FORMACIÓN CIENTÍFICA Y DESARROLLO DE COMPETENCIAS PARA LA INVESTIGACIÓN EXPERIMENTAL EN LAS CIENCIAS AGRÍCOLAS

SCIENTIFIC TRAINING AND SKILLS DEVELOPMENT FOR AGRICULTURAL RESEARCH IN EXPERIMENTAL SCIENCES

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Resumen

La formación científica del estudiante de agronomía tradicionalmente ha estado arraigada en los modelos conductista que vinculan su quehacer profesional al desarrollo de habilidades y destrezas tecnológicas, con claros tintes pragmáticos y utilitaristas. Bajo este contexto, las instituciones de educación superior en América Latina, y particularmente en México, no han sabido aportar abordajes modélicos que faculten el tránsito inteligente hacia mejores formas de intervención didáctica, en busca de reorientar la formación científica del estudiante, lo que eventualmente permita dotar a los maestros de los fundamentos para alfabetizar científicamente a los futuros profesionales de las ciencias agrícolas. Atendiendo esta necesidad, el presente capítulo expone los resultados obtenidos en la aplicación de una propuesta didáctica constructivista relacionada con la alfabetización científica del estudiante de ciencias agrícolas. Registrada a lo largo de 11 años, se presentan los resultados encontrados al desplegar las estrategias dirigidas al logro positivo del aprendizaje significativo, a partir del desarrollo de metahabilidades para el razonamiento crítico y creativo, componentes del pensamiento científico y de una educación para la vida.

Palabras clave. Ciencias agrícolas, enseñanza, aprendizaje, sostenible.

Abstract

The scientific training of agronomy student has traditionally been rooted in behavioral models linking their professional work skills development and technology skills, with clear tints pragmatic and utilitarian. In this context, institutions of higher education in Latin America, particularly in Mexico, have failed to provide exemplary approaches that empower the intelligent traffic towards better forms of educational intervention, seeking to refocus the scientific training of the students, which will eventually allow teachers provide the foundation for scientifically literate future professionals in agricultural sciences. In response to this need, the chapter presents the results of applying a constructivist teaching proposal regarding student scientific literacy of agricultural sciences. Recorded over 11 years, the results found when deploying strategies aimed at positive achievement of meaningful learning, from the development of meta-skills for critical and creative thinking and scientific components of education for life reasoning are presented.

Keywords. Agricultural science, teaching, learning, sustainable.

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THE FOUNDATIONS OF A NEW VISION FOR EDUCATIONAL AGRICULTURAL SCIENCES

Science is a virtuous process, although plagued by stigma and iconic performances. Such clear assurances that challenge the intelligence and common sense of the human being. This defines its bearings and highlights their goals ... but also shadows and chiaroscuro.

Faced with this investment it may seem the most immutable of tasks, the most colossal of the unknowns, the most sophisticated resources, the more challenging duties. Nothing so far from it.

Science view from inside is shown as a true reflection of what can be, what is implied behind the mirror. It's gaze is lost in the detail of the foreign, of the far, what has shaped and may change. Reality that at the time it is transformed into preface of what needs to be refused to continue to exist.

In the end, science is not only litigation seeking way to express themselves, but talent that imagines and recreates life scenarios.

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Under current educational models defined as necessary for the top level in the world, both as a technological university level, is known for its broad international consensus that shed points as inescapable scientific formation of the student, especially now that humanity is immersed in the so-called Decade of Education for Sustainable Development, which aims to make all education, both formal and informal, provide care to the chaotic situation that exists in the world and favors a correct perception of the various problems it faces and allow possible solutions, while promoting attitudes and behaviors favorable for achieving truly sustainable future. . According to Vilches et al, (2005) can not address the wide range of problems just thinking locally, as it is well known that there are profound interactions between phenomena (systems); but the authors themselves who pose a question that is key to understanding the present approach: To what extent science and technology education contributes to a sustainable future?

This simple question, placed on the table analysis that science education is not only a requirement fashions emanated from simple start of the millennium, but a true global coverage policy, which focuses its support on broad foundations international, such as achieved at the World Conference on Science for the XXI century, sponsored by UNESCO and the International Council for Science, where he emphasizes the importance of addressing the needs of the population, providing it with the means consensus and instruments that take you to achieve true scientific literacy, which itself achieves enhance human development (Gil-Perez and Vilches, 2006), to conceive it as a strategic imperative (Budapest Declaration, 1999). The central idea revolves around a longstanding aspiration that since late last century continues as a pending issue: the structuring and promoting holistic curricula for comprehensive educational training, led through teaching-learning science and the technology.

Several references point to the need to transform the current reality of developing countries, which during the last half of the twentieth century focused their educational models exclusively in training its citizens to use technology that transformed science a charged rhetoric of aphorisms which were repeated in the official educational discourse and translated into descriptive letters referred curricula. In this regard it highlights the approaches of the National Science Education Standards, sponsored by the National Research Council (1996), which emphasizes the natural freedom and right of every person to use the available scientific information, to understand from his auspices, frames of reference what happens in the near and immediate environment, to engage with the transformation that carries its approaches to give up being a mere spectator of reality (which is usually constant change), to become a player of his time. Ideologies which remain in force after more two decades.

However, despite all the efforts to make higher education an enabling environment for the development of space knowledge, skills, abilities and attitudes required to consolidate the scientific and technological literacy, these initiatives have only served to show clearly and blunt the huge backlog that is suffering (Vázquez-Alonso et al., 2005). What the entry of this century has been to question the validity of school education, including the school itself as a social institution.

The explanation for this failure has been approached from several perspectives, which explains why some people sitúen the genesis of the phenomenon in a poor basic education (Fourez, 1997, 2002). Without going into details about this, one must consider that even the greatest difficulties are found in developing countries (Latin America is a clear example), the problem still persists in those classified as highly industrialized (Vázquez-Alonso et al. , 2005). The crisis in the global science education can not be explained in simple coordinates, since it involves various components of political, economic, social, and even cultural, that provide nuances to the context of implementation and completion of curriculum models in operation, many of which despite being properly grounded in conceptual designs, they have failed to substantially change the educational reality, which makes them failed projects.

Among the factors that are related to the problem are the following: 1) a significant proportion of teachers with little scientific training, which are in charge of giving the courses or subjects related to science. This often leads to the perception that scientific literacy is not required to move into that area; 2) teachers with strong scientific and technological training, with enough experience, but no attitude to the teaching profession (Villarruel, 2002); 3) curriculum without a solid curricular structure without mainstreaming requires that the scientific curriculum; 4) development of an educational practice in behavioral and encyclopaedic sustained postures, detached from reality and centered education paradigm (repetition of facts and scientific events, laws and theories); 5) promoting an image of dogmatic science and routinely constructed from naive epistemological positions, which make the learning process a boring and irrelevant event; 6) instructional strategies that lead to the dismantling of the groups of students who do not cultivate cooperative learning; 7) evidence of cultural factors, which are usually established as ideological and social constraints that impede the continuity of the processes of scientific-technological training. One example is the fact that women tend to have more negative attitudes about science and technology than men (Acevedo, 2005; Sjöberg, 2004; Sjøberg and Schreiner, 2005), although this depends on the areas of knowledge that the case.

The consequence is that students fail to connect learning of science with its forms and ways of life, which leads them to think that has nothing to do with the classes they take in his career (ethics, sustainable development, and language drafting, administration, etc.), looking at them the idea that only serves to investigate, or that is devoid theory of practice, unable to gauge the benefits of scientific literacy. The result is displayed obvious indifference and even rejection to receive such education, arguing that what it takes to be a good profesionista is practice. They overlook that practice without theory makes education a simple act training, and science in an instrumentalist fallacy.

When referring to science education as a necessity that goes beyond the scope of higher education institutions (HEI) to be placed within the culture itself, necessarily you have to bring to the stage the objectives of the current called Science, Technology and Society, which requires broadening the spectrum of the purposes of such education, which suggests its curricular structure based on the ongoing socio-technical discussion of real problems (Vázquez et al., 2006) and the level of its impact on society and education; This is due to explain in terms of its historical development, its epistemological foundation and cognitive and metacognitive, procedural (practical) and attitudinal improvement (axiological). On this last point should lie the greatest educational impact, since it's behavior researcher future takes shape, to maintain interest that students often manifest, motivating them to keep curiosity and improve their performance in order to generate attachment and link to science education (sense of belonging), not only throughout the school year, but also throughout life (Fensham, 2004).

Finally, the transition to a paradigm that privileges science for all, consider the following components (adapted from Fensham, 1985 and Garritz, 2006): a) the contents possess an obvious and immediate social relevance for apprentices and staff at the beginning of what they already know, and their pre-school experience. This implies start of their preconceptions about science, reality and truth criteria employed by them (popular epistemology, previous pedagogical knowledge); b) practical skills and knowledge acquired must be related to achievement criteria or goals that all learners can achieve. That is, they should relate to the substantive progress being obtained in the process of scientific training, to ensure meaningful learning; c) the contents and strategies will be visible constantly, so that the student can refine the components of learning.

The learner must perceive clearly their progress in the process of scientific literacy, seeking their commitment to it is growing; d) pedagogy used must incorporate all the series of demonstrations (modeling) and practices that are inherent to science and cultural learning (socially constructed), without ignoring that which is obtained as previous (preconceptions); e) learning practices, cognitive and metacognitive skills arise as a result of the relevance and significance of the topics of science. This requires particular attention to collaborative and cooperative work, aimed at knowledge management and negotiation; f) evaluation will recognize, as noted, all prior knowledge that learners have about science and its subsequent achievements, the objectives outlined in the integrated science curriculum.

Subparagraphs b, d leave open the possibility of paying special attention to experimental approaches, paragraphs a, c and f underscore the individuality and the necessary integration of the groups.

By referring to the statement by Garritz (2006), a proposal for educational innovation should be the repository of the precepts of constructivism, as this ensures a vision that transcends the simple definition psicologista. In this regard it should be clarified that this is not just a theory of learning, but also a philosophy of science and education, a true worldview (weltanschuung) "... to provide an overview of the meaning of the human adventure on the way humans impart meaning to their entire existence in order to survive and adapt ... "(Pépin, 1998).

Note that when constructivism a perception of reality, which is comprised of dissimilar visions and sometimes found (cognitivism, genetic psychology, psychology of meaningful learning or socio-historical school, without discarding the postulates of Vygotsky) from which it is assumed that knowledge is not something given and ready for use, but is integrated from the socio-cultural interaction of collective synergy, where negotiation of meanings takes radical importance, it is that it can be intended as a theory of knowledge, which accounts for the constitution of science, where the production of individual knowledge and practice of science are entirely social processes.

Thus it is accepted that improving the learning process requires educational support that the teacher-mediator you can offer the apprentice science, in order to enhance their self-employment and self-regulating, which aims to improve the network of meanings and conceptual connections that are often brought into play when knowledge is built. Both elements are considered closely related and mutually interdependent (Coll et al., 2006). This support has provided the goal of transferring, from teacher to student, control and responsibility for learning (Coll et al., 1995), which involves promoting their autonomy and self-regulation.

The assistance to the process of student learning, according to Coll et al., (2006), should be based on the systematic and continuous monitoring of their progress, and must necessarily include forms of support and a variety of support depending on the time process and the needs of the students (not always the same).

Under this renewed conception of educational work, the realization of the objectives requires a design according to each performance context where collaborative work is privileged. To achieve this should promote positive interdependence in the daily work of the members of the collective, direct face to face interaction, effective teaching social skills in group interaction (not substitute for existing), constantly monitoring the activity I developed and individual and group comprehensive assessment (Johnson, Johnson and Holubec, 1994), designed to ensure that students are placed assertively meet the demands and typical problems that receives a professional from your golf performance, assumed as its natural space, psychologically and socially for them operable action.

One aspect that should be included throughout the proposal is to enhance motivation within the working group, seeking to ensure that the quality of the relationship between members, mutual support, esteem, affection (the latter modulated the emotional capital of the protagonists) and the success, are those determined and correlated intrinsic motivation of all learners.

The teaching strategies employed will seek to conceptualize learning as a process of constructing meaning and making sense of the contents and tasks performed away from the simple routine that ordinarily undergo science learners. Such teaching tasks and teaching practices will attend case analysis and resolution of problem situations in situ and in vivo. It is therefore proposed to link theory with practice, but not in the traditional sense, but by nesting the teaching and learning of conceptual, procedural and attitudinal. This requires self-instructional settlement of traditional curricula (institutional curriculum) is exceeded, which make a clear differentiation of theory and practical hours, seeking to turn (in this case), all hours in theory and practice , addressing theoretical knowledge from its use in solving cases and problematic situations. The sense of negotiation of knowledge, typical of these strategies is approached as a skill (unit) competition to develop.

With respect to metacognition, the approach of the proposal recovers approaches Flavell (1979), in the sense of providing care for both the person, as to the tasks and strategies, as well as how these factors interact during the and the cognitive process of learning to learn. However, it is appropriate to add two components: the materials (Brown et al., 1981), which in agricultural sciences are toral importance, since they bear the cognitive and metacognitive activity, and the context for this alluding to the stage of learning time. All related to the content component previously pointed out.

At this point it should be noted the need to foster student-oriented declarative knowledge to know what, aimed to know how (Flavell, 1985) procedural knowledge and conditional knowledge channeled to know when and why to use a particular strategy (Paris et al., 1983). Nor should we forget that there is a clear difference between metacognitive knowledge and metacognitive activity, the latter concerning the relationship between consciousness and metacognition (Peronard, 1999). It is understood that consciousness to be involved in metacognitive activity, the student from it can monitor its processes (the subconscious) and monitor their regulation, including implementing strategies before, during and after the activity or task (pre-instructional, instructional and post-instructional). In this regard it should be clarified that although there is evidence that some of the cognitive activity can be conducted at a non-conscious level, should not be overlooked that the most effective participants in their adaptation to the environment (context of action) are the have greater awareness of their own mental processes, ie they have a higher level of meta-cognitive skills (such as alleged Reeve and Brown, 1985). Alcalay and Simonetti (1992) clarify this regard that the development of a progressive subject's ability to control their cognition conditions increasing their coping skills, which among other things enables the integration of the subject within the group, which favors the establishment of dialogue and learning communities.

At this point it is easy to identify how traditional schemes in educational work, efforts are directed to the domain of contents, under the assumption that a solid knowledge capital itself guarantee the development potential of the individual. However, although knowledge is essential to the development of thought (Nickerson, 1988), there is no reliable evidence that accumulating knowledge will ensure the development of critical and creative thinking. This is demonstrated by the results of research conducted by Glaser (1984), Perkins (1985) and Whimbey (1985) (cited by Ponce-Torres, 2006), who claim that there is a lot of people that despite pursue formal studies, even university, they fail to develop critical thinking; that is, there is no direct impact of schooling on the development of skills for this kind of thinking. Obviously, these traditional school models are far from analogue and metaphorical thinking.

To achieve this, it is necessary to design and conduct strategies aimed at the effective achievement of cognitive and metacognitive skills, seeking that they be present in each of the teaching tasks and teaching practices designed and coordinated by the teacher-mediator actions.

Finally it should be emphasized that the permanent inclusion of students in concepts, procedures (heuristics) and attitudinal tasks (axiological) closely related to their research skills, allow intelligent and creative traffic, a passive or receptive thought, to one active or reflective backbone of a proposal seen as a process. From here it is possible to think about the desired interactivity in academic groups.

THE CONTEXT OF SCIENCE EDUCATION IN THE FIELD OF AGRONOMY

Agronomy as a science, is now seen as a profession whose main goal is to increase agricultural and livestock production, and aquaculture and fisheries recently, particularly associated with the improvement of living standards of the rural population. However, it should be noted that since its inception in the mid-nineteenth century as a field of knowledge has faced various challenges, the most severe is that which places it as one of the causes of the serious environmental problems.

With theoretical models and methodological approaches it has influenced directly in the exploitation of natural resources, seen from the discipline of knowledge as inputs that must be harnessed to meet the needs of a demanding population food. His pragmatic and utilitarian worldviews, consolidated since the Green Revolution, defined traditional relationships between man and nature, without any to date real sustainability approach to reorient its mission and vision for the future.

Thus, in Latin America agronomy has been conducted under a common denominator, technological and scientific sense of their operation schemes, which seem to justify any cultural, economic, ecological, political and certainly productive intervention is made in search of achieve their ends. This has meant that universities and technology are in these premises, the ways and means to organize their academic proposals, seeking to align the interests of the profession with the educational function of these institutions, in strict compliance with social requirements.

Based on this "... most agricultural professionals have been trained from a disciplinary and atomistic perspective with a strong expertise ..." (Brown and Romero, quoted by Victorino and Quispe-Limaylla, 1998). For these reasons it is currently seen as programs and curricula are full of aphorisms callers science, looming a linear relationship between it and the technology, the legacy of the nineteenth century worldviews of empirical-analytic. This fact encourages still think that technology is applied science or do not distinguish between environmental education for sustainability and sustainable development.

Without an appropriate curriculum that fosters scientific literacy in agronomy student, and without a teaching mainly to accompany him, the future of the race seems destined to form graduates with practical skills and technology skills, talking about science, but not in it or from it.

Among the factors that are associated with the indicated problems are the following: 1) a significant proportion of teachers with little scientific training, which are in charge of giving the courses or subjects related to science. This often leads to the perception that scientific literacy is not required to move into that area; 2) teachers with strong scientific and technological training, with enough experience, but no attitude to the teaching profession (Villarruel, 2002); 3) curriculum without a solid curricular structure without mainstreaming requires that the scientific curriculum; 4) development of teacher education practice in behavioral and encyclopaedic sustained postures, detached from reality and centered education paradigm (repetition of facts and scientific events, laws and theories); 5) promoting an image of dogmatic science and routinely constructed from naive epistemological positions, which make the learning process a boring and irrelevant event; 6) teaching strategies used by teachers leading to the dismantling of the groups of students who do not cultivate collaborative learning; 7) evidence of cultural factors, which are usually established as ideological and social constraints that hinder continuity in the processes of scientific-technological training.

In this aspect it is possible to point out the need to consider the prior knowledge or preconceptions that have students who as apprentices deployed methodologies diffuse from these interpretive frames, without having to be an obstacle to the process of conceptual change, or even more, to the conceptual evolution that should guide the teaching-learning process. This means abandoning the old practice of discrediting the knowledge and procedures of students, seeking to have, in a metaphorical sense, with a blank slate, without considering that students have previous teaching skills, which prescribe how they should be taught, to be learned, where and how to do it and above all, who should teach; They may even indicate the direction and nature of the meta-contents that should be addressed. While this may be a challenge for the inexperienced teacher and didactic training, who has serious problems to generate the scaffolding needed, ideally from them learning the new set. This is particularly undeniable in agronomy students, who generally come from rural areas where field practice endow them with a wealth of skills and expertise.

Based on the above, in this chapter the design of a model is proposed to undertake scientific training in agronomy student, looking for orienting the didactic approach to the discipline of knowledge. It is valid to emphasize that this model has been tested with success in the career of Agronomy in the context of technological higher education in Mexico, which does not rule out its use in university environments.

LITERACY TRAINING AND SCIENTIFIC EXPERIENCE: THE NEW AGRICULTURAL EDUCATION

Fundamentals model

Conceptual and epistemological foundation of the activities. Strategies and actions in the deployment of the proposal were based on the following theoretical and methodological principles. 1) instructional design called expert-apprentice (rookie). The expert models and through it promotes certain knowledge. 2) discovery learning approach, individual and cooperative-collaborative. Focused on the activities of the apprentice from the tasks and practices proposed by the facilitator, same as the student carried out individually or in small groups, which are oriented discovery learning, as well as solving open problems (problem-based learning: systematic questioning skills and test conjectures from students.). 3) On the basis of learning communities. Whose socio-linguistic approach leads to joint participation by the students, who exhibit and trade their (relevant and authentic) collective experiences. It is expressed from the cooperative work, the dismantling and reconstruction of knowledge. 4) situated cognition. Which takes the form of a reorganization of representations, coupled with psychological, cognitive and individual thought processes, which are placed against specific social and cultural processes (meaningful contexts). This has implications in the instructional design model and situations that include classroom teaching, assisted by teaching materials and resources (both physical artifacts as semiotic instruments or signs). 5) problem-based learning. Whose purpose is that students reach understanding with regard to a particular fact situation, which arises as a result of their interactions with the environment. It also seeks to promote cognitive conflict, since the student to face a new situation can stimulate learning. The student must learn that knowledge is developed through recognition and acceptance of social processes, which evaluation of the various individual interpretations of the same phenomenon arises. 6) The competency-based approach. Under the position defining competition as a set of desirable social and emotional behaviors that accompany the development of cognitive, psychological, sensory and motor skills that allow realize the demands of a profession.

Methodological design. Model validation was performed at the Technological Institute of Ursulo Galvan (ITUG), Veracruz, Mexico, which is an institution of higher level under the General Directorate of Higher Education Technology (DGEST). The evaluation period was conducted in 2000 and 2011. The study population was the number of students who completed the fifth semester of the career of Agricultural Engineering (= 30 ± 5 per school year), within the field of experimental designs.

The research that gave sustenance to the evidence was classified as a case study because it was an description and detailed analysis of a social unit or educational institution analysis, which was in turn a deep understanding of the unique reality, whose value He lay in its ability to generate hypotheses and discoveries, as well as its flexibility and applicability to natural situations (Pérez-Serrano, 1994). Based on this methodological perspective the technique used to collect data was the participant observation and situational analysis focused on the principles of action research. In order to reduce the sources of own studies of this type of disability, every stage was regarded as a measurement and Journals Working and observation guides took.

Collisions design was made based on the model of Hodson (1992) who notes that research in science education shows that significant understanding of the concepts requires overcoming conceptual reductionism and raise the teaching of science as an activity , next to scientific research (that integrates conceptual, procedural and axiological aspects) in Figure 1 strategies systematically developed throughout the process of management, coordination and evaluation, which are based on the research methodology is considered one consistent with scientific literacy tool (Buzzo-Garrao, 2007), based on the criteria of exploration, conceptualization and implementation generalization, from the actual experience, which begins with the observation and analysis (What actually happens? What is the relationship between the process and the end result?), continue with the concept and then the generalization (Why is it relevant? What can you learn from that?), And concludes with thinking about how to apply learning (how and when I can use?).

To achieve this research module (field experiment), which was established in dynamic classrooms where learning situations were generated and constructive student activity took place was established in each course. The ordered sequence of pedagogical practices and teaching tasks tried all respond to a dynamic moment of reflection, through research established in these experimental modules (learning scenarios), which led them to compare their preconceptions with empirical data collected during field research and managed in cabinet. As already noted, this module allowed recreate continuous learning situations, to change the traditional concept of class (Figure 1).

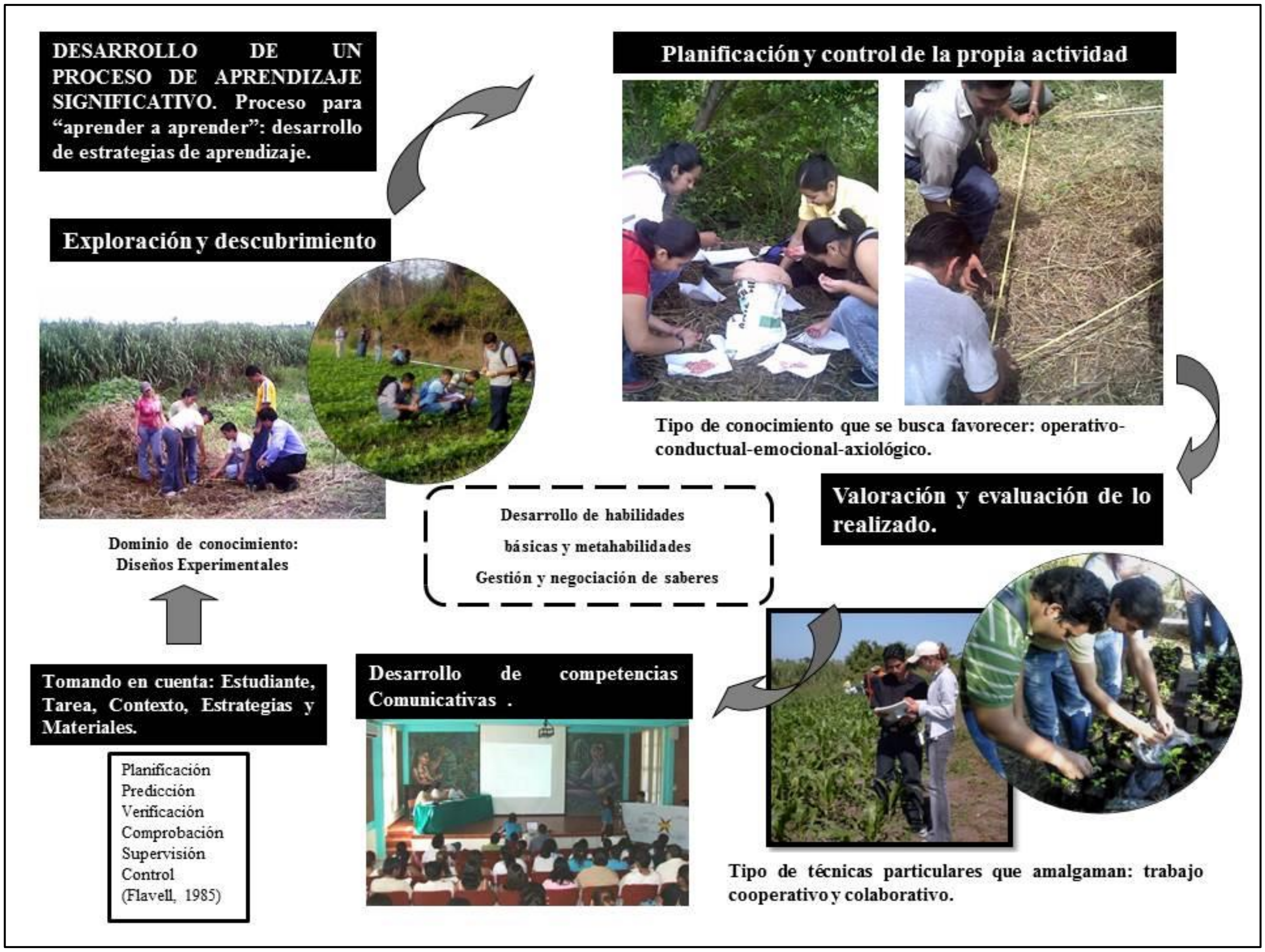

Figure 1. Development of a process of significant scientific training of students of Engineering in Agronomy learning.

The activities allowed to ensure balance between production and essential group individual responsibility in collaborative and cooperative (two of the basic principles of constructivism) work. Table 1 shows the teaching strategies used and widely recommended to achieve the goals.

Table 1. Instructional design and teaching strategies employed to scientific training and skills development for experimental research in agricultural sciences. Technological Institute of Ursulo Galvan, Ver., Mexico.

ESTRATEGIAS		
Conceptuales	**Procedimentales**	**Axiológicas**
Identificación de los canales de aprendizaje.	Encuadre. Dinámica de reconocimiento y acercamiento. Presentación de material didáctico (escrito).	Elaboración de un contrato social. Establecimiento de las *reglas de oro*.
Análisis y reflexión en torno a los principios de la experimentación agrícola. Preguntas eje: ¿Qué sabes? ¿Qué piensas? ¿Qué esperas? Identificación de *saberes previos*.	Intercambio de experiencias. Proceso de retroalimentación. Evaluación de conocimientos, habilidades y actitudes previas en torno a la experimentación.	Identificación de percepciones y vivencias previas en torno al objetivo de la asignatura.
La estrategia de mantener la dinámica interrogativa como base de la didáctica empleada, implicó una intensa negociación de saberes e intercambio de códigos lingüísticos, redefiniendo, a partir de la cognición situada, sus conceptos base, bajo la premisa de *que nada cambie para propiciar el cambio*. Dentro del contexto de las ideas y experiencias que el estudiante tuvo durante la fase exploratoria y de análisis efectuado en cada práctica, se mantuvo una intensa actividad de apoyo (aprendizaje guiado) a través de clases expositivas y demostrativas, de apoyo bibliográfico mediante el uso de material didáctico elaborado o seleccionado por el maestro, empleo de software y otros medios audiovisuales, en busca de que los estudiantes refinaran sus concepciones iniciales y construyan nuevos conceptos. Estas actividades, guiadas por preguntas claves o articuladoras (secuencia de preguntas que pueden guiar la reflexión de los estudiantes) que se hacen por parte del maestro-facilitador, ayudaron a que los estudiantes cuestionaran sus creencias y clarificaran concepciones equivocadas o difíciles de entender. El uso de analogías y metáforas resultó de suma importancia como estrategia de modelado metacognitivo.	Los estudiantes al manipular objetos, exploraron ideas, con lo que adquirieron una experiencia común y concreta. A los estudiantes se les pidió que establecieran relaciones, observaran patrones, identificaran variables y clarificaran su comprensión de conceptos y destrezas importantes, necesarias para el abordaje metodológico de las prácticas pedagógicas. Las cuales consistieron en: a. Identificación de fuentes de variación en campo. b. Trazado y diseño de una parcela experimental. c. Determinación del tamaño y forma de las unidades experimentales. d. Diseño de tratamientos. e. Aplicación de tratamientos en campo. f. Manejo uniforme de las unidades experimentales. g. Determinación del efecto de orilla y parcela útil. h. Aplicación de la técnica de muestreo sistemático. i. Determinación y toma de variables de respuesta. j. Identificación de los criterios prácticos y científicos para determinar el uso del diseño más adecuado en campo. k. Toma de datos y análisis estadístico de los mismos. l) Realización y entrega de un informe de investigación. Se pidió a los estudiantes que aplicaran lo que habían aprendido, solicitándoles predecir los resultados obtenidos en una nueva situación (transferencia). Estas *actividades de aplicación* también permitieron al maestro y al estudiante establecer el grado de dominio de los conceptos, procesos y destrezas definidos en los objetivos y metas de aprendizaje (lo que incluye elementos de auto-evaluación y coevaluación), a partir de la continua exploración y manipulación de los objetos de aprendizaje.	Los estudiantes se integraron en un colectivo o comunidad de aprendizaje y trabajaron en grupos pequeños. En un primer momento se mantuvo la constitución general del grupo, a fin de generar el sentido de pertenencia, *creando* el aula colaborativa, para después dividir el grupo en segmentos funcionales, sin perder de vista la meta, las tareas y la identificación del contexto. La anticipada tipificación de saberes previos y la integración de los estudiantes permitieron conjugar habilidades personales en torno al grupo y sus deberes académicos (aprendizaje cooperativo y colaborativo).
Como parte de las estrategias didácticas, los estudiantes de cada generación asistieron al menos a una reunión científica, simposio o panel de investigación, donde tuvieron la oportunidad de corroborar la aplicación práctica de los distintos diseños experimentales, analizarlos y discutirlos con los investigadores profesionales (modelo experto-aprendiz).		

A basic strategy and considered closed within the teaching sequence was delivering a detailed report of the activities developed to the length of each course. This report, defining for evaluation, adjusted in structure to the guidelines of the scientific method and was based on continuous gathering evidence of performance by students, which were supplemented with constant troubleshooting statistics raised and recorded by the master (portfolio or folder evidence).

Mediation and interpretations

As can be seen, the ordered sequence of actions was aimed at developing scientific expertise in the learner. Beyond the controversies that promotes this concept in education, what is important is not to lose sight that seeks to promote meaningful learning, that stand in a dynamic and inclusive scenario, it can lead to multiple possibilities for action, not always predictable by the teacher. This should be exploited for the benefit of the goals set by the group and by the same curriculum. Condition requiring a minimum level of teacher training, experience in research and methodological expertise on the part of the teacher. Here lies one of the basic requirements of the model, which should lead to a program of training for science teaching and research in agricultural education campuses, in the upper level and graduate, and that while being an active researcher it is a requirement to teach science, it is not enough to achieve scientific literacy of students, let alone to promote their integral education.

Additionally it should be noted that the approach focused on the assertion that defines the genesis of thought on the questions asked, and not to the facts as traditionally supported. These are the questions that guide the itinerary to follow in the framework of the intervention that the student must perform within the learning scenarios. For it is expected that under the modeling teacher, students provide continuity to the series of questions that stimulate the process of learning. If these questions include a critical, proactive, analytical and reflective component, they must be regarded as indicators for the comprehensive evaluation, under which generate new skills, which contributes to the strategies outlined by the teacher.

As is easy to see, the interrogative own dynamic empowered a higher level and depth in the communication established within the groups, as well as the already mentioned knowledge management and negotiation, the scaffolding and the eventual transfer of knowledge. In many ways this approach broke with the linearity of positivism itself, which has infiltrated the areas of science education, particularly in the field of agronomy.

It was to pay the heuristic thinking, without giving up the algorithms that have been questioned from both these exemplary perspectives. Denying the need to develop in students the skills of abstraction, reasoning, logical order in thoughts, systematization of ideas and procedures would be a contradiction if it is science. The proposed heuristic encouraged students to the ongoing search for problematic situations, never unique solutions in a proactive and interactive attitude sustained by self-learning and the need to find themselves those rules that make the association between theory and practice which they have highlighted the development of higher intellectual operations.

In support of the actions taken by the students, the teacher must, as in this case, provide them with heuristic aids (materials, equipment and appliances in general), as well as promoting the use of analogies and metaphors designed to recreate the early generality, induction, mobility and modeling, to name a few, which means placing in learning conditions (Figure 2). The approach is to take various forms of learning (discovery, transmit-receive, repeat, etc.), without opting for one of them; for it was thought in terms of teaching strategies rather than teaching models.

Figure 2. Scenarios metaskills learning and development for the scientific work of students studying agronomy IT Ursulo Galvan.

Unlike the various voices proclaiming the teaching and learning of science exclusively from solving problems through organizing teaching units articulated basically as collections of problems, selected with care and ordered in sequences that aim to achieve meaningful learning, assessments under testifying academic performance in the present proposal projected that students build a conception of the world closer to the conception that scientists have, which as already indicated lines back convenes the conceptual change and learning by investigation. Only in this case without resorting exclusively to counterexamples, simple falsification or cognitive dissonance, as used in these guidelines. The idea was to diversify strategies and use them to promote metacognition. It claimed that the teacher knew how scientific knowledge is constructed. That is, to make the learner develops the ability to observe, classify, compare, measure, describe coherently organizing information, predicting, making inferences and hypotheses, interpreting data, modeling, and draw conclusions, you must first know how to do the teacher. In the end no one gives what he has not.

To support the process, the students took a field journal, which allowed so log record their achievements, field experiences and progress in the process of constructing scientific thinking. In this way both the teacher and the student could monitor changes, reorient and evaluate them.

All of the above took explicit bridge the gap between science and professional school science gap is explained by the distance that exists between the situations of teaching and learning and the way in which scientific knowledge is built, which for many specialists is the biggest problem to face in the process of forming the new research.

CONCLUSIONS

In all cases, successfully it achieved the goal of scientifically literate students by integrating the group around common interests and goals linked to their scientific training.

The strategies used within the modules allowed to promote the following achievements of student learning: a) define terms and concepts, identify problems and define tracks; b) identify needs of individual and collective learning about what is going to investigate; c) identify individual needs, transforming them into learning objectives, which should be related to the group's objectives and the curriculum; d) develop skills of critical and creative thinking; e) promote decision making in new situations; f) develop self-directed and independent learning; g) search for, identify, select and analyze information necessary to address the problem; h) develop communication skills; i) promoting the ability to work collaboratively and cooperatively; j) developing the capacity for empathy and tolerance; k) promoting the confidence to speak in public; l) enhancing the ability to identify own strengths and weaknesses (emotional intelligence); ll) coevaluarse and learn to evaluate themselves.

Participation within modules always remained constant (95 percent of the group), performing 100 of the planned activities. A final report requested about the activities undertaken within experimental modules allowed to verify the progress made in terms of cognition and metacognition achieved, the reflective stance and critical thinking. The report also included the analysis, interpretation and conclusions drawn for the practices, which hinted at the extent of negotiation of knowledge achieved by each group. This to the extent that a certain level of freedom allowed in the format without losing the methodological rigor that scientific writing demand.

Integration within scientific events (seminars, symposia, etc.) led to reinforce skills by allowing students to agree to a scenario of broader and inclusive learning, where possible and appropriate new constructs related to science concepts and technology, which made the academic experience in an experience that gave meaning to the learning acquired. Additionally it should be noted the integration of new linguistic and semantic codes, which were reinforced through the degree of communication achieved in such events. The fact that, after the course, 80% of students were associated in some way with scientific activities (social service, professional residence, postgraduate) stands out, which gave meaning to this proposal. That is, they sought to stay within the scenarios and scientific and research experiences.

The level of disapproval was reduced from 30% to levels of 5% at the end of each academic experience. The strategy conceive of educational mediation of the teacher as a permanent support throughout the entire process as a mediator teacher, allowed to break with the traditional behaviorist schema that usually guide the scientific training of apprentice science, without it meant leaving responsibility to effectively lead the dynamics of learning to respect the expert-apprentice scheme.

Finally, the definition of a model of sustainability around the student scientific literacy (education in life, for life and for life), under which are clearly identified criteria, indicators and measurement units stands that define the integral-holistic education (Table 2).

Table 2. Indicators of sustainability for scientific training of students of Agronomy

	Criterios	Indicadores	Unidad de Media
Educación Integral	Aprender a aprender	Desarrollo de habilidades metacognitivas. Desarticulación-reconstrucción de saberes. Construcción de redes semánticas y códigos lingüísticos. Autorregulación (aprendizaje sistemático y regulable).	Empleo del pensamiento analógico y metafórico. Transito del razonamiento cotidiano al razonamiento científico. Formulación de preguntas a partir de ideas previas.
	Aprender a hacer	Desarrollo de metahabilidades metodológicas-heurísticas.	Despliegue de estrategias heurísticas. Habilidades presentes en cada tarea: 1) recopilar información; 2) dar sentido a la información (procesarla); 3) diseñar, aplicar y evaluar estrategias de acción en situaciones concretas.
	Aprender a ser	Desarrollo de habilidades intra e interpersonales.	Regulación y autorregulación del comportamiento (sujeto que participa de forma consciente y activa en la determinación de su comportamiento).
	Aprender a convivir	Desarrollo de habilidades sociales. Nivel de empatía, autocontrol (evaluación y regulación de la comprensión). Automotivación para el aprendizaje.	Inactividad-actividad-reactividad-proactividad e interactividad.

RECOMMENDATIONS

General recommendations for good teaching mediator:

1. Select the tasks to be performed according to the goal, to the best available learning scenarios, content, materials and learning objects.

2. Make sure the student record the new information made available.

3. questioned the student through mediators questions or liaison that take you to go beyond the obvious to rule the superficial.

4. Emphasize the relationship between the new job and previous contents of the students and in the achievements made and / or acquired with the activities.

5. Encourage students to solve the present problems.

6. Model behaviors as well as strategies.

7. Change the mode and learning situations as often as possible.

8. Promote feedback constantly.

9. Take into account the proposals of the students.

10. Give meaning and value to the results, as well as the process

Finally it should not be overlooked that for science teacher attitude is required in addition to disciplinary training and educational preparation. Being a good researcher does not become de facto a person a good teacher, and vice versa.

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