Socioformation and the Formative Evaluation in Engineering

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Abstract: The society demands nowadays that the educational models of the institutions at the university level focus in an integral formation developing knowledge, skills and competences. Nevertheless, the systems of evaluation are not necessarily according to the requirements and methods of teaching and learning in the classroom. This investigation describes the effect of implementing a checklist as a medium so that the student acquires knowledge and gives feedback on the process of teaching and learning, promoting the integral formation. The checklist was designed under the socioformative approach and was used as a mean for the formative evaluation and shared during a course of differential and integral calculus. The qualitative investigation of analytical and descriptive type was based on the action-investigation, with students of the Career of Engineering on Communications and Electronics of Instituto Politécnico Nacional. Among the obtained results, it turns out that the students had a better academic performance and a change of attitude towards the learning of the mathematics in engineering, because they can take the control and the regulation of it. Concluding, we can say that the instruments of evaluation constructed under the socioformative approach promote the formative and participative evaluation and are a good way to improve the academic performance of the student and to develop competences like the collaborative work, the resolution of problems and the autonomy in the learning. It becomes necessary to continue the research regarding the design of instruments of formative evaluation as a didactic medium and the roles that the teachers and students must follow in order to promote an integral formation from the socioformative approach.

Keywords: Socioformation, formative evaluation, integral formation and engineering, mathematics and engineering.

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1. Introduction

Society demands nowadays that educational institutions at the university level focus on an integral formation that responds to the rapid development of science and technology. So, it demands the formation of professionals capable of contributing to improve the scientific, technological and social dimensions with ethical commitment towards the development of human beings, turning the learning process into a complex process in which the main actors for this change are the teacher and the student (Llerena, 2015), (Reynoso, Castillo, & Dimas, 2014), (S. Tobon, Gonzalez, Nambo, & J., 2015).

This research is related to the integral formation through mathematics as a basic discipline in the formatting of an engineer. It is assumed that the entire curriculum must articulate and work systemically to promote complex competences for the labor and the personal life with ethics and social commitment. For which, it is required that the practice and teaching mediation be outlined towards the development of competences from the integrity and appropriate discipline, doing the relation and articulation with the ability to self-regulation and self-control, elements that are part of a metacognitive process and nowadays help in the pursuit of quality in everything is done and in achieving competences such as learning to learn (Ortega-Carbajal, Hernandez-Mosqueda, & Tobon-Tobon, 2015), (Montes de Oca & Machado, 2014).

Regarding mathematics as a required discipline in the area of engineering, teaching has generally focused on promoting rote and algorithmic development, which has resulted in low efficiency and weak disciplinary formation reflected in problems like school dropouts, high failure rate and a poor development of the essential mathematics skills in the professional life of an engineer. Researches have been done to give sense and meaning to mathematics knowledge, in order to achieve a better learning of university mathematics. Mathematical modeling, problem-based learning, handling different semiotic systems, involved with mathematical object, have been used as a didactic mean (Romo-Vasquez, 2014), (Vrancken & Engler, 2014), (Yee & Bostic, 2014), (Costa, Arlego, & Otero, 2014). However, these researches do not consider the integral formation in a specific way; some of them only consider the labor-professional field. Some others consider the importance of involving methodologies that incorporate good scientific basis, where the knowledge is integrated with the being able to be, being able to coexist and being able to learn, but only as a consequence of mathematics

learning. A comprehensive formation becomes possible only if the mathematical thinking skills and analytical thinking, critical and reflective forming mathematics are encouraged with a collaborative work that contributes to develop solidarity, responsibility, ethics and honesty. And it is only possible with an integral formation of a balanced form; (S. Tobon, 2015), (Trejo, Camarena, & Trejo, 2013), (Tarmizi & Bayat, 2012).

This research addresses the following issues:

- How to promote a comprehensive formation from the mathematical dimension in the engineering careers?
- How to articulate the cognitive dimension of the discipline with affective and metacognitive dimensions, so that the student is integrally formed?
- How to assess the development of learning in a systematic way to promote learning, feedback and to have a continuous improvement?

2. Reference Framework

The research proposes to use a checklist as a didactic mean and teaching strategy that promotes the construction of mathematical knowledge. The basis instrument takes the socioformative approach, articulating the cognitive dimension (mathematics), the affective dimension (self-esteem and the universal values) and the metacognitive dimension (regulation and control of the knowledge), Figure 1.

2.1 The socioformative approach

The socioformation is a Latin American proposal of Sergio Tobón, which is focused on transforming the teaching and the traditional learning (this one focused on content teaching) by processes centered on the student, who takes an active role and is aware of his own learning upon incorporating metacognition as a medium that contributes to the development of any competences. The socioformation is based on the learning through solving context problems, through co-creation and knowledge management, collaborative work from an ethical life project and involving information and communications technology (S. Tobon, 2015), Gonzalez, Nambo & Vázquez, (2015), Tobón, Guzman, Hernandez & Cardona (2015).

Fig. 1. The socioformative checklist articulates three dimensions for the comprehensive formation.

The checklist was designed and constructed within the socioformative framework. So, the cognitive dimension, the affective dimension and the metacognitive dimension are articulated for an integral formation.

2.2 The cognitive dimension

This research proposes the use of a checklist as a mean and a didactic strategy that contributes to the social construction of mathematical knowledge. The basis is to use the process of solving mathematical problems according Polya (Polya, 1965) and Shoenfeld (Schoenfeld, 1987) in the figure 2 are showed the criteria of the checklist which form a cyclical process.

Fig. 2. The process promoted by the checklist in relation to the cognitive dimension

In the problem identification, the student must understand and identify the problem through heuristics such as: what are the requirements

and unknowns, what data is contained in the problem, what is the information that relates data with unknowns?

Problem statement, is necessary that the student prepare a drawing, a sketch, a diagram of the problem and a possible solution or an action plan to solve it.

Coherence and relevance in the resolution require that the student have order, cleanness, consistency and pertinence in the development of the solution, from the identification to the final solution.

Manipulation of mathematical language, the student must consistently manage and coordinate the different systems of semiotic representation: graphical, analytical and algebraic, tabular and natural language, based on the work done by Raymond Duval (Duval, 2006). When handling semiotic representation systems, the mathematical object is constructed in a holographic form.

Control and regulation of knowledge, the student must justify and argue why the development and the solution are correct and this form he relates theory and practice.

When the process takes place oriented by the checklist, the mathematics takes sense and meaning, motivating the learning in the student. And, with the semiotic representation of the different registers of representation of the mathematical object, they develop skills such as mathematical abstraction, visualization of concepts according Cantoral & Montiel (Cantoral & Montiel, 2002), argumentation, inductive processes and deductive processes among others and symbolic language (Oviedo, Kanashiro, Bbzaque, & Gorrochategui, 2012), (Caligaris, Rodriguez, & Laugero, 2015)

2.3 Affective Dimension

It is assumed that the affective dimension consists of emotions, feelings, beliefs, judgments, tastes, attitudes and values that the student (or teacher) has in the learning of one discipline and they determine the quality of the same one (Gil, Blanco, & Guerrero, 2005), (Sanchez, Becerra, Garcia, & Contreras, 2010), (Gamboa, 2014). In the case of mathematics, students have certain beliefs about discipline and themselves regarding their ability to achieve their learning or not. Throughout the educational process they receive various stimuli that generate some tension, before which they react emotionally either positively or negatively; depending on their prior beliefs and experiences of the environment. The reactions produced generate feelings (emotions) of satisfaction, frustration, etc. If the conditions generated in the classroom are repeated again and again, emotions are solidified to become positive or negative attitudes towards the discipline

(mathematics), their learning and themselves influencing their personal training (Gamboa, 2014).

Following the checklist helps the student to begin taking control and regulating his learning. It gives him own-confidence by improving his self-esteem and changing negative attitudes towards mathematics to positive attitudes and self-motivating.

2.4 Metacognitive Dimension

Metacognition has been assumed as a conscious control of the own cognitive activity in a process of control and regulation of the knowledge. From the socioformative approach this notion is assumed as a process of continuous improvement over the performance of the individual, which is done through reflection and constructive criticism that encourages action to boost skills, abilities and knowledge, correct mistakes and strengthen the weaknesses. And it is applied to the development of all competences, not only to the cognitive things. It is an individual and social process that focuses on achieving goals through problem solving. It articulates with the ethical life project, which means that addressing problem solving and achieving goals are lived through all the process with the universal values such as responsibility, honesty, respect, and assertiveness, among others. Which leads to incorporate the affective dimension (Marshall, 2013), (S. Tobon et al., 2015; Tobon S. et al., 2015), (Mariscal, 2013).

The checklist has been designed based on the socioformation assessment in the metacognitive process, questioning reflexively on the achieved aspects, the areas to improve, the self-evaluation and the co-evaluation.

3. Methodology

The research was of a quasi-experimental type. An intervention in the classroom was done, which was conducted through activities focused on the process of solving mathematical problems, the process was assessed with the checklist. The methodology of action research was used, considered as an active and systematic process that shows the reality of the classroom, involves descriptions of situations, events, people, gives the perspective of the participants, to register their attitudes, considering their voices and their behavior. Thus it seeks a better understanding of evidence and the results of the research done (Colmenares & Pinero, 2008), (Erazo, 2011), (Varela & Vives, 2016).

The methodological strategy implemented to develop the classroom intervention was conducted in four phases based on Mar Mateos' model

(2001) cited in (Osses & Jaramillo, 2008). In the first phase the teacher explains how to follow the activities oriented by the checklist or didactic mean.

The methodology involves mathematical problem solving and process assessment through reflection, regulation and how to control the knowledge in an individual and collaborative manner. The second phase is a guided practice in which the student, with support from the teacher and his peers, develops the activity according to the presented model. In the third phase, activities are performed through collaborative work, following the previous model. In the fourth phase, there is a final activity, where the student works alone with the intention of appropriating of the method and the process metacognitive in a gradual way.

The collection of information was done in four stages: 1) The implementation of a survey that allowed to establish the general characteristics of the sample study, observe the time and the ways that the student dedicates to learn a subject. In the same survey was obtained information to diagnose the status of the group in relation to the methodology of problem solving and metacognitive process. The survey was reapplied at the end of the process with the intended to contrast the results.

2) Analysis of the information obtained by the checklist, considering three dimensions a) cognitive dimension through the criteria into the checklist related with the mathematical problems solving, b) the affective dimension for the reflection and the follow-up of the performance through self-evaluation, co-evaluation and hetero-evaluation, achievements and areas for improvement, and collaborative work c) metacognitive dimension was guided through the teacher's socioformative mediation, following the MADFA methodology (by its Spanish acronym): metacognition before, during and at the end of the process (S. Tobon, 2013).

3) Analysis of the student's productions (activities and exams applied to students) throughout all the intervention procedure, which lasted one semester.

4) An observation guide carried by the teacher with records on the behavior and attitudes of the students and some interviews of them made during class sessions and at the end of the intervention.

3.1 Participants

The work was carried out with a pilot group (PG) 27 students from the carrier of Computer Engineering, an experimental group (EG) of 27 students of the carrier of Engineering in Communications and Electronics, both of them from the first semester (the subject was differential and

integral calculus, which is common to both academic programs). The participants were informed that all information collected in the study would only be used for purposes of the research and that all personal data would be protected, in accordance with the Law on Personal Data Protection with validity in Mexico (Diario Oficial de la Federación, 2010).

3.2 Instruments

The following instruments were used:

1) Assessment of metacognitive process in problem solving, this instrument was designed to assess the degree in which the participants are involved with a metacognitive process through a methodology of solving mathematical problems. The activities designed within the academic context were taken based on Monereo (Monereo, 2001), who believes that the strategies or situations of the metacognitive learning should be given and taught in conjunction with the various disciplines of the curriculum without additional time and with the resources the teachers can implement (Huertas, Vesga, & Galindo, 2014), (Jaramillo & Osses, 2012), (Monereo, 2001). This instrument has been validated for its implementation in the classroom (Rodriguez-Peralta, Nambo, & Aniceto-Vargas, 2016).

2) Checklist for promoting mathematical problem solving, the instrument aimed to guide the student's learning through the methodology of mathematical problems solving based on Schonfeld (1987) and Polya (Polya, 1965), which were shaped as a method to promote the checklist (L. Rodriguez, Nambo, Viveros, & Aniceto, 2015), (L. Rodriguez, Rodriguez, & Hernandez, 2016).

3.3 Procedure

The study was initiated in the corresponding semester from August to December 2016. The survey of metacognition was applied first at the beginning of the semester to characterize the study sample and diagnose their metacognitive process.

Once started the course in each work session with students, the process metacognitive was promoted. Teaching mediation to achieve the implementation and monitoring of this instrument was based on action research. It was applied in each activity done by the student who worked on collaborative work teams (three members). The teacher guided the metacognitive process in each activity in order to reflect about the personal and collaborative work, helping to identify weaknesses and ways to promote (continuous) improvement for the subsequent activity. At the end of the

semester, the survey of metacognition was applied again to contrast the initial results.

4.Results

4.1 The Students' Ways of Studying

The graphs show the situation that prevailed throughout all the procedure. PG is the pilot group and EG is the explored group.

Fig. 3. Time and resources devoted by students when studying.

4.2 Metacognitive process

Information gathered at the beginning of the intervention in relation to the student's situation with the metacognitive process is presented in Figure 4. The results of the survey are based on three categories: 1) cognitive process, 2) execution and implementation of action plan and regulation and 3) control of learning.

Fig. 3. Results of the survey of metacognitive process.

4.3 Checklist

Regarding the implementation of the checklist, it was induced to be used by the students, though not all of them did it. Figure 4 shows the percentage of students who implemented it in their activities, who implemented it wrongly and those who did not implemented it.

Fig. 5. Students who implemented the checklist in their activities.

Regarding the content of the checklist in Table 1 it is showed how the students approached the checklist.

Table 1. How students followed the checklist

How they apply the checklist	Percentage of students
Apply 5 criteria of the checklist	37.00

Apply 3 of the 5 criteria of the checklist	27.16
Do not apply any criteria of the checklist	35.84
They managed to do self-assessment objectively	18.52
They managed to make co-assessment objectively	37.00

4.5 Course evaluations

Even if the student understands the importance of the learning process, the final grade represents for him learning. Course evaluation was performed by a continuous and cumulative evaluation, the results can be seen in Figure 6.

Fig. 6. Percentage of pupils approved.

5. Discussion

The work developed in this research shows several important results:

1) The pilot group, in the initial survey metacognition of Figure 3, showed that there were no changes in their responses to the survey, in relation to the categories 2 and 3 (action plan, control and regulation of the learning). There is a tendency to answer that they have a metacognitive process, nevertheless, with the activities they made during the semester, it is observed that there is no consistency between what is answered and what they are doing, which shows that there was no intervention with the checklist.

The exploration group, in this case slight changes in what students do to a mathematical problem are showed. However, it is noted that there is an improvement in the action plan, the regulation and control of learning; showing the effect of implementing the checklist. Apparently, in relation to the management of knowledge, this management was weakened.

2) If the information is triangulated with students' production and the implementation of the checklist, it can be considered that:

a) The student must be sensitized regarding the goal of learning mathematics at the higher level, learning must be meaningful in order to be applied in any other context, this awareness is not a few days' work, it should be permanent. The student must change his attitude (usually passive) in order to have a more active participation in the construction of his knowledge, should ignore a bit the algorithmic part and believe that a score is not the knowledge. This should motivate him to do the activities with the guidance that the teacher does. In some cases, the students said that "*carrying out activities in this way robbed them time and complicated the task, so it was better to keep doing what they did before the implementing of the checklist*". They presented opposition to working with the checklist.

b) In the case of the students who followed the checklist, the following performances were showed:

Cognitive dimension. For the students it is complex to make a change in their conception of learning, the general idea that they have is that they learn the subject only if they use the memory (rote learning) and if the teacher is a teacher "that explains well," then they learned and did not even need additional activities. Also, if the subject is mathematics, why should values be promoted? Which is the *raison d'être* the teamwork or things they consider beyond their educational performance? In the first survey, the answers they gave show that all they know how to solve a problem, how to identify a problem, that they relate the theory and concepts they have, that they do an action plan, etc. However, when they began to implement the checklist, their activities were done without these elements. When they filled the survey at the end of the intervention, they were sensitized regarding the criteria of the checklist and improved their performance. They began to give sense and meaning to what they learned, and they could argue, conceptualizing, applying knowledge in various contexts.

Affective dimension, collaborative work, the self-assessment and peer assessment, allowed them the development of assertive communication, to achieve make co-evaluations with constructive criticism, with the idea of providing elements for the growth of their peers, to reflect about what they achieved with the goal they hoped. They learned to identify

the achievements at each activity, noticing which aspects they could improve and how to communicate with their peers in order to motivate them to improve as was due.

Metacognitive dimension. Becoming aware of how the students learn and how they have and seek strategies to regulate and control the learning is something that usually is not taught and less practiced in educational institutions. The checklist allowed to introduce students into a metacognitive process through guided reflection by the teacher and oriented by the checklist. This led to improve the student's learning, which is evidenced for him in his course approval.

The course, Figure 6 shows that in the first partial, the approved ones' number is smaller, because the change in the way of working affected them. This possibly influenced the evaluation ratings, which were of an average lower than the other partials. During the second partial, it is appreciated an increase in the number of approved students. They are being sensitized to the use of the checklist and the working method. In the third partial, the number of the approved ones decreases, since the final grade is the average of the three sets, they must have as a total at least 18 points in the three evaluations and some students could not pass because the sum of the grades of the first and the second partials were not enough. And it was observed that in the third assessment, they did not work enough to keep improving, which affected the final assessment.

Among the results it is seen a better academic performance in the group in which the intervention was performed. A change in the attitude towards mathematics of engineering, they were self-motivated towards a greater participation in the development of their learning, because they could take the control and the monitoring and the regulation of the process of their own learning.

6. Final remarks

One of the problems that arise in educational institutions of the higher level, is how to make the integral formation of a future professional, formatting him for working and personal life within a society that should look every day for the benefit comprehensive of itself. Metacognition has become relevant to enter the education process since it contributes in the development of competences. However most of the strategies to promote metacognition are made about the cognitive dimension, this research shows the possibility of promoting the metacognition for the development of skills, abilities and knowledge of a comprehensive formation.

The work done by students showed weakness in their knowledge and skills before the beginning of the course, then arose the necessity of selecting the competences that should be promoted from the different levels of the subjects belonging of curriculum. The idea is to develop them (the competences) gradual and transversally to give feedback by the other subjects. This would make a consistent and coherent learning scenery, which approaches to a common goal in developing both works and life competences.

The research showed the necessity that the teachers accompany the student in order to monitor any learning strategy implemented in the classroom. In this specific case of the checklist, the teacher can consider it as an assessment instrument that can guide the progress in learning that shows the methodological errors made by the student, or the achievements that will motivate him to keep going.

So, in the methodology of problem solving, he must learn to identify a problem in order to propose an action plan, each part of the process of solving the problems must be learnt gradually. Then it is not enough a semester to achieve the learning of a metacognitive process and the methodology of problem solving. Each of the subjects should contribute to the formation of these processes that should be encouraged through a teacher's mediation in a continuous, pertinent and timely way.

Regarding firstly the increasing development of the society, the economic, political and social problems and, in addition to this, the technological and scientific development, the society demands citizens with social commitment, professionals with ethics, sensitive and prepared to contribute to the social growth in any area of their competition. The universities have the responsibility of forming this class of professionals. Worldwide the educational institutions have confronted this commitment in diverse ways, some of them incorporating strategies that allow the development of values like the ethics, some others have made an emphasis in the humanistic dimension and some others in the education of values by means of the holistic formation, or incorporating historical or cultural activities (Gluyas, Esparza, Romero, & Rubio, 2015), (Llerena, 2015), (Reynoso et al., 2014), (Yampolskaya, 2014), (Zhuravlyova & Zhuravlyov, 2015).

In this research, it has been introduced a proposal from the socioformative approach that evidenced a way of promoting positively the generic competences like the metacognition, the learning to learn, the collaborative work; the strengthening of values like the responsibility, the honesty, the social responsibility; the construction of a mathematical

functional knowledge for the engineering, with activities of a systemic form, integrated and articulated by means of the continuous assessment inside the classroom.

As a conclusion we can say that assessment instruments built under the socioformative approach promote the participatory formative assessment and are a good way to boost the student's achievements and the development of competences like the collaborative work, problem solving and the learning autonomy, which are the basis of a comprehensive education.

It is necessary to continue researching on formative assessment instruments as a teaching tool and on the roles to be followed by teachers and students when the framework is the socioformative approach.

References

- Caligaris, M., Rodriguez, G., & Laugero, L. (2015). Learning styles in numerical analysis and visualization. . *Social and proceeded-Behavioral Sciences*, 3696-3701.
- Cantoral, R., & Montiel, G. (2002). *Visualization and mathematical thinking*. Mexico: Centro de Investigacion y Estudios Avanzados del Instituto Politecnico Nacional.
- Colmenares, A., & Pinero, M. (2008). A heuristic methodological tool for understanding and transforming realities and socio-educational practices. *Laurus*, 14(27).
- Costa, V., Arlego, M., & Otero, R. (2014). Journal of Formacion e Innovacion Educativa Universitaria. *Vector Calculus teaching at the University: Proposed Study Tours and Research.*, 7(1).
- Duval, R. (2006). A crucial issue in mathematics education: the ability to change the registration of representation. *RSME Gazette*, 9(1), 143-168.
- Erazo, M. (2011). Scientific rigor in qualitative research practices. *Ciencia, Docencia y Tecnologia*, 22(42), 107-136.
- Gamboa, R. (2014). Relationship between the affective dimension and learning of mathematics. *Revista Electronica Educare*, 18(2), 117-139.
- Gil, N., Blanco, L., & Guerrero, E. (2005). The affective domain in learning mathematics. A vision of their basic descriptors. . *Revista Iberoamericana de Educacion Matematica*, 2, 15-32.
- Gluyas, R., Esparza, R., Romero, M., & Rubio, J. (2015). Model of holistic education: an offer for the formation of the human being. *Revista Electronica Actividades Investigativas en Educacion*, 15(3), 1-25.

- Huertas, A., Vesga, G., & Galindo, M. (2014). Validation of the instrument "inventory of metacognitive skills (MAI) with Colombian students. *Praxis y saber*, 5(10).
- Jaramillo, S., & Osses, S. (2012). Validation of an Instrument on Metacognition for graduate students of General Basic Education. . *Estudios Pedagogicos*, 38(2), 117-131.
- Llerena, O. (2015). The training process from a complex historical and cultural view. *Revista Actualidades Investigativas en Educacion*, 15(3), 1-23.
- Marshall, A. (2013). *The role of Socioformation in improvemet the quality of education*. Venezuela: University of Carabobo.
- Monereo, C. (2001). The strategic education. To teach for the autonomy. *Aula de Innovacion*, 100.
- Montes de Oca, N., & Machado, E. (2014). Training and skills development in Cuban higher education. . *Humanidades Medicas*, 14(1).
- Ortega-Carbajal, M., J., Hernandez-Mosqueda, & Tobon-Tobon, S. (2015). *Documentary analysis of the management of knowledge through conceptual cartography*. (Vol. 11).
- Osses, S., & Jaramillo, S. (2008). Metacognition: a way to learn to learn. *Estudios Pedagogicos*, 24(1), 187-197.
- Oviedo, I., Kanashiro, A., Bbzaque, M., & Gorrochategui, M. (2012). Semiotic representation registers in mathematics. *Revista Aula Universitaria*, 13, 29-36.
- Polya, G. (1965). *How to suggest and solve problems*. . Mexico Trillas Mexico SA de CV.
- Reynoso, M., Castillo, J., & Dimas, R. (2014). The formation of the engineering students through continuing education. . *Revista Electronica Educare*, 18, 77-96.
- Rodriguez-Peralta, L., Nambo, J., & Aniceto-Vargas, P. (2016). *Design, validity and reliability of the instrument: Assessment of metacognitive process in problem solving*. *Avances de Investigacion en Salud a lo largo del Ciclo Vital*.
- Rodriguez, L., Nambo, J., Viveros, P., & Aniceto, P. (2015). *Checklist for the development of an advanced mathematical thinking*. Paper presented at the Congress Proceedings: V International Congress on Education and Human Resource Management. CIFCOM 2015, Cancun, Mexico.
- Rodriguez, L., Rodriguez, J., & Hernandez, J. (2016). Paper presented at the Content validation of a checklist for solving mathematical problems, Proceedings of the Fourth International Conference on Educational Contexts and Psychological Health. Almeria Spain.
- Romo-Vasquez, A. (2014). Mathematical modeling in engineering education. *Mathematics Education*, 314-338.

- Sanchez, J., Becerra, J., Garcia, J., & Contreras, M. (2010). *The affective dimension and performance statistics in college students*. Leston: Patricia.
- Schoenfeld, A. (1987). *What's all the Fuss About metacognition? Cognitive science and mathematics education* (Vol. 189): AH Schoenfeld.
- Tarmizi, R., A. , & Bayat, S. (2012). Collaborative problem-based learning in mathematics: A cognitive load perspective. *Procedia - Social and Behavioral Sciences*, 32, 344-350.
- Tobon, S. (2013). *MADFA metacognitive process and strategy* (Vol. México,). Mexico: CIFE.
- Tobon, S. (2015). *The socioformation: progress and challenges in the knowledge society*. Paper presented at the Keynotes National Congress of Educational Research, Mexico.
- Tobon, S., Gonzalez, L., Nambo, J., & J., V. (2015). The Socioformation: A conceptual study. *Paradigm*. 36, 7-29.
- Tobon S., C., Guzman, J., Hernandez, & S, C. (2015). *Knowledge Society: Documentary study from a humanistic and complex perspective*. *Paradigm* (Vol. 26).
- Trejo, E., Camarena, P., & Trejo, N. (2013). Mathematics in the formation of an engineer: mathematics in context as a methodological proposal. *Revista de Docencia Universitaria*, 11.
- Varela, M., & Vives, T. (2016). Authenticity and quality in qualitative educational research: multivocality. . *Investigacion en Educacion Medica*. doi:<http://dx.doi.org/10.1016/j.riem.2016.04.006>
- Vrancken, S., & Engler, A. (2014). An introduction to derived from variation and change: findings of an investigation freshmen college. . *Bolema*, 28, 449-468.
- Yampolskaya, L. (2014). The principle of holistic education and the ideal of a single integrated culture: towards the formation of an approach. *Procedia-Social and Behavioral Sciences*, 166, 488-496. doi:10.1016/j.sbspro.2014.12.560
- Yee, S., & Bostic, J. (2014). Developing a contextualization of students' mathematical problem solving. *Journal of Mathematical Behavior*, 36, 1-19. doi:<http://dx.doi.org/10.1016/j.jmathb.2014.08.002>
- Zhuravlyova, I., & Zhuravlyov, S. (2015). Humanistic sense of creativity in professional university education: the role of creativity in forming innovation model and modernization of university training. *Procedia - Social and Behavioral Sciences*. doi:10.1016/j.sbspro.2015.10.081