Inverted learning model for the online high school mathematics class

Modelo de aprendizaje invertido para la clase online de Matemáticas del bachillerato

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ABSTRACT

In these times of covid-19, the Ecuadorian educational system has been challenged to sustain the teaching-learning processes in the online modality. This has demanded initiative and creativity on the part of teachers and students in order to meet the expected results. The present work proposes the inverted learning model designed for the development of online Mathematics classes, which includes students and teachers of the first year of high school of the Vinces Educational Unit, Vinces canton, province of Los Ríos. In order to obtain the results, an observation guide was applied to the virtual classes, a questionnaire to 177 students and an interview to teachers as data collection instruments. These made it possible to show the current reality of the teaching method, as well as the limitations faced by educators and students in making possible the online adaptation of the planning of the development of the contents of the subject of Mathematics.

Keywords: Inverted classroom, inverted learning, online classroom, virtual classroom, Baccalaureate, Mathematics.

RESUMEN

En estos tiempos de covid-19, al sistema educativo ecuatoriano se le ha planteado el desafío de sostener los procesos de enseñanza-aprendizaje en la modalidad online.

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Este ha demandado iniciativa y creatividad por parte de maestros y estudiantes a fin de cumplir con los resultados esperados. El presente trabajo propone el modelo de aprendizaje invertido diseñado para el desarrollo de las clases online de Matemáticas, que incluye a educandos y docentes del primer año bachillerato de la Unidad Educativa Vinces, cantón Vinces provincia de Los Ríos. Para la obtención de resultados se aplicó una guía de observación a las clases virtuales, un cuestionario a 177 estudiantes y una entrevista a docentes como instrumentos de recolección de datos. Estos permitieron evidenciar la realidad actual del método de enseñanza, además de las limitaciones que afrontan los educadores y educandos en posibilitar la adaptación online de la planificación del desarrollo de los contenidos de la asignatura de Matemáticas.

Palabras clave: Aula invertida, aprendizaje invertido, clase en línea, clase virtual, Bachillerato, Matemática.

INTRODUCTION

Currently, information and communication technologies (ICT) have modified the social encounters between individuals worldwide, giving rise to the emergence of new paradigms that propose a diversity of knowledge and skills focused on the variety of existing technologies. In this context, education is not at the margin of this, the presence of platforms for teaching and learning, have facilitated the substantial change between face-to-face and online in terms of academic activities, which have allowed to continue with the educational processes in these times of pandemic, avoiding the permanent paralysis of school actions.

The process of adaptation from face-to-face to online has revealed shortcomings in the use of technology, especially for teachers, who have had to relearn new ways of presenting didactic content. In this scenario, there is a need for motivated teachers and students, willing to receive new information. This will encourage the use of ICT in education, facilitating access to content and teaching-learning methods, in full harmony with the individuals who handle it. The interaction between the subject and the technology to educate requires new views on how to proceed and act in a context which is mediated by a computer.

Thinking about online education requires first of all to look at the current pedagogical models and dialectically deny their best contributions in order to build an educational option in new Learning Management Systems (LMS). There are several proposals: Blended-learning (Bartolomé and Sandals, 1998), E-learning (Elliott Masie, 1999), Inverted Classroom (Lage, Platt and Treglia, 2000), among others that have transcended and by their nature propose diverse pedagogical actions. Therefore, the inverted

classroom offers a direct coincidence between what is developed in face-to-face classes and what is intended to be achieved in the future, being essential its study and theoretical systematization.

According to the authors Abío et al., (2017) Llanos and Bravo (2017, p. 6) the flipped classroom learning model or flipped classroom consists of turning the class around, the student outside the classroom, seeks from his own autonomy the acquisition of knowledge by accessing the contents, mainly those of audiovisual type developed and selected by the teacher according to the educational needs, the technological tools that allow appropriating and expanding knowledge. Gallardo et al. expresses that this model allows the teacher to dynamize and modernize the teaching-learning processes, facilitating the use of classroom time aiming at achieving greater depth in the study of disciplinary contents. (p. 96)

The flipped learning model is based on the need to match different types of learning, the use of multimedia tools is considered as an important contribution to teaching and a highly influential tool for acquiring knowledge, in which students actively contribute to the elaboration of knowledge and value their own learning in a very significant way (Park and Choi, 2017, p. 192).. In addition, Mendoza (2017) highlights that, the intentional material taught by the teacher refers to the evaluation of the contents to be taught and the resources to be used inside and outside the classroom, for the better understanding of concepts, procedures, skills, abilities, aptitudes and values.

Fúneme (2019, p. 161) refers that the learning model aims to study the conditioning factors of the teaching and learning process of Mathematics, in order to adequately focus the efforts of teachers in the educational field. The central objective of mathematics teaching is the cognitive development of students, which is correlated with the form of instruction and interaction of the teacher in the classroom. (Holguín et al., 2016, p. 287).. Mathematics teachers should consider the interests and needs that allow them to create an active environment of motivation, enthusiasm and attention to their class for problem solving in a mathematical context. (Pochulu and Font, 2016, p. 15), students should assume the acquisition of knowledge, directed by the educator, strengthening class discussion or reflection. The teacher points out Oviedo (2018, p. 5)., for his part must assume strategies to generate student participation in class; therefore, it is necessary to make known the evaluation strategy to be implemented to determine the impact generated in the population of students who acquire knowledge through the classes (Vega et al., 2015, p. 11)The evaluation is a fundamental dimension for the fulfillment of the virtual educational process. (Jimenez, 2019).

Moncada Cerón (2013) defines the concept of model as a conceptual pattern on which is built from reality, providing elements that direct actions (p. 39). Relating this definition to the educational level, Tünnermann (2008)conceptualizes the term educational model as the concretion of each of the elements an institution possesses (teaching, research, extension, linkage and services) in order to make its educational project a reality. (p. 15).

For the development of this research, a literature review was carried out in different scientific databases on the variables of study: flipped learning, online class and its related terms based on the glossaries of the Social Sciences. Likewise, search chains with exclusion criteria were applied in Spanish, English and Portuguese to improve the accuracy of the results related to the research topic.

From the search carried out, a total of 15 research precedents related to the variables, descriptors and scope of the proposed topic were compiled, namely: Núñez Paz and Rodríguez (2020); Fúneme (2019); Madrid et al.;Guerrero (2019); Rahmadani et al. (2020); Lai & Hwang (2016); Wei et al. (2020); Cevikbas and Kaiser (2020); Seitan et al. (2020); Kumar et al. (2017); Clark (2015); Urban (2020); Cedillo et al. (2021); Lo et al. (2018); TARAZI, (2016).

With the literature review of the different studies and the consideration of systemic summaries related to the inverted learning model and the online mathematics class in the baccalaureate, it has been possible to identify that the topics studied are the following:

The inverted classroom as a strategy to improve performance, academics and attitudes in mathematics learning.

Transformation of mathematics teaching through the application of the inverted classroom.

The inverted classroom, impact and effectiveness in motivation and learning for Mathematics versus traditional teaching models.

Proposal for a didactic intervention with an inverse methodological approach to learn inequalities.

Once the conclusive summaries of the study background have been exposed, it can be seen that the tendency is to produce inverted classroom technologies in order to motivate and intervene, but there is a model thinking of inverted learning as a process for learning to teach mathematics online at the baccalaureate level, therein lies the importance of the research.

After the introduction, this paper is organized in the following sections: literature review on the flipped classroom learning model, the online mathematics classroom, a description of the research design, the modeling, discussion of the results obtained and the corresponding conclusion.

MATERIALS AND METHODS

The analysis offered does not dispense with a subject that contextualizes it, in the particular case of this study we choose the subject Mathematics, which within the common core of the curriculum is essential in the learning of students and its presence in secondary education levels. In accordance with everything reviewed concerning the subject, the central scientific question posed for this article is: how to model the learning invested in the online classes of the subject of Mathematics in students of the first year of high school?

This research is assumed as explanatory from a high preponderance of modeling of the processes of inverted learning applied to Mathematics classes through the face-to-face modality, which seeks to discover the current situation on the methodology or strategies used by teachers to achieve compliance with the teaching in online session and achieve learning in their students; all this from a model thinking of inverted learning which facilitates its future transformation perspective in the use of teaching of the Baccalaureate.

For the development of this research, 320 students in the first year of high school in the specialties of Science and Computer Science Technician and 2 teachers of the subject of Mathematics were considered as the study population. The random probabilistic sampling was calculated by means of the online data processing sheet, obtaining a sample of 177 students to whom the scientific research instruments were applied.

For the collection of research data, the observation of online classes of the subject of Mathematics was used, which allowed obtaining information for the realization of a documentary analysis on how teaching-learning activities are developed, determining the role of teacher and student in the inverted learning model in the online modality. Likewise, an interview was conducted with the teachers who teach the subject in the first year of high school, with the purpose of determining the strategies used in the development of their classes, in order to reach the contents and achieve assimilation. Finally, a survey was applied to students to identify their perceptions about the learning model used, as well as the didactic resources and assertiveness of the teacher when interacting with the online Mathematics class.

All the instruments offered (questionnaire, observation and interview guide) facilitate the triangulation of data for a systemic analysis, modeling the process of teaching-learning Mathematics, through the logical procedures of thinking that facilitate the use of modeling as a direct scientific method of research.

RESULTS

Table 1. *Availability of technological equipment for the development of the online class.*

Description	Frequency	Percentage
Totally agree	66	37,29%
Agreed	74	41,81%
Neutral	11	6,21%
Disagreement	22	12,43%
Strongly disagree	4	2,26%
Total	**177**	**100,00%**

It can be seen that more than 70% of the students have technological equipment for the development of the virtual session, 20% do not have this resource. In the courses observed, a great majority of them connect to the online class, being highlighted by the teachers, those who do not have technological resources, look for options to connect.

Table 2. *Digital resources sent by the teacher to review the class topic*

Description	Frequency	Percentage
Totally agree	81	45,76%
Agreed	76	42,95%
Neutral	0	0,00%
Disagreement	17	9,60%
Strongly disagree	3	1,69%
Total	**177**	**100,00%**

It is evident that more than 80% of the students receive didactic material from the professor, while 12% indicate that they do not have access to it. In the observations made, it is evident that the teacher sends the material at the end of the class online, but in his opinion not all students can receive it due to different difficulties regarding accessibility to a technological device.

Table 3. *Review of class material by the student at home*

Description	Frequency	Percentage
Totally agree	26	14,69%
Agreed	93	52,54%
Neutral	50	28,25%
Disagreement	6	3,39%
Strongly disagree	2	1,13%
Total	**177**	**100,00%**

It was determined that more than 60% of respondents review the material of the subject of study, about 30% do not review it. As for the development of the classes, no activities are generated to strengthen the review of these materials, as stated by teachers, this is due to the short time allotted for the development of the virtual class.

Table 4. *You actively participate in the online class (ask questions or contribute ideas).*

Description	Frequency	Percentage
Totally agree	42	23,73%
Agreed	24	13,56%

Neutral	44	24,86%
Disagreement	64	36,16%
Strongly disagree	3	1,69%
Total	**177**	**100,00%**

It is evident that 60% of respondents do not participate in the online session, while 30% do. It was determined that the development of the class is established on the basis of the explanation of the subject, expressing the teachers that the short duration of the class does not allow the participation of all students.

Table 5. *In the online class you learn by working as a team and collaboratively using forums, networks, chat*

Description	Frequency	Percentage
Totally agree	24	13,56%
Agreed	1	0,56%
Neutral	5	2,82%
Disagreement	96	54,24%
Strongly disagree	51	28,81%
Total	**177**	**100,00%**

More than 80% of the students stated that they do not perform collaborative work in the online class, while 30% reflect a positive response. It was possible to observe the assignment of group activities to be done at home, however, the teacher does not know digital educational tools to develop this online activity.

Table 6. *In the online class, your teacher answers your questions or doubts about the class topic.*

Description	Frequency	Percentage
Totally agree	54	30,51%
Agreed	82	46,33%
Neutral	31	17,51%
Disagreement	9	5,08%
Strongly disagree	1	0,56%
Total	**177**	**100,00%**

Seventy percent of the students state that their concerns about the class topic are answered, while 20 % say that this is not done. It was verified that the teacher motivates the students to express their doubts, but according to his criteria many do not do it, due to different situations (connectivity, embarrassment, lack of interest).

Table 7. *Is evaluated in the online class by the teacher to verify their learning online form.*

Description	Frequency	Percentage
Totally agree	1	0,56%
Agreed	19	10,73%
Neutral	45	25,42%
Disagreement	71	40,11%
Strongly disagree	41	23,16%
Total	**177**	**100,00%**

Eighty percent of respondents claim not to be evaluated in the online class, while 10% reflect a positive response, it is observed that the teacher explains in great detail the subject, but no LMS platform is applied for the evaluative part in a synchronous manner, according to their criteria this is due to the lack of expertise in the use of these learning tools.

Table 8. *The teacher reinforces the explanation of the class topic.*

Description	Frequency	Percentage
Totally agree	18	10,17%
Agreed	0	0,00%
Neutral	0	0,00%
Disagreement	85	48,02%
Strongly disagree	74	41,81%
Total	**177**	**100,00%**

It is emphasized that 90% of the respondents agree that there is no reinforcement of the class topic, while 10% affirm that there is. In the courses observed, it was found that there is no generalized feedback of the contents, teachers report that the student does not express concerns about the explanation provided.

Table 9. *You would like to receive a much more engaging and fun learning experience in online classes*

Description	Frequency	Percentage
Totally agree	40	23%
Agreed	60	34%
Neutral	52	29%

Disagreement	22	12%
Strongly disagree	3	2%
Total	**177**	**100,00%**

Fifty-eight percent of the students want fun learning, while 42% indicate that they do not. As for the observations made, it was evident that the development of the online class is limited to the transmission of information, without prioritizing interaction. According to the teachers' criteria, this is due to a lack of knowledge of a specific methodology for teaching through a computer.

Table 10. *The Inverted Classroom learning model will improve your mathematics learning in the online classroom.*

Description	Frequency	Percentage
Totally agree	41	23,16%
Agreed	71	40,11%
Neutral	45	25,42%
Disagreement	19	10,73%
Strongly disagree	1	0,56%
Total	**177**	**100,00%**

Of those surveyed, 63% consider that the invested learning improves their training in Mathematics, while 36% give an unfavorable answer. In the observations, the lack of a model designed for online education is evident; in the teacher's opinion, students do not achieve the academic level through this modality of study.

DISCUSSION
The educational process in the context of the covid-19 pandemic, has been developed in the online modality, by public and private institutions, generating a number of questions and challenges due to the same activities on which they have tried to establish. According to the results obtained, it was found that students and teachers have technological equipment (PCs, tablets, smartphones) to connect to the online class. However, teachers express the complexity of coupling to this modality, due to the lack of knowledge of methods, techniques, strategies, use and application of digital tools that allow them to make the most of this learning space.

In the same analysis of results, students expressed their desire to receive dynamic and interactive learning that motivates them to participate and be active in the construction of online knowledge. From this, the need arises to offer adaptations to the acting learning model, singularized in its inverted character for the online modality, from the assumptions of the conception of this in the face-to-face (Jon Bergmann and Aaron Sams, 2007).

The modeling of the online teaching-learning of the mathematics class, in its conception of inverted learning, requires a simplified representation of this process, in subsystems and components that constitute it.

The online inverted class, arises in the processes of its conception, therefore the authors consider that the first subsystem has to be established in: the orientation of the autonomous online activity, which has as purpose to project the individual actions of the student with the digital learning objects by internet, previous to the interaction with the teacher and other students in the synchronous class schedule, originating in a particular way the interrelation of the students with the materials oriented by the teacher to learn before the asynchronous class.

In the analysis carried out, it is emphasized that the digital resources used by the teacher are sent to the students at the end of the asynchronous class, and not prior to it as proposed in the model, in which this first subsystem composed of three components is proposed (See Illustration 1Subsystem 1.-Orientation of online self-employed activity).

In the first component, digital resources (videos, podcasts, presentations, blogs, among others offered) are received through the EVEA (Virtual Teaching-Learning Environments) according to the educational institution. Subsequently, the contents shared by the teacher should be understood individually through the reading, systematization and analysis of the digital resources offered. This will facilitate the processes of interpretation of the learning objects, from the synthesis of the contents and their assimilation that prepares them in advance for the development of the online session.
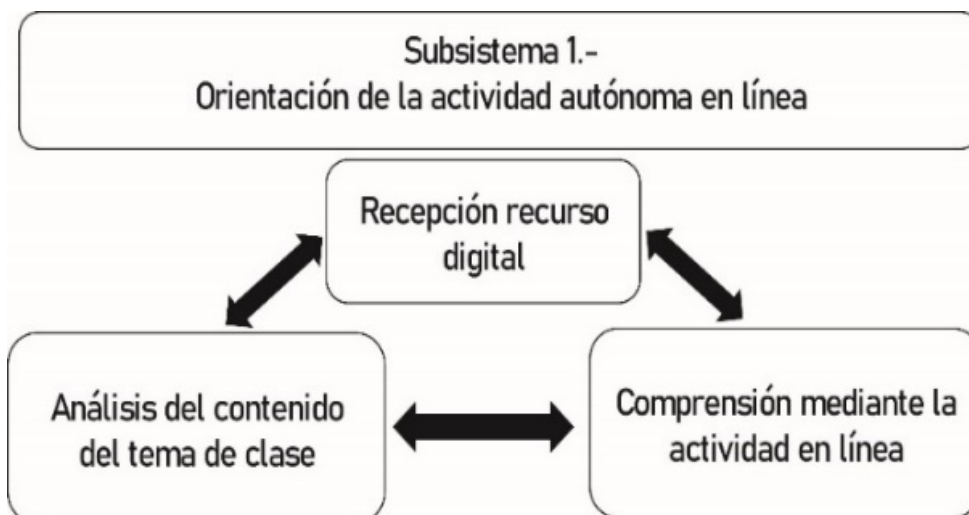

Illustration 1 Subsystem 1.-Orientation of online self-employed activity

The teacher in the application of the inverted learning model, during the orientation of the autonomous online activity, must define the objective of the class, select or create the digital didactic resources and prepare the interactive activity for the students. Once

the first phase has been executed, a second subsystem is proposed, which is composed as an online synchronous learning process, where the main objective of the subsystem is to systematize the theoretical and practical contents of the Mathematics class in a synchronous way, through the interaction of the teacher with the students and the online learning objects (see Figure 2: Subsystem 2). Illustration 2Learning Feedback Subsystem 2.).

The referred subsystem is established on the logic of the internal relationship of the components of the teaching-learning process, namely, objectives, contents, methods, resources and evaluation. The first component is called: Orientation of learning objectives and contents, in which the guiding phase of the activity takes place on the basis of what has been previously learned by the student and facilitates the asynchronous online pedagogical interaction, where the learner exemplifies what has been learned, proposes unresolved questions during his individual understanding and interpretation, in addition the teacher explains and argues to homogenize the previous knowledge and the content of mathematics treated, which as a third component will allow revealing the cognitive feedback of the content and the learning method used.
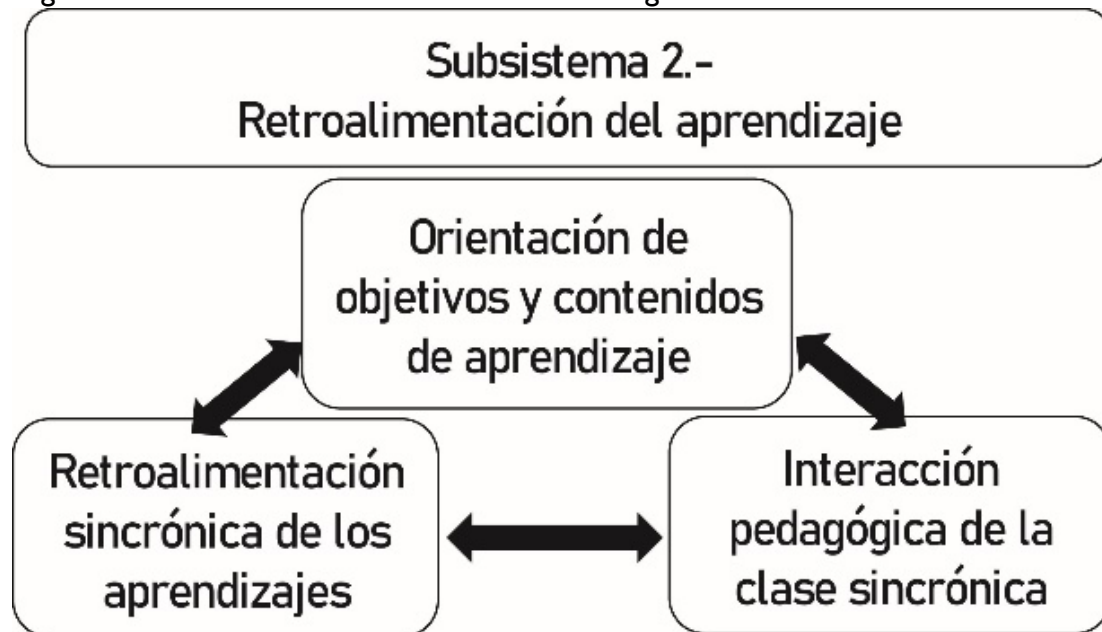

*Illustration 2*Learning Feedback Subsystem 2.

The role of feedback seeks to improve cognitive skills and consolidate knowledge in students. In the online mathematics class currently being developed, there is a lack of practice activities, reinforcement and evaluation of what has been learned. Therefore, it is emphasized that the third subsystem will consist of an online feedback and consolidation process, its objective is to strengthen the practical knowledge of Mathematics through practice as a key point in the evaluation of learning.

On the other hand, one of the elements of greater attention is the evaluation, this responds to the need to obtain the progress of how much the student is learning. The first component is called autonomous practical exercise, this proposes that the student consolidates the knowledge through the development of practical activities of mathematical exercises, as well as digital support material, if any of them find difficulties in this activity to reinforce what they have learned, which, as a third component of evaluation, allows to demonstrate the assimilation of the contents taught by the teacher. (See
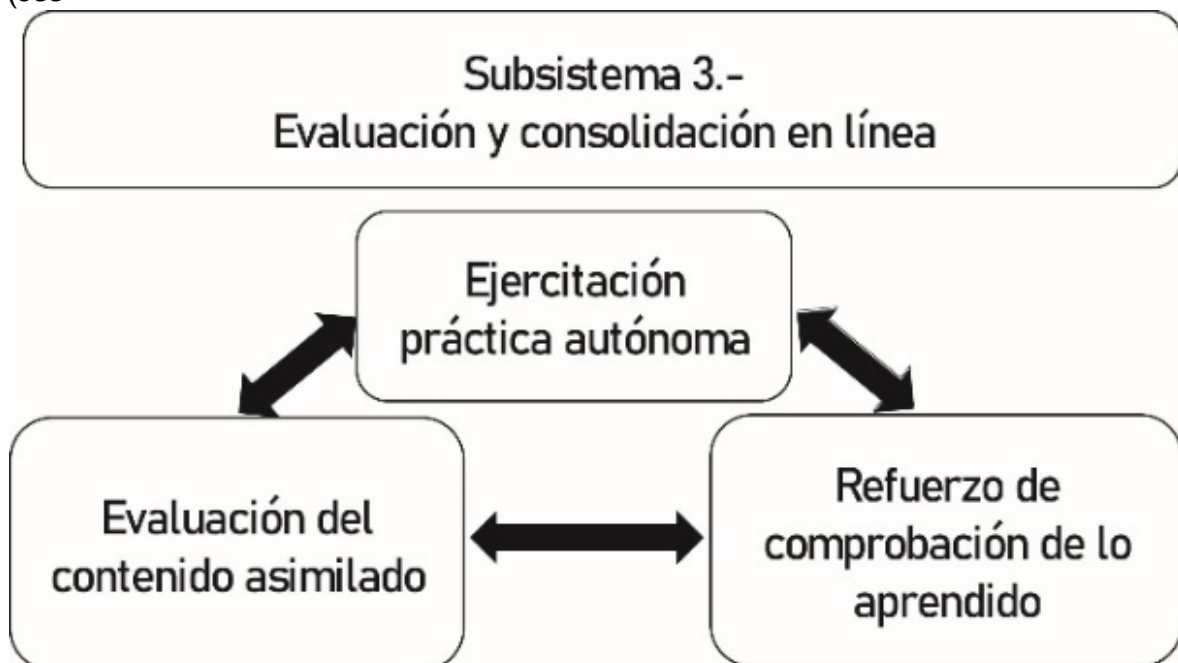

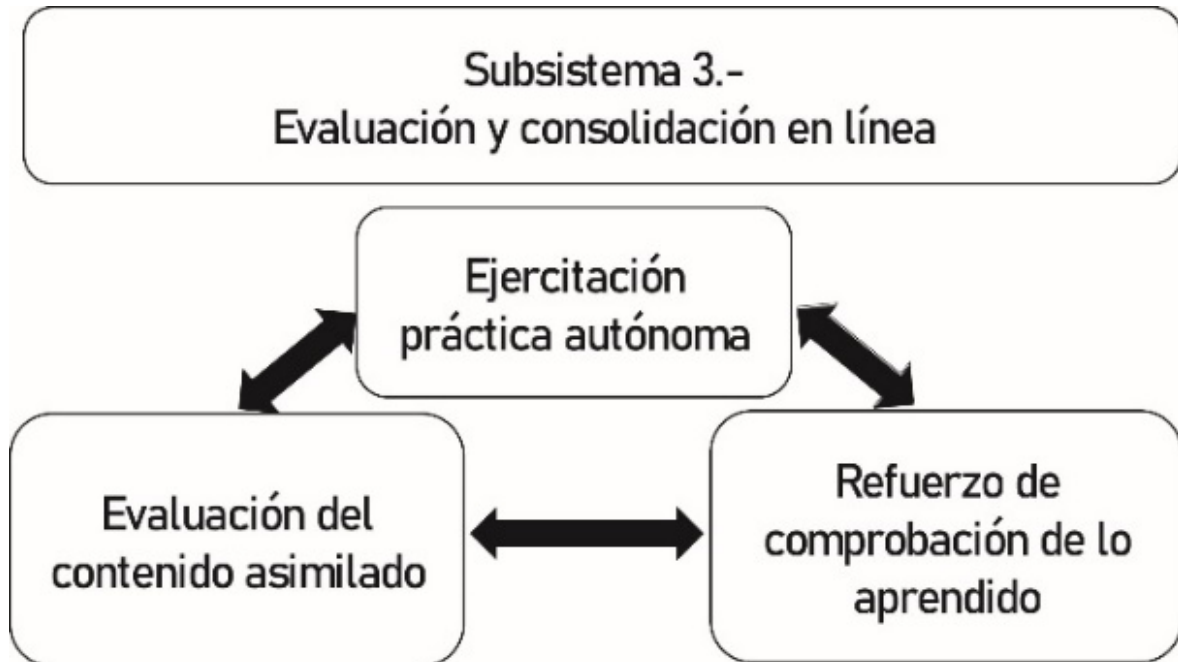Illustration 3 Online evaluation and consolidation)

Illustration 3 Online evaluation and consolidation

The inverted classroom learning model for online modality, from the conception of the proposed subsystems: orientation of the autonomous online activity, learning feedback, evaluation and online consolidation, then, the internal relationships that arise in the epistemological analysis are established.

- The essential relationship between the content, the analysis made by the student of the subject through technological resources and facilitates understanding. Therefore, a quality of asynchronous internalization of the autonomous activity measured by the technology and the Mathematics content is revealed, which allows the student to be prepared to act in the following synchronous didactic space.
- The communicative relationship between the teacher-student action mediated by educational technology and the study contents simultaneously reveals the synchronous communication process of learning, which is characterized by the achievement of the stated goals.
- The internal relationship between the independent work done by the student, the reinforcement of learning based on the materials offered, the self-assessment based on interacting with technological resources, is where the asynchronous individual assessment of learning achievements is revealed.
- Therefore, the internal logic of the subsystems, their particular relationship approach, the singularization of the synchronous-asynchronous correlation of

inverted teaching-learning and the achievements of the online mathematics class mediated by educational technologies are unveiled.

In summary, inferences must be made on the integrative quality generated from the direct interaction of the proposed subsystems, where the processual character of the online Mathematics class is revealed, from the adaptation of the inverted classroom learning model for its conception, development and improvement, in the subsystems offered in this article. (See Illustration 4. Design of the Inverted Classroom Learning Model aa)
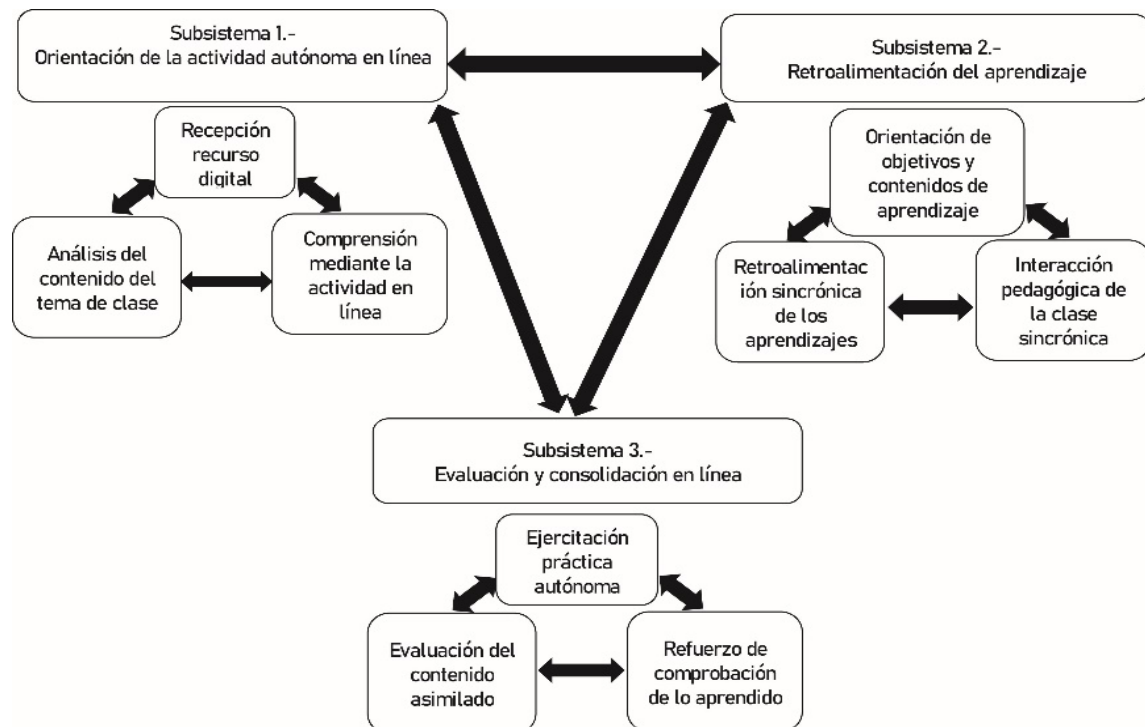

Illustration 4. Design of the Inverted Classroom Learning Model a

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