathematics.

Empowerment

Empowerment was initially conceived as the process of searching for the basic opportunities that those marginalized or disadvantaged groups aspire to obtain, either

through direct help or through non-marginalized people who share their own access to these opportunities; it is based on the change in collective mentalities and the capacity that people seek in their aspirations for development, well-being and fulfillment of rights and freedoms, which they count on as human beings. Empowerment attacks any attempt to deny people the development of skills for self-sufficiency, with an emphasis on the elimination of needs, with greater participation in activities at the individual, social, cultural and economic levels, where ICT resources help to promote these activities, in the last two years the concept has shifted towards the inclusion of society as a whole and towards the preparation to live in a digital world, for the development of skills in general.

Empowerment refers to the process by which the strength of individuals and social groups is increased to drive beneficial changes for the group in the situations in which they live. It generally affects the beneficiary, in the development of confidence in their own capacities and actions. It is by changing attitudes individually and collectively that students change the way they act in problem solving. There are different areas in which in recent years there has been greater participation and increased empowerment, within the current educational context there is a strengthening of digital empowerment for the efficient performance of various academic and administrative tasks.

The phenomenon of empowerment analyzes the theoretical distinction between process and result of empowerment, which is not viable in objective and absolute terms or in terms of essence, but useful, in analytical terms, from the perception of the community involved, which must be understood by the external collaborator. It is also proposed to establish a difference between context and level of empowerment, and to analyze the context of the phenomenon at the individual, organizational and community levels of the social aggregate, which brings clarity to its definition. In this way the conception of empowerment acquires centrality as a process in successive contexts that benefit not only individuals but also social collectives (Silva and Martínez, 2004).

Digital Empowerment

Digital technologies offer new possibilities that require new, more collaborative methodologies, with greater possibilities of communication and interaction from anywhere and at any time: they also offer us greater access to information in different formats, as well as the collaborative construction of knowledge. But the use of these new resources also requires new attitudes such as being critical, creative, ethical, flexible and adaptable, responsible, with initiative and autonomy. In short, they require a civic digital attitude and an ability to learn throughout life, progressively accelerated.

To be digitally competent means to be provided with the knowledge, skills and attitudes required to identify, access, manage, analyze, integrate and evaluate digital resources; to build new knowledge based on different media and information sources; and to communicate and collaborate with others in an effective, efficient, critical, creative and ethical way, in the context of specific situations (work, personal and professional development, learning and knowledge socialization). In other words, the student must be able to benefit from digital tools in a meaningful way in various areas of life (Ala-Mutka, 2011; Ferrari, 2012; Vivancos, 2008). The same that leads to the digital empowerment that

> offers different development possibilities that require more collaborative techniques or methodologies, with greater possibilities of communication and interaction from anywhere and at any time, as well as greater access to

> information in different formats and to the collaborative construction of knowledge (Carruyo, 2017, p.21).

Currently, higher education institutions are undergoing important changes with the aim of promoting innovative experiences in teaching-learning processes based on ICT (Coll, 2004; Salinas, 2004), oriented towards the development of the so-called digital competences (sum of skills, knowledge and attitudes, in technological, informational, multimedia and communicative aspects), a key and essential component for successful development in today's society (Severin, 2011).

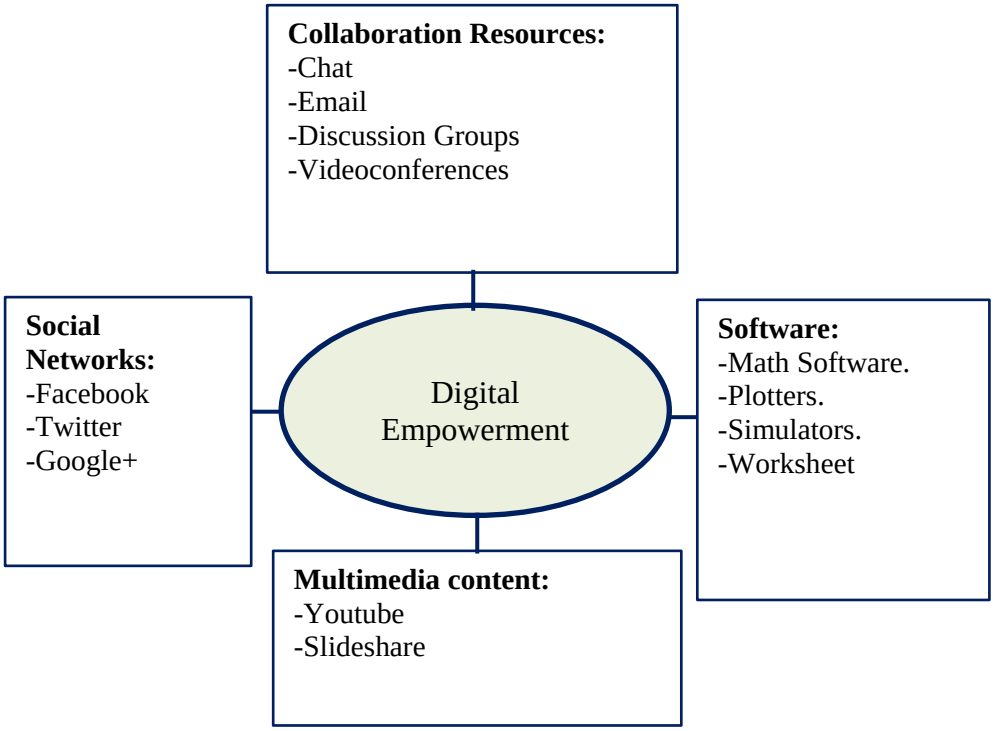

Figure 1. Digital resources most frequently used in the learning of mathematics.

> Digital empowerment means having a foundation of advanced training in digital skills, which encourages individuals to be more efficient and critical, and to have personal and professional skills that go beyond the simple use of technology, in order to search for, capture, manage and process information, to present and disseminate content in the appropriate format, and to communicate and collaborate on the network (Guitert, 2013, p. 98).

In general terms, digital empowerment should be considered as a multidimensional social process in which leadership, communication and self-managed groups replace the mechanistic pyramidal structure with a more horizontal structure (Jiménez, Martelo and Jaimes, 2017). For this reason, being empowered with digital technology currently entails “being digital” as an individual, possessing knowledge of technology, network communication, multimedia languages and how to manage information in the most efficient way using ICT and digital media. It also allows us to decide which software may be the most appropriate to manage the teaching-learning process. In short, we need to know how to integrate digital technologies into the higher education environment to be as efficient and effective as possible, to innovate, create and transform in the personal, social and professional environments of today's society.

Competency-based Approach to Education

Competencies are an approach to education and not a pedagogical model, since they are not intended to be a perfect representation of the entire educational process, determining what the instructional process, the development process, the curricular conception, the didactic conception, and the type of didactic strategies to be implemented should be. On the contrary, competencies are an approach, because they only focus on specific aspects of teaching, learning, and evaluation (Tobón, 2005), as the following:

1. The integration of knowledge, cognitive processes, skills, abilities, values, and attitudes in performance in the face of activities and problems.
2. construction of training programs in accordance with the disciplinary, investigative, professional, social, environmental, and labor requirements of the context; and
3. the orientation of education by means of quality standards and indicators in all its processes, which can be carried out from any of the existing pedagogical models, or also from an integration of them.

Mathematical competence consists of the ability to use, relate, apply, analyze and model mathematical elements such as: geometric elements, numbers, symbols, functions, algebraic expressions with their basic operations, forms of expression and mathematical reasoning, both to produce and interpret different types of information, to expand knowledge about quantitative and spatial aspects of reality, and to solve problems related to daily life and work.

The competencies or general processes, for the area of mathematics, chosen by the PISA project (OECD, 2004, p. 40), cited by Rico (2006, p. 59), are:

> Thinking and reasoning. This competence includes (a) asking questions specific to mathematics (How many are there? How to find it? If so, then?); (b) to know the types of answers mathematics offers to the above questions; (c) to distinguish between different types of formulations (definitions, theorems, conjectures, hypotheses, examples, conditioned statements); and (d) to understand and use mathematical concepts in their extension and limits.
>
> Debating. This competency includes (a) knowing what mathematical tests are and how they differ from other types of mathematical reasoning; (b) following and valuing chains of mathematical arguments of different types; (c) having meaning for heuristics (What can [or not] happen and why?); and (d) creating and expressing mathematical arguments.
>
> Communicating. This competence includes (a) expressing oneself in a variety of ways, on subjects of mathematical content, orally and also in writing; and (b) understanding formulations about these subjects from other people in oral and written form.
>
> Modeling. This competence includes (a) structuring the field or situation to be modeled; (b) translating reality into a mathematical structure; (c) interpreting mathematical models in real terms: working with a mathematical model; (d) reflecting on, analyzing, and offering critique of a model and its results; (e) communicating about a model and its results (including its limitations); and (f) directing and controlling the modeling process.
>
> Raising and solving problems. This competence includes (a) posing, formulating and defining different types of mathematical problems (pure, applied, open-response,

closed); and (b) solving different types of mathematical problems through a variety of pathways.

Representing. This competence includes (a) decoding, interpreting, and distinguishing between different types of representation of mathematical objects and situations, as well as the interrelationships between different representations; and (b) choosing and relating different forms of representation according to the situation and purpose.

Using symbolic, formal and technical language and operations. This competency includes (a) decoding and interpreting symbolic and formal language and understanding its relationships with natural language; (b) translating from natural to symbolic and formal language; (c) handling statements and expressions containing symbols and formulas; and (d) using variables, solving equations, and understanding calculations.

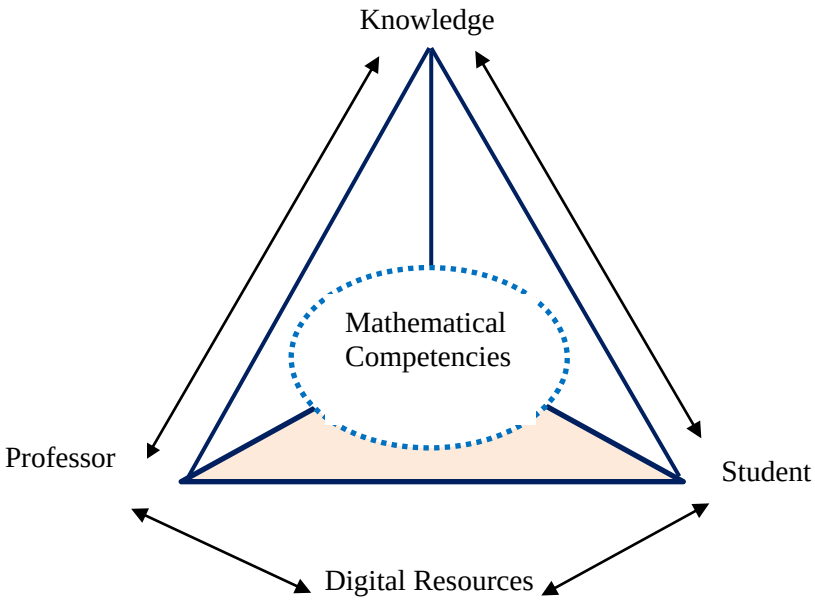

Figure 2. Pedagogical tetrahedron: digital empowerment and mathematical competences.

The development of mathematical competences can be developed efficiently through student-teacher interactions, mediated by digital resources and knowledge. However, a teaching approach with the use of digital resources must be well structured, pursuing individual, group, contextual, social, and technical learning in which the student will be able to learn and understand the issues addressed, since the management of information, time, place, and skills in the management of technological resources are present in the teaching-learning process through experience and practice.

Method

The objective of the study was to describe and analyze the level of digital empowerment of teachers and students during the teaching-learning process of mathematics, based on the development of digital skills through the use of collaborative resources, free software, multimedia content and social networks, and its impact on the development of mathematical skills in the initial training of mathematics teachers.

Methodological process

The study was approached through the qualitative methodology, in its phenomenological variant, to describe and analyze the different events of the studied reality in a conscious, open and objective way, from where the senses and meanings are perceived to understand the reality where the investigation of the use of digital technology as a learning resource took place, within a systemic process, reliable from the criteria of the investigative rigor, which allowed to generate an approximation to the relation between digital empowerment and development of mathematical competences, from which the methodical of this research is presented.

According to Husserl (2005) the end of phenomenology is not so much to describe a singular phenomenon, but rather to discover in it the universally valid essence, and scientifically useful. From this posture the method takes for real everything that is thought in a clear and different way, besides being put in a temporal perspective, in other words, what we see is not the object in itself, but as it is perceived and experienced in the context.

Likewise, Martínez (2009, p.139) considers that the phenomenological method "focuses on the study of experiential realities that are not very communicable, but that are determinant for the understanding of the mental life of each person". Particularly it can be said that the phenomenological method is the most suitable to study, as well as to understand the experiential structure of the people, inasmuch as it focuses its attention on the description and the study of those realities or focused activities.

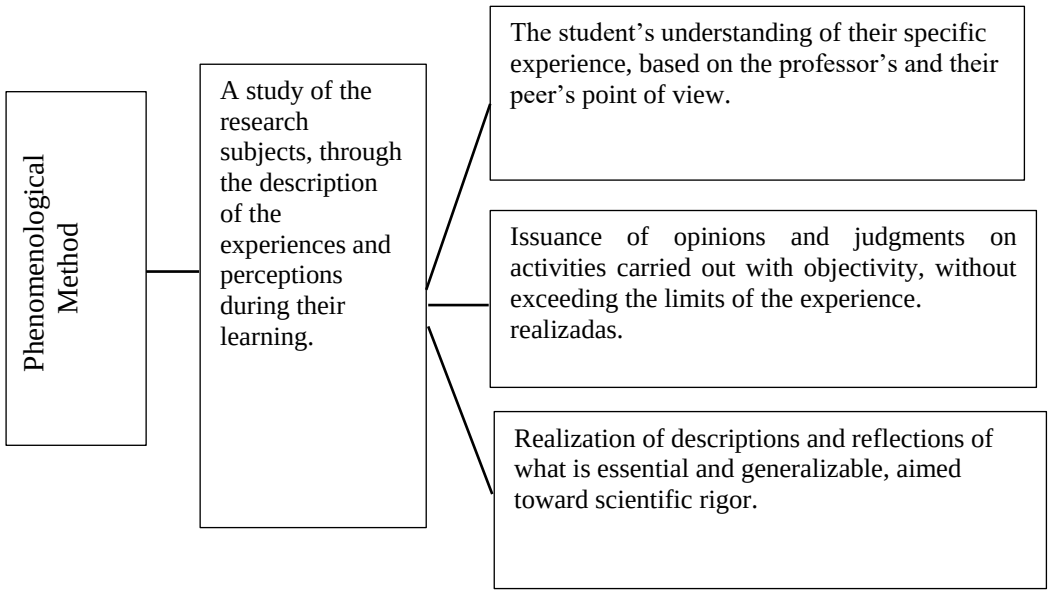

Figure 3. Diagram of the conception of the phenomenological method.

In order to carry out the qualitative study, it is based on the conviction of the traditions, functions, values and norms established in a context. Under this premise, an exposition of the phenomenological process is made in order to respond in a systematic way to the demands of the scientific rigor of the work carried out. In this research journey, the construction of a route related to the use of digital technology was considered important, which accounts for a set of actions and interactions that are developed during the research process. This structure of interactions between the

subjects under study and the researcher, which according to Martínez (2009) is expressed in four stages: previous, descriptive, structural and discussion.

1. *Previous Stage:* Preparation to carry out the study.
2. *Descriptive stage:* Tactics for conducting the study.
3. *Structural or Interpretative Stage:* Intersubjective reflection of the researcher and those researched.
4. *Stage of Discussion of Results and Approach to Knowledge:* Discoveries and Reconstructions from the Reflective Horizon:

This research was characterized by the application of some techniques and instruments used in qualitative research, in order to investigate the senses and meanings given by the actors involved in the study, to the use of digital technology in the development of mathematical skills during university education.

The technique of participating observation (phenomenological) was aimed at capturing aspects of the reality in which the subjects of study (students of mathematics and physics), as well as the appreciation of symbolic elements, such as gestures, expressions, attitudes and other manifestations during the process of gathering information. Furthermore, an in-depth interview was applied, which allowed the discovery of findings through a dialogical exchange, in a cordial and confidential way. It has also the aim of unveiling the structures that allowed to fix the support for the construction of categories of such manifestations.

Design

Phenomenology is based on the description of phenomena as they exist, are experienced, lived and perceived by man (Martínez, 2009). The phenomenology tries to explain the meanings in which we are immersed in our daily life, and not the statistical relations from a series of variables, the predominance of such or such social opinions, or the frequency of some behaviors. The stages of a phenomenological process are shown in Figure 4.

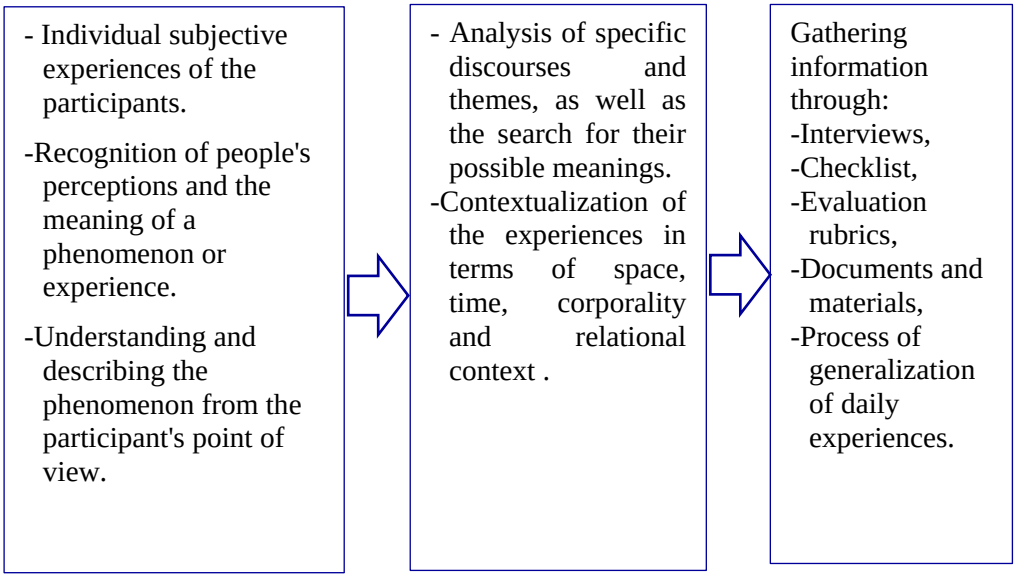

Figure 4. Diagram of the conception of the phenomenological method.

Participants

In order to carry out this research, the population was formed by 26 students of third year from the Degree in Mathematics and Physics of the Faculty of Education Sciences, Universidad Nacional Hermilio Valdizán in the department of Huánuco, Peru. The study population was chosen intentionally, and a homogeneous level of access and use of digital technology and Web resources for different purposes was previously confirmed. These resources were easily routed for the use of these technological resources for didactic and instrumental purposes, in the process of learning mathematics.

Tools

The techniques and instruments used in the information gathering process were: participant observation, in-depth interview and the rubric. Participant observation was aimed at direct inquiry into the activities of study subjects in their natural setting, direct or participatory in the events experienced (taking notes, collecting data, etc.), but always trying not to alter them with our presence. The observation was developed in parallel to the class development in the computer lab, by a record sheet, where the dimensions and indicators of the observation are recorded; the same that is carried out during the interactive activities with the computer, systematically evaluating knowledge, procedures, attitudes, constituting an effective support to analyze and evaluate the information obtained.

The colloquial or dialogical interview with the subjects under study was conducted to obtain relevant information of the students on their use of technologies during the conduct of their academic activities. Those reagents was aimed at obtaining maximum collaboration and achieve greater depth in the knowledge of attitudes and academic development of students, to have a rich content that facilitates analysis and description. They were posed as open-ended questions with the aim of finding out their opinion on the use of technological resources in the development of their mathematical tasks outside and inside the classroom. The aim of the interviews was to find out about the level of digital empowerment and its importance, and about the mathematical competences developed by the research subjects. The information obtained is categorized and then presented through semantic networks.

The third instrument for carrying out the research was the rubric, through which personalised scoring criteria or scoring criteria based on results are established. The rubric is used to communicate quality expectations in the development of mathematical competencies; the rows of the rubric format were used to define and evaluate the development of the mathematical competencies developed; while the columns defined the levels of performance in each competency.

Procedure

The first stage consisted of taking how it shows students of the specialty of mathematics and physics users of digital resources for the study of mathematics. Once the sample was selected with the students, a dialogue was initiated where they were explicitly explained the importance of the use of ICT resources in the process of learning mathematics and to have the necessary time to apply the techniques and instruments of data collection (observation, interview, survey, questionnaire).

The second stage was the design of the research instruments for data collection, observation, survey and questionnaire. It should be noted that the instruments were

designed and subjected to a pilot study in order to fine-tune the instruments, techniques and procedures that will be used in the data and information collection process.

The third stage consisted of collecting data and information through data collection techniques and instruments, obtaining from students' information relevant to the research process.

Finally, the fourth stage was developed, which consisted of analyzing and interpreting the data obtained, through this process, the results obtained were studied in order to draft the conclusions of the study. The process of data collection (observation, application of interviews and rubric), analysis of data, results and conclusions of the research was carried out during an academic semester, with a duration of 17 weeks.

Data Analysis

The qualitative analysis of the interviews was carried out using coding, categorization and construction of semantic networks. The presence and co-occurrence of the categories were considered in order to highlight the aspects with the greatest substantive interpretation among the interviewees. Text fragments and textual quotations were coded for analysis (Tójar, 2006).

While for the presentation and interpretation of the quantitative data, from the comparison list and the rubric, frequency and percentage analyses were used; using the statistical software Minitab 18 as an aid.

Results

For the participant observation, the comparison list was used as an instrument, through which relevant data were obtained on the mathematical activities carried out by the students using as a representation resource, data processing, the same that are detailed in table 1.

Table 1
Level of digital empowerment according to areas of digital competence

Level of achievement	Multimedia content	Collaboration resources	Using social networks	Use of software	Total
Start	4	3	2	4	13
	3.85	2.88	1.92	3.85	12.50
Ahievement	12	11	10	12	45
	11.54	10.58	9.62	11.54	43.27
Process	10	12	14	10	46
	9.62	11.54	13.46	9.62	44.23
Total	26	26	26	26	104
	25.00	25.00	25.00	25.00	100.00

Note: Source: Comparison list applied to research subjects

From the results of Table 1, it is evident that 43.27% of the students are considered to have reached the advanced (or achievement) level in the use of digital

resources in the performance of academic tasks, i.e. they are fully empowered in the use of digital technology; 44.23% of participants are in the process of using digital technology (they are in the process of empowerment); and only 12.5% are in the initial stage; they still do not make adequate use of the benefits of digital technology for learning mathematics. In summary, more than 87% of students make relevant use of digital technology, i.e. show an acceptable level of digital empowerment.

According to the information from the *interview*, one can appreciate in the network of concepts and categories generated by the qualitative treatment with Atlas.ti of the students' opinions, the main activities that the participants carry out with respect to digital empowerment focus on: level of use of ICT for educational purposes, time and frequency of use of digital resources, activities carried out with use of ICT, use of free software, use of the Internet among other resources. The university students consider that the use of digital technology in its diverse manifestations and uses favors the study and learning of mathematics, since they allow the investigation of concepts, procedures for the resolution of problems, through video tutorials and other means that facilitate a didactic explanation of the process of resolution of mathematical problems, likewise, they serve as support for the improvement of the conditions and the relations of the teacher and the student, in the different dimensions of the digital empowerment, (Figure 5).

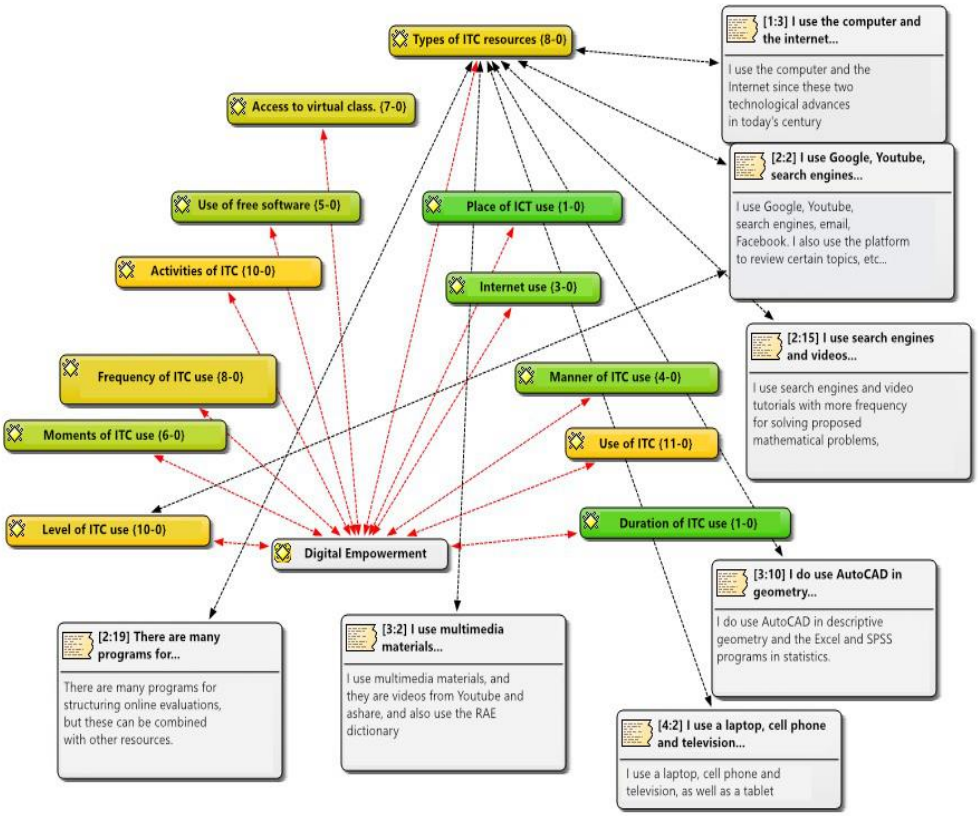

Figure 5. Semantic network of the dimensions of digital empowerment.
Note: Source: In-depth interview applied to research subjects

The graph in Figure 5 also shows the components of the digital empowerment of the interviewees, responses that underlie the different modes of use that are given to ICT resources as a means of learning for students in the specialty of mathematics. Describing some of the dimensions of students' digital empowerment based on the type

of ICT resources used during the study of mathematical topics, most of them coincide in the educational use of multimedia programs, mathematical software, social networks and the use of computers connected to the Internet. The answer to this dimension is an indicator that students, *centennials*, are capable of using learning analytics, regardless of the technological infrastructure they possess, having as their main activity the intensive use of data and information, that is to say, they are sufficiently empowered of the use of digital technology, which significantly affects the process of their learning.

As can be seen in *Figure 6*, from the results of the interview, the categories of digital empowerment and development of mathematical competence could also be established. In the same, the interviewees emphasize the importance of digital resources in the teaching-learning process of mathematics, during monitoring activities, in the stage of learning evaluation, and in the accomplishment of academic or research tasks; emphasizing that it has greater preponderance in the process of mathematical communication; the digital resources becoming effective and efficient mediators of the didactic process in the classroom and outside it. The versatility and ubiquity shown by digital technology in its use, develop students' positive attitude towards learning, as well as their motivation, reinforcing capacities and competences.

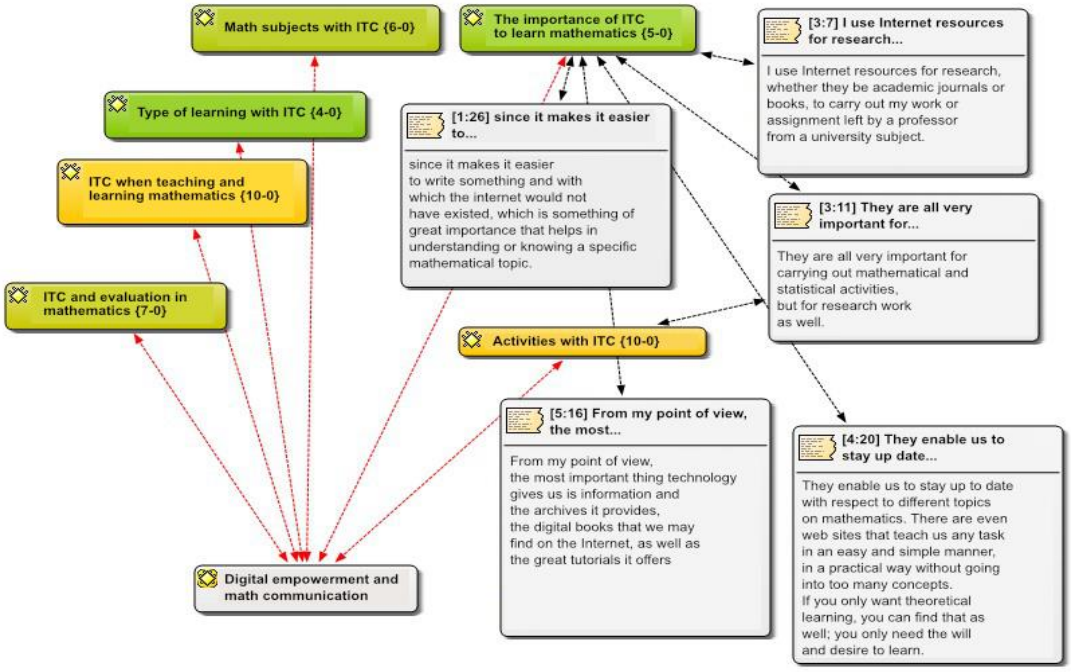

Figure 6. Semantic network of digital empowerment and the mathematical competence
Note: Source: In-depth interviews applied to the research subjects

The semantic network of the *figure* 7 indicates that there are a lot of technological opportunities, likely to be used with educational purposes and in the mathematical teaching-learning process, in accordance with the response of participants, the ICT are used in different activities, in all time, space and mean with significant pedagogical aims, which are focused on innovating the student´s teaching and studying ways, as *centennials* and participants inserted in virtual spaces. Thus, the incorporation of digital technology in learning processes motivates and facilitates the empowerment and the inter-connection of the educational practices. The interaction generated through the Internet, the network, the virtual communities, among others, evolves as a natural element within the educational process, when different technologies, the synchronous,

asynchronous, real and virtual communication spaces are articulated with the pedagogical strategies; the same which have a positive impact on learning and development of students´ mathematical competences.

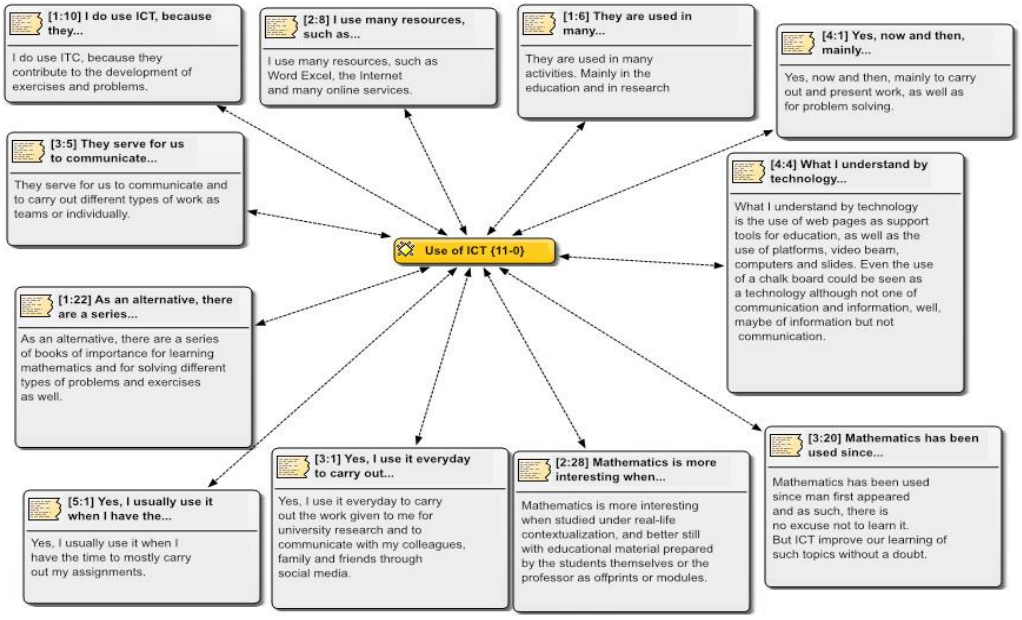

Figure 7. ICT use in initial training of the math teacher.
Note: Source: In-depth interviews applied to the research subjects

Below in Table 2, we will proceed to present the results the assessment made gave through a general and integrating rubric of the indicators on the achievement of competences, with the aim of arguing an interpretative view regarding the research intentions of the research findings associated to the six mathematical competences suggested by the Organization for Economic Cooperation and Development (OECD), through the PISA project (Program for International Student Assessment on the year 2000).

Table 2
Results of the assessment of mathematical competences and learning achievement levels

Competence	Qualifier qualitative-quantitative				**Total**
	Fail	Passing grade	Grade	Outstanding	
Thinking and reasoning	2	5	9	10	26
Mathematical argumentation	1	6	10	9	26
Mathematical communication	2	5	8	11	26
Problem solving	3	4	9	10	26
Mathematical representation	2	5	9	10	26
Symbolic and formal language	2	4	8	12	26

Total	12 (7.69%)	29 (18.60%)	53 (33.97%)	62 (39.74%)	156 (100.00%)

Note: Source: Assessment rubric applied to the research about their competence development.

According to the data in table 2, in the assessment through the rubric of the six competences considered in the mathematical area: a fail grade is given to 7.69% of the participants; whereas the 18.60& of the participants received a passing grade. This means that they have developed their mathematical competences regularly, using digital technology; 33.97% of the participants obtain a passing grade, which means that they achieved successfully the development of the mathematical competences. At the same time, 39.74% of students achieved an outstanding grade, that is to say, they developed to fullness their mathematical competences, using the digital tools. Analyzing the results of the rubric from the achievements reached as summarized in the table. We can affirm that more than 73% of participants achieved a satisfactory learning level, the same which indicates the importance which the digital technology use has in the study of mathematics.

The results shown of the findings through the three tools applied during the study, a digital empowerment has been shown, based on the use of mathematical software, collaboration resources, social networks and some multimedia contents; they have very positive effects in the development of the mathematical competences in the formation process of the future math teacher, who will have the responsibility of inculcating a mathematical culture to youth, citizens in the very near future.

Discussion

The incorporation of Information and Communication Technologies (ICT) in the educational setting, is one of the major challenges of the knowledge society. The capacity for transformation of these tools through computers and other digital devices, such as mobile phones, cameras, among others, provide opportunities to education in the different levels and modalities with infinite possibilities (Alvarado, 2012).

Carruyo et al. (2016) conclude that there is weakness in digital empowerment as an integration strategy of university, business and public policies, due to they do not handle easily the digital media, which they allow to get access to information fast and with the advantage of knowing contents deeper about a subject. This phenomenon was also evidenced in the findings made before the execution of this research, where teachers and students did not use properly the ICT resources in the learning event.

According to the UNESCO, “Nowadays, education practitioners need to be prepared to offer their students learning opportunities supported in ICT, to use them and to know how they might contribute to the student learning. These capacities are now an integral part of the list of basic professional competences of a teacher” (Catts & Lau, 2008, p.56). This assertion of the UNESCO evidences the concern of this important institution in the teacher´s development and particularly, about the use they might give to ICT to enrich the student learning.

The ICT incorporation requires not only the knowledge and control of the tools, but also a pedagogical approach aimed to the learning facilitation, the teachers´ and students´ level of digital competences is a power for the use of ICT for academic

purposes, but there is a an use with greater intensity for leisure, social or cultural activities, and to a lesser extent for academic purposes (Nakano et al., 2017, p.73).

Therefore, from the results of this study, the inclusion of ICT as pedagogical resource is deduced as fundamental for teachers, both in the actions of their initial and continuous training plan. This would allow them, among other things, to be up to date with the discoveries in their training area or specialty, to attend to the possibilities offered by ICT, to process possible innovations in the teaching-learning processes and to design strategies that satisfy the needs of their students in the development of the curricular contents they teach.

Information and Communication Technologies bring innovative aspects to the field of education, which indicate a qualitative improvement in the ways of teaching and learning, making students feel and express a great sense of relevance and commitment to the performance of academic tasks and fully develop their training actions, such as communicative skills, information selection, organization, problem solving in an interactive way with relevant use of ICT. In this perspective, it is shown that digital empowerment is fundamental for the achievement of an efficient learning of the subject under study; therefore, through the inclusion of digital resources during the academic process and the achievement of significant learning. To this end, it is essential to propose curricular reorientations with a view to overcoming the difficulties identified, and to train teachers in the pedagogical use of these technologies and to offer support to students for their true digital empowerment (Jiménez et al, 2017).

The teaching-learning activities mediated by digital technology lead to new conceptions of the didactic process, which accentuate the active involvement of the student in the learning process; attention to intellectual skills and interaction practices at a homogeneous level; the insertion of students into the constantly changing technological world; the use of digital technology as the main resource during their incursion and permanence in the world of work; and the necessary competencies to become involved in this process of continuous learning.

Finally, we consider that the use of digital technology as a didactic resource is one of the tools of this century that should not be neglected in the educational field. It is important to continue advancing in teacher training for the pedagogical use of ICTs, to offer support to students for their true digital empowerment and to create a digital culture in which university interactions function as virtuous circles according to the demands of the globalized world in which we are developing.

Conclusions

The conclusions emerge from the analysis of the dimensions of digital empowerment and the development of mathematical competencies in the initial training of teachers in the specialty of mathematics.

The use of ICT, during the initial training of mathematics teachers, as catalysts of the teaching-learning process, makes it possible to create new learning environments through communication networks, in order to provide timely responses to the learning demands of mathematics. In this sense, the educational environments mediated by ICT contribute to the generation of knowledge in the teaching-learning processes where students gain autonomy to channel their own learning mediated by digital technology resources.

The digital empowerment of students is based on (multimedia content, free software, collaboration resources and social networks) in computers or mobile phones, allowing to strengthen links and interaction with online information, which significantly favors the teaching-learning process, becoming a catalyst for the didactic process in the classroom and the performance of academic tasks outside the classroom. Digital resources are effective measures for the achievement of learning and the development of mathematical competencies in the initial training of mathematics teachers.

The incorporation of information and communication technologies (ICTs) in the educational scenario constitutes one of the great challenges of the knowledge society and contributes very efficiently to the process of problem solving. Argumentation and mathematical communication through the realization of activities of mathematical thought and reasoning, sustained in mathematical arguments, from a heuristic perspective creating, recreating concept with mathematical rigor; are able to express themselves fluently on topics of mathematical content; both orally and in writing; and also improve their ability to understand statement about these subjects from other people in oral and written form.

Through the appropriate use of digital technology, students in initial mathematics teacher training were able to decode and interpret symbolic language and understand its relationships with natural language, translating it into expressions that contain variables and expressing them through statements and expressions that contain symbols and formulas for solving equations and understanding calculations and their results; to then reflect, analyze, and offer critique of a model and its results from its practical usefulness and limitations for directing and controlling the modeling process.

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Date received: 02/11/2018
Date reviewed: 19/02/2019
Date accepted: 11/03/2019