An Epistemological approach for Learning Computer Programming Languages

Emilio Buendía Cervantes[1], Jesús Manuel Olivares Ceja[2]

[1] Acciones para el Aprendizaje Autónomo, S. C.
CP 03300 D. F., México, Ciudad de México

[2] Centro de Investigación en Computación del Instituto Politécnico Nacional (CIC-IPN)
Av. Juan de Dios Bátiz esq. Othon de Mendizabal S/N
CP 07738, Ciudad de México

expressdelavida@yahoo.com.mx, jesuso@acm.org

Abstract. This article presents the results of applying an epistemological model for students learning computer programming languages. The proposal is based on a characterization of the typical elements that form an information system.

Three learning principles, an epistemological model are used to facilitate students' knowledge acquisition. Information availability, activity performance and feedback are applied for each epistemological category to detect student advances and provide guidance and supplementary materials.

Motivation toward innovative ideas proposal and development is provided whenever possible during knowledge acquisition process.

Learning evaluation is based on the mastering of the epistemological categories and final evaluation is assigned considering the best category reached during learning process.

Keywords: epistemological model; programming languages learning; learning principles

1 Introduction

This paper presents an epistemological model and learning principles as an alternative to promote knowledge acquisition in e-learning [1] [2] and F2F (Face to Face) teaching-learning process mainly focused on learning computer programming languages, as an attempt to contribute in the formation of professionals required by enterprises, the academy and the science. It is known that programmers with adequate preparation and experience each year are increasingly needed for software development since software crisis started in 1968.

Advances in Computer Science and Engineering
Research in Computing Science 67, 2013 pp. 41–51
Paper Recived 21-09-2013 and Acepted 21-10-2013

What to teach and how [3] has been considered by free thinkers like Plato, Rousseau, Froebel, Dewey and others dating back several centuries. The ideas discussed by those people follow two extremes: on one hand, children and young people must learn what government dictates, or on the other hand, they should be given freedom to learn knowledge and skills. Currently both initiatives are used for teaching and learning and it is hard to notice any separation.

Technology and computer development during the late twentieth century promoted interest to include them in classrooms as tools to support the teaching-learning process. Many terms to describe this trend have emerged such as learning online, virtual learning, Computer Assisted Learning (CAL), e-Learning, m-Learning, among others. In many cases the teacher can be replaced by computer programs like online tutorials or online content that use computer questionnaires for students to check their progress.

Computer science advances are notable, starting with the representation of numbers using bits, continuing with coding letters using groups of bits, sequences of characters, and until recent information representation in augmented reality systems and high speed networks for information exchange. However, technology advances are not enough to guarantee that people could learn how to build computer programs. Besides technology cannot reach people with no electricity service, and software advances are out of reach of those who lacks of computers.

In literature there are many papers and online reports on the use of learning platforms and tools [4] [5] [6] [7] [8]. Learning styles [9] could be grouped on presence, distance, and blended learning; and have been applied with different success levels. Evaluation considering several variables measures student progress and the learning process (tools, schedule, and contents) to improve online courses. Interest on these new learning styles is concentrated on teaching different subjects.

Nowadays, the most common strategy to promote knowledge is "reward and punishment". For example, many children attend school to avoid punishment from parents, and at school they pretend attending the class and learning to avoid punishment or lose points for not paying attention. However, the reality is revealed during exams; the students did not learn and failed the exams. As a consequence of the "reward and punishment" strategy many students decide to abandon schools at different levels.

Technology and developments such as computers, tablets, smartphones, the Internet and Web do not guarantee that the learning processes occur or students get motivated for learning, nor eliminate dropping out of school. Despite technology and the introduction of multimedia presentations students are abandoning the learning process.

As a consequence of teaching problems and lack of interest of the students, some researchers [10] [11] question whether reviewing learning theories should be considered. Some theories of learning already proposed are:

A. Behavioral theory [12] (attributed to B. F. Skinner)

This theory is based on reinforcing the action of a person that corresponds to what is expected to be learned. For measuring learning it is observed if there is a change in behavior. To promote learning both the stimuli and the environment need to be organized adequately.

B. Cognitive Theory (represented by J. Bruner)

In this theory knowledge acquisition involves an internal coding and structuring by the student. Learning is a process of rearranging or transforming the data so that a student acquires and understands. Learning is expected to occur by discovery (serendipity).

C. Soci –historical–cultural theory (attributed to L. S. Vygotsky)

This theory considers that the human being is a social being and learning occurs when multiple people interact.

D. Theory of observation and imitation (attributed to A. Bandura)

This theory shows that there are internal mechanisms of information representation that allow learning by observation and imitation.

E. Eclectic theory (attributed to R. Gagne)

The learning process is organized based on needs and priorities; therefore this theory is aimed for students achieving specific goals.

F. Theory of constructivism (attributed to J. Piaget)

Learning takes place through two simultaneous and opposite movements: assimilation and accommodation. In assimilation individuals explore the environment and make decisions that transform and integrate parts that are found in the environment. In accommodation, the individual trans-

forms their inner structure to reflect the nature of the objects found in the environment.

G. Theory of complexity (attributed to E. Morin)

Consider learning as based on a combined epistemology: social, biological, mind, spiritual, logic, linguistic, cultural, social and historical; as opposed to traditional epistemology that is only cognitive. This means that systems under study are "complex systems" that should be considered under different viewpoints.

H. Conexionism theory (attributed to G. Siemens and S. Downes)

This theory was created to take into account the influence of technology (mainly computer and networks) on the learning process.

The inclusion of computers in the teaching-learning process is an alternative tool that provides contributions to the transmission of knowledge and also helps detect the progress of students learning. Furthermore, learning theories have greatly contributed to the development of mankind. However, it requires some guide in the learning process that in this work is provided by an epistemological model.

2 Epistemological model for learning computer programming languages

Epistemology is a discipline dedicated to study knowledge and its genesis. Based on experiences looking for models to enable students to acquire knowledge, particularly in computer programming languages, an epistemological model was proposed in [13] and adapted [14] for this paper as shown in figure 1 considering that computer programs could be considered formed by three main elements [15] [16]:

a) Data, those representing values, variables and real entities representations.
b) Process, those that transform data.
c) Structure that determines the order of process application on data.

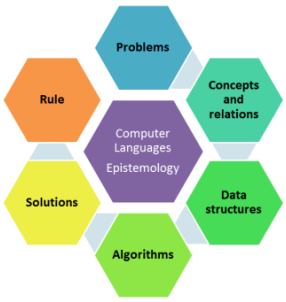

Figure 1. Epistemology for learning computer languages

A. Scenario

The scenario consist in configuring with materials and tools needed to promote learning and exercise activities and practices related with the topic of interest that in this case is computer languages learning and application. This is the main labor of the teacher who makes arrangements and prepares materials, projections and the agenda for the teaching–learning process guided with the epistemological model.

B. Problem establishment and hypothesis

Each problem is proposed, discussed and has a hypothesis to solve it. This activity is mainly carried out by the student with the teacher supervising them and asking to use their imagination in a certain situation related with the problem. Sub-problems may arise during the process. In this step, it was found that many times some student proposed solutions instead of problems; therefore, the feedback was devoted to help students on detecting what a problem is and what is not. The tools that were used to register problems and hypothesis were text processors.

C. Concepts and relations among them

In this epistemological category, each student is given questions with concepts related with the problem under consideration. They are asked to look for answers in different media including books, magazines, Web pages, or their own experience. The answers must be placed in documents showing the question, the author (student name), the reference, the answer and an example.

Students answer questions using a text editor and send the result to the teacher via email. Feedback on each answer is provided by the teacher and the student is asked to produce a conceptual map that reflects the understanding on the concept relationship. In this activity any soft-

ware tool can apply (e. g. EDraw Mindmap®). The result is also sent to the teacher via email and returned with feedback and teacher's conceptual map for the student to review it. After the student reviews, a group discussion is carried out to obtain conclusions.

Once the students have knowledge [17] [18] [19] about concepts and relationships among them, the next step is on applying the knowledge implementing data structures and algorithms to solve small problems first then more difficult ones.

D. Data structures

In this category, a problem is proposed for the student to apply the concepts learned to data structures. Here it is expected that the student implements the solutions using a computer programming language. Data and the structures are formed using variables relating them in different ways. For example sorting a list of integers, and asked how to solve the problem (hypothesis), compare their proposal with known methods and then to identify which data and structures appear in the proposals. Teachers provide feedback to precise and complete the proposals. For this and the following categories it is necessary that the student manages an Integrated Development Environment (IDE), like Java programming language or C language.

E. Process

Computer processes transforms data in different ways: operators in expressions, control structures in program flow and functions in both of them.

Computer languages nowadays are provided with rich libraries of functions devoted to provide specific solutions. Regardless of that, students are motivated to build their own code to show their abilities to produce computer programs. The teacher reviews and analyzes each algorithm and invite students to compare their solution against other existing implementations to check which one has a better performance and then a discussion is opened.

F. Solutions

Solution is the category intended for the students to show their programs running with test data prepared by the teacher. For postgraduate students measuring performance is a very important topic.

G. Applications

Application is a category related with the use by a third party of the program produced.

H. Rule

Rule category reflects the experience obtained by each student during the development process; it is expressed in the form of a principle, postulate or in the best case a rule.

This model was applied to students from several universities and states of the Mexican Republic, providing for each of its categories the appropriate feedback as soon as possible.

3 Evaluating Learning

Evaluation is an important concern in the teaching–learning process. In this proposal, evaluation is related with mastering each of the categories of the epistemological model. Students are qualified related to the best epistemological category that each student reaches.

In a group of 19 students randomly selected to produce computer programs guided with the epistemological model proposed, the results shown in table III were obtained. Each student is represented with a confidential number.

Table III show the results of applying [13] the Epistemological Category Oriented Evaluation (ECOE). In that 4 out 19 students reached the rule category, resulted excellent oral presenters. Self-motivation is found in students that reached top categories.

Application level students are close to finding rules and therefore the labor of the teacher is to invite them to reflect and write on the learning process to find patterns that may be established as a principle or rule.

In other students, it was observed that they only learned concepts and rejected applying their knowledge on computer program implementation. They did not want to attend practices due to lack of interest. It is considered that should be incentivized to learn by providing more simple exercises and eventually provide more complex ones until they are able to face problems and develop a solution with data structures and algorithms.

Between the two mentioned distinguishable groups there are some students that are considered having reached the data structure or process

categories, and therefore, the teacher labor for them is to provide more practice that prepares them to eventually face real-life problems is an important concern in the teaching–learning process. In this proposal, evaluation is related with mastering each of the categories of the epistemological model. Students are qualified related to the best epistemological category that each student reaches.

TABLE III. EPISTEMOLOGICAL CATEGORY ORIENTED EVALUATION (ECOE)

Student	**Aspect evaluated**		
	Epistemological level	***Oral presentation***	***Feedback provided***
1	Relations	good	Personal attention
2	Rule	Excellent	Already self-motivated
3	Rule	Excellent	Do more practice
4	Rule	Excellent	Apply skills
5	Application	No	Share skills
6	Concepts	Very good	Try to learn
7	Concepts	Regular	Get interested
8	Concepts	No	Get interested
9	Rule	Excellent	Self-motivated
10	Concepts	Bad	Get interested
11	Process	Regular	Must try to learn
12	Application	Very good	Learn more
13	Application	Very good	Learn more
14	Application	Very good	Self-motivated
15	Process	Good	Must try to learn
16	Concepts	Good	Get interested
17	Application	Very good	Need Learn more
18	Relations	Good	Need Learn more
19	Relations	Good	Need Learn more

TABLE IV. COMPARISON AMONG PROPOSALS FOR LEARNING COMPUTER PROGRAMMING LANGUAGES

Proposal	**Criteria**				
	Explicit epistemology	***Information availability***	***Activities***	***Feedback on activities***	***Explicit thought formation***
[4]	No	Yes	Yes	Yes	No
[5]	No	Yes	Yes	Yes	No
[6]	No	Yes	Yes	Yes	No
[7]	No	Yes	Yes	Yes	No
[8]	No	Yes	Yes	Yes	Yes
This proposal	Yes	Yes	Yes	Yes	Yes

4 Comparison with other approaches

Different authors and organizations have proposed tools for learning computer programming languages [4] [5] [6] [7] [8]. Table IV shows a comparison among those works and the proposal of this paper. It is possible to notice that in most cases information is provided to the student, examples and evaluation, but some of them lack of an explicit epistemological model to guide knowledge learning, for example, distinction among problem statement and solution is not emphasized; therefore students usually are guided to develop code without an application and as consequence students sometimes learn that code production do not deserve a benefit.

5 Conclusions and future work

In this paper an epistemological model and an evaluation approach based on categories are proposed to guide the teaching–learning process.

The application of the proposed model guides students in learning computer languages to produce computer programs by categories: concepts, relations among them, distinguish data and process, and implement algorithms that solve a problem. Preferably, the students should provide the program to solve a real-life problem and establish learned knowledge as a rule. The proposal was applied with students (male and female) at the graduate and postgraduate level from several universities in Mexico.

It was observed that the students who understood the model became self-motivated while other refuse to develop practices and only obtained limited concept learning. That indicates that the model should be learned first. More tests with students should be carried out to determine if the proposed model is convenient for computer language learning.

6 References

1. L. García, "Educación a distancia; ayer y hoy", retrived from http://www.quadernsdigitals.net/, published 1996
2. L. García, "De dónde venimos y hacia dónde vamos en Educación a Distancia" (Spanish), retrived 27.08.2013 from http://www.youtube.com
3. B. Cohen, Introducción al pensamiento educativo (Spanish), Ed. Publicaciones Cultural, S.A., México, D. F., 1977
4. Z. Harley, E. R. Harley, "A wizard for e-learning computer programming", International Congress on e-Learning and e-Technologies in Education (ICEEE), pp 95-98, 2012

5. S. Almajali, "Computer-Based Tool for Assessing Advanced Computer Programming Skills", International Congress on e-Learning and e-Technologies in Education (ICEEE), pp 114-118, 2012
6. A. Williams, "The Development of a Computer-Aided Learning Tool for Supporting the Teaching of Assembly Language Programming", Proceedings of the 29th Annual Hawaii International Conference on System Sciences, pp 323-331, 1996
7. A. Dzib-Tun, et. al., Una herramienta didáctica interactiva para la enseñanza-aprendizaje de los autómatas finitos deterministas en Memoria COMTEL 2013, ISBN 978-612-4050-69-5, Lima Perú, 2013
8. E. Vidal Duarte, Python como primer lenguaje de programación: un enfoque orientado a juegos en Memoria COMTEL 2013, ISBN 978-612-4050-69-5, Lima Perú, 2013
9. J. Stal, G. Paliwoda-Pekosz, "Teaching computer science blended-learning modules: A case study", International Congress on e-Learning and e-Technologies in Education (ICEEE), pp 119-123, 2012
10. R. Andrews, "Does e-learning require a new theory of learning? Some initial thoughts", Journal for Educational Research Online, Vol. 3, No. 1, pp 104-121, 2011
11. Hoyos M. C., et al., Epistemología y objeto pedagógico ¿es la pedagogía una ciencia?, editorial UNAM, Instituto de Investigaciones sobre la Universidad y la Educación, editorial Plaza y Valdes, ISBN 978-607-402-234-6, 2010
12. Skinner B. F., The Behavior of Organisms: An Experimental Analysis, Cambridge, Massachusetts: B. F. Skinner Foundation. ISBN 1-58390-007-1, ISBN 0-87411-487-X, 1938
13. E, Buendia, S. Leger, Epistemología para el aprendizaje autónomo (Spanish) (in press), Ed. Saber-hacer-comprender, México, 2013
14. Bochenski I. M., Los Métodos Actuales del Pensamiento (Spanish), octava edición, Ediciones Rialp, S. A., Madrid, España, ISBN 84-321-0106-0, 1973
15. F. Galindo Soria, Sistemas Evolutivos (Spanish) in *Boletín de Política Informática*, México 1986
16. F. Galindo Soria, Sistemas Evolutivos: nuevo paradigma de la informática (Spanish), in *memorias del congreso TEC-COMP 91*, México 1991
17. J. M. Olivares, A. Guzmán, "Aprendizaje aprovechando las ontologías del usuario y una fuente de conocimiento" (Spanish), Proceedings of the "28 Simposium internacional de computación en la educación" (Spanish), México, 2010
18. Vargas-Medina E., Figueroa N. J., Redes semánticas naturales y construcción de ontologías, en Metodología para la educación a distancia, CIC-IPN, México, ISBN 978-970-36-0431-9, 2007
19. Diez-Rodríguez H., Olmedo-Aguirre J.O., Gerencia del conocimiento en entornos virtuales de aprendizaje constructivista mediante ontologías, en Metodología para la educación a distancia, CIC-IPN, México, ISBN 978-970-36-0431-9, 2007