DESIGNING AND IMPLEMENTING A CONSTRUCTIONIST APPROACH FOR
IMPROVING THE TEACHING-LEARNING PROCESS IN THE EMBEDDED
SYSTEMS AND WIRELESS COMMUNICATIONS AREAS

1I. A. Garcia, 2E. M. Cano

1Technical University of Madrid, Spain
2Technological University of the Mixtec Region, México

Nowadays, there has been a real change in the traditional (Mexican) methodology for learning and teaching; the teaching of Electronic Sciences needs to identify the real necessities of students to avoid deficiencies in static classrooms. The benefits of the constructionist theory as a learning paradigm are widely recognized, because they support significant learning environments where students are actively related in implementing their own public artifacts; passing through passive to active learning states. Thus, the constructionist theory stresses the need to understand the student’s thinking and to encourage them to reflect on their models as a means to improve them. This paper aims to show the results derived from developing a constructionist platform for embedded systems and wireless communications education, using a dedicated methodology based on the constructionist theory.

INTRODUCTION

During the first decade of XXI century, popularity of portable devices equipped with one or more wireless technologies has increased (e.g. Wi-Fi, Bluetooth, ZigBee, etc.). In addition, the advent of new paradigms, such as Ubiquitous Computing, has generated the need to reformulate the educative strategies for traditional teaching methods, used for the training of specialists in Communications and Computer Networks, Information Technologies and Embedded Systems areas. Different Universities around the world have been incorporating educative strategies based on learning psychology theories in their curricula, providing in this way, a different way of
learning where students can fortify theoretical concepts through constructing and developing artifacts (prototypes, documentation, papers, etc.) [1-3].

In Mexico, the traditional technical education promotes rivalry and individualism among students, contributing in this way to obstruct any innovation of educative strategies; due to the fact that it still uses traditional methods completely based on reading, in which students are steered towards elaborating a summary of a literature review with minimum comments, and not focused on the form or on the context. This situation creates a lack of reflection in the students’ passive attitude, favoring the consumption of reading, where remembering and memorizing are more important than internalizing and questioning.

Constant changes in Engineering education, especially in embedded systems development and wireless communications, require that teachers incorporate real world problems into the classroom, and support them with learning psychology theories, through the action and construction of tangible artifacts [4]; to strength traditional methods based on reading and to develop the students’ significance and understanding [5].

In this paper we present a learning-teaching constructionist platform, called DreamBlue, to help students in developing their own platform based on systems’ specification, design and implementation; guiding them towards developing flexible, significant and robust tools; and motivating them to establish future research. The rest of the paper is organized as follows. Section 2 provides a background to engineering education and the motivation for this research. Section 3 summarizes the work related to improve the teaching-learning process in engineering areas using constructionist approaches. Section 4 presents our constructionist approach focused on the embedded systems area. Sections 5 and 6 present the experimental results achieved and conclusions from the research respectively.
MOTIVATIONS

Recently, in Mexico, a participative perspective in education has been developed [6]. This perspective considers the student’s intervention in his/her own training through reflection on his/her experience. In this experience, knowledge is not external; it is elaborated from critique and auto critique. Under this approach, reading is the way to deepen the reflection on experience; because this experience is the axis and starting point which provides meaning. Thus, when a student establishes connections between new material (potentially significant) and the established cognitive structures, he/she assimilates the knowledge, reaching a significant point in learning.

However, the dominion of education based on traditional methods (reading particularly) has impacted on the poor performance of graduate students in areas as Computer Science [7], Electronic Science [8] or Mechatronic Science [9]. On the other hand, a main problem in developing countries is the limited budget assigned to public Universities. This issue is reflected in the minimal infrastructure and insufficient equipment to teach specialization courses like engineering areas. The teachers have to find a way to provide the technical knowledge of courses for all students in the same way that they could do it with traditional methods. In our specific case, the Universidad Tecnologica de la Mixteca (UTM), is a Mexican Institution with more than 20 years of experience. The laboratory of Electronics Research has a limited infrastructure to satisfy three areas needs (Electronic Sciences, Computer Sciences and Mechatronic Sciences), in 8 groups (a total of 205 students) in each of these specific areas. We decided to develop a different teaching approach in order to avoid the current deficiencies (concerning infrastructure) of the traditional educational techniques in this area.

Considering the learning theories supported by the construction of tangible artifacts, and deficiencies in education, both practical and theoretical, of students from UTM; a constructionist platform for supporting engineering education in undergraduate courses is proposed. This
approach actively involves students in the solving of real problems, providing a solid basis for knowledge recreation and to develop new ideas from meaningful artifacts construction where reflections, experiences and critiques are shared.

**LEARNING THROUGH THE ACTION: A BRIEF REVIEW**

One of the most important cognitive psychology theories based in learning through action is the constructivism of Jean Piaget [10]. Piaget’s theory states that “learning is an individual process that is formed when knowledge is built by students when they try to make sense of their own experiences”. Thus, many researchers have worked considering constructivism for developing educative strategies (e.g. [11-13]). In this context, the constructionist, that is derived from Piaget’s constructivism and developed by Seymour Papert, is focused on knowledge reconstruction by students using meaningful artifacts [14]. Papert alluded that knowledge is not totally transmitted from person to person as a final product, but each individual reconstructs its own knowledge in a progressive manner and through significant experiences. In this way, Papert takes the Piaget’s theory and emphasizes in the use of meaningful artifacts¹ as vehicles for knowledge construction (or reconstruction). Lev Vygotsky, for example, provides a different approach for constructivism in [15], where besides the artifacts intervention, individual’s social interaction is a part of the learning process; he emphasizes the addition of tools for constructing the individual’s mental process. The use of these tools and the meaningful artifacts construction along the learning process, are elements of the authentic learning approach presented by Brown [16]. Brown defines the authentic learning as a process composed by diverse authentic activities, which should be coherent, meaningful and constructive in developing the student’s learning.

---

¹ Papert is interested in how learners engage in a conversation with (their own or other people’s) artifacts, and how these conversations boost self-directed learning, and ultimately facilitate the construction of new knowledge. He stresses the importance of tools, media, and context in human development. Integrating both perspectives illuminates the processes by which individuals come to make sense of their experience, gradually optimizing their interactions with the world. In the engineering context, a meaningful artifact can be a computer program, animations, or robots.
According to Ogata [17], authentic learning is classified by four types: situational, incidental, experimental, and by action; the authentic learning by action, specifically, is constructed when students learn creating, observing, and imitating an expert. Some research related to authentic learning is presented in [18] [19]. In a similar manner, the Project-Based Learning (PBL) perspective has increased the teaching quality in areas as Communications and Computer Networks [20] [21], Computer Sciences [22-24], Embedded Systems [25] [26] and Electrical Circuits [27-29]; among others. The motivational approach for PBL support, presented by Blumenfeld [30], states that during the project students affirm concepts learned through a generation of tangible artifacts, because these artifacts are a representation of their understanding status. Tangible artifacts can be compared and criticized, feeding back in this way the student’s emergent knowledge because PBL is a comprehensive approach to classroom teaching and learning that is designed to engage students in an investigation of authentic problems. According to Blumenfeld’s research, the use of technological tools for supporting the learning process can improve knowledge acquisition.

The aforementioned teaching approaches foment learning construction through the development and active use of tools and artifacts, motivating students in the development process of their cognitive skills through practical classes, and fortifying the knowledge obtained by reading classical methods. We believe that these perspectives could be the key for teaching and learning on an Embedded Systems Design area, which involves different topics (microcontrollers, hardware, software, etc.) for implementing a specific functionality.

**Related work.**

The constructionist approach of Seymour Papert has been applied to improve the teaching-learning process in many areas. For example, the creation of the LOGO programming language tool focused on supporting the teaching-learning process in math and basic geometry for
elementary students [31]. The LOGO’s success was reflected in an interactive environment called “Turtle”, which consisted in a robot with capabilities for walking and drawing geometrical figures on the floor through simple commands from a computer. In the middle of 90’s, Martin and Resnick presented the system LEGO/LOGO [32] in which children could build their own mechanical projects using LEGO parts and manipulate them using the LOGO language. The LEGO/LOGO system is supported by the idea that children learn in a meaningful way when they construct and program their own LEGO/LOGO machines and not only learn scientific concepts, but design also, and mechanical platforms invention processes are learned too. Research by [33] presented the interactive simulation environment “Talos” to learn the principles related to the operating and programming of mobile robots. Research by [34] exposed a case study to model a tool based on sensors for developing scientific research on multiple intelligence agents, where students could construct and connect platforms with electronic sensors in real time. Mavridis [35] analyzes the application of the constructivist theory on undergraduate projects, in which students reaffirm the basic aspects on robotic areas and apply research on the fundamental concepts, experimenting with basic concepts or working groups, project management, and analysis and resolution of real problems. using the LEGO mindstorms robots. Finally, Cuéllar and Pegalajar [36] provide a set of projects to put in practice artificial intelligence techniques using LEGO mindstorms in an undergraduate computer degree, covering reactive and deliberative agents, rule-based systems, graph search algorithms, and planning methods.

In an engineering context, there are diverse examples of previous work focused on constructing and developing experimental platforms for improving teaching in areas such as, Wireless Communications, Embedded Systems Design and Wireless Sensor Networks Analysis. For example, research by [37] showed a low-cost wireless platform that used an AM radio transmitter for improving the development and teaching process related to applications with wireless sensors
and actuators. Research by Sang [38] presents several interesting laboratory experiments to provide students with hands-on experiences in low-cost Small Office/Home Office (SOHO) networking technologies, including SOHO Router/Firewall, Wi-Fi Wireless LAN, HomePlug Powerline Communication, and HomePNA Phoneline Networking. Licea et al. [39] develop the MADEE (Mobile Application Development and Execution Environment) platform to support the development of small and middle size mobile and wireless information systems for handheld devices. Beutel [40] developed the BTnode Platform for researching and teaching wireless network applications and sensors networks. Aguilar et al. [41] designed and developed a wireless sensor network using commercial-off-the-shelf components and assembled in-house. This wireless network is used as a support tool for teaching in undergraduate engineering programs in Electronic and Computing, providing students a hands-on experience with emphasis on embedded software design. Research by Alejos [42] uses an experimental platform based on ZigBee wireless sensors for teaching location techniques on wireless systems and radio communications courses at postgraduate level in the Universidad de Vigo in Spain. Zhong et al. [43], showed the implementation of a platform for teaching, analysis and construction of “Mesh” wireless networks. Research by [44] introduces a tool, which simplifies the description of wireless sensor networks applications by means of a visual language and automatic generation of executable code.

Limitations on equipment access, budget reductions and poor knowledge in diverse communications laboratories in educational institutions, have meant that researchers around the world have developed alternatives to solve these problems. For example, Melkonyan et al. [45] and Abu-aisheh and Farahmand [46] implemented remote communication laboratories using commercial platforms to solve limitations related to equipment availability; however the use and acquisition of these platforms is presented as a “black box”, and is too costly, and difficult for
students and/or Institutions to acquire them. In this sense, research by [47] is focused on developing tools based on microcontrollers to guide students in the Embedded Systems learning and motivate them to make their own projects, highlighting the approach for designing and implementing software and hardware. Lim et al. [48] presented a cost-effective curriculum on Embedded Systems which used one monolithic environment, virtual platform, to introduce all the layers of the system components (i.e., from hardware to operating systems to user applications). Research by [49] presents a distance laboratory framework with transparent and ubiquitous access platforms for various console-based experiments, especially for networking and embedded system laboratories. Thus, the literature review on related works shows that a learning improvement is distinguished by the student’s construction of artifacts (prototypes, hardware/software tools, documents, etc.); however, teachers have to act as mentors to achieve a coherent development [50]. In this context, our platform establishes a formal method in working through students/teacher collaboration, the SPIES method [51] for constructing the DreamBlue tool.

A CONSTRUCTIVIST APPROACH FOR TEACHING/LEARNING EMBEDDED SYSTEMS AT UNIVERSITY LEVEL

The purpose of our constructivist approach is to teach engineering students topics for the Designing and Modeling of Embedded Systems in real time, and show them how to integrate the knowledge obtained from previous courses such as: Microprocessor Architecture, Digital Systems, Communications and Computer Networks, Structured Programming, and Instrumentation and Automatic Control Theory. During the course, students have to work in three-member teams with the aim of obtaining meaningful learning. From our point of view, it is preferable to instruct students how to construct a tool in a simple and functional way, instead of developing a tool with complex functionality that probably will not be implemented during the
limited time of the course (approximately 15 weeks). In this way, the students will be conscious of the meaning in developing real projects in a limited time.

The established course in the UTM has included two fundamental principles. Firstly, students are motivated to propose extensions for a specific system (with established functionality) with the objective being to construct their own personalized replica and therefore meaningful. Secondly, and as consequence of the first principle, there is no obligation to use specific hardware and software to build students tools; different tools are constructed through practical examples and the student’s creativity is achieved. Thus the constructivist approach is established as the framework shown in Figure 1.

Fig. 1. General framework of constructivist approach

The framework’ phases are summarized as follows:

- In the planning phase, the students receive the project, locate the required modifications, and organize the collaborative work. Through these activities, the student identifies and presents a problem, gathers relevant information and generates a potential solution. During the first week of classes, students are trained to use a specific system (constructed in each previous course) and a brief introduction and literature review on existent platforms and similar tools is provided. Later, during the second week, students learn the
UML modeling basis, using Rhapsody© for modeling embedded systems (requirements diagrams, use case diagrams, class diagrams, activity diagrams, sequence diagrams, state chart diagrams, and more); at this point, students are motivated to propose their own ideas on the expansion of tool functionality and think about the requirements that these changes involve. On the third week of classes, students should provide four proposals to increase the tool functionality (selected from previous courses) and write a preliminary description of the involved work. This process enriches the process learning in the classroom, because the exposition of ideas creates an excellent environment for developing and practicing communication and critique skills. In this scenario, the role of the teacher is very important to guide students and to define the expansion of the functionality in replica systems. Once that proposal has been approved, the constructivist approach establishes a “way to do the things”.

- The second phase is creating, or implementing the project. This phase includes activities such as implementation and documentation, coordination and a blend of member contributions, and the construction of a prototype. In this stage students are expected to construct a new version of a previous system that can be shared with other teams. The process is controlled by the SPIES method, which strengthens the collaborative work and formalizes the design process of embedded systems.

- The activities for the third phase, “learning” about the project, include reflection and follow-up on the projects. In this stage, students record their artifacts in a repository of lessons learned and share them with the entire class, obtain feedback, and reflect on the learning process and the project. Students share each team’s project and exchange feedback.
Thus, our constructionist approach proposes a model to support the learning process, over which pedagogic models can be developed for discipline at undergraduate level (see Figure 2). The first step in our model is to incorporate a formal method to support the creative process with certain characteristics related to the content. Secondly, our model forms an interactive scenario surrounded by tasks, topics, software tools, learning modules, and communication artifacts. Also, the model triggers a cycle that includes student evaluations and feedback. Finally, this engagement in interaction means the student is taking part in constructionist learning.

Fig. 2. Model for implement a constructionist approach.

The SPIES method.

The Software Process Improvement for Embedded Systems (SPIES) method [51] consists of a language to specify the elements and relationships among a system’s components, and a whole process (activities, products, inputs, outputs, metrics, entry criteria, exit criteria, roles, and more), which indicates what parts of language to use, how to use them, and when to use them. SPIES specifies an integrated set of activities (adapted from CMMI-DEV v1.2 [52]) to guide developers
during all the development lifecycles to develop robust, capable and secure systems; proposing new tangible artifacts, designing a solution and, finally, creating their own knowledge.

SPIES, is organized by phases which are composed of more specific activities. This method uses an artifacts repository (or repository of assets) to introduce the process improvement in each phase. This repository contains templates for each activity (artifacts), guidelines to perform activities, and role assignment. The variation for incorporating this repository of knowledge to each phase ensures us high levels of success and promotes knowledge acquisition. Figure 3 shows that this method is composed of three layers and eight phases. Layers are dependent and related progresses.

Fig. 3. SPIES phases and processes.

The interactive course is designed under a constructionist approach, assessing the student’s knowledge and showing content and activities adapted to the characteristics and learning styles of
students at undergraduate level. Besides, the constructionist approach allows the students and teachers to autonomously create and consolidate knowledge, with permanent automatic feedback and support, through instructional methodologies and educational activities explored in a constructionist manner. The constructionist approach of SPIES is based on a progressive self-assessment (interactive exercises, tasks, and more), completed by the students and which evolves in difficulty and topic.

**ILLUSTRATING EXAMPLE**

An initial implementation in the engineering course of Communications and Control at undergraduate level is performed in two different stages.

- Firstly, twelve students (with an average of 23 years old) participated in the construction of a basis tool that will be used in future replicas. This tool corresponds with a previously selected topic from the course. At this stage, a constructionist approach (planning-creating-learning) is implemented at the same time as a traditional course is developed. Obviously, we will try to demonstrate the effectiveness of our approach.

- Secondly, once a basis tool is delivered, a second implementation with another six students (with identical characteristics) uses this tool as a starting point. Thus, meaningful learning will involve both groups of students and knowledge will be constructed.

The implementation follows SPIES’ activities and process shown in Figure 3, and summarized in the following sections.

**Planning with students.**

At the beginning of the course, the topic of *Wireless Communications: Bluetooth Protocol* was selected. The course objective is to understand the concepts of Bluetooth protocol. The construction of a prototype for communicating devices is planned. Students use the planning process to obtain a project plan which captures all the estimations on time, budget, schedule and
characteristics of the project. Figure 4 shows that our constructive approach provides artifacts to formulate a Project Plan, and (at the reverse of plan) the information that guides the student to fill the artifact is provided. This artifact (and more) is supported by the eight phases of SPIES.

**Requirements specification through students understanding.**

Once the working plan is established, students and teacher determine the embedded system specifications to produce and analyze the components and subsystems that correspond with the topic established in the course. As a basis tool, the construction of the DreamBlue system is proposed. Figure 5 shows that students determine that DreamBlue is composed of two nodes which communicate through the Bluetooth protocol. Each node has a Data Terminal Equipment (DTE) as a user interface and a Bluetooth module, or Data Circuit-terminating Equipment (DCE), that establishes the connection to create a piconet\(^2\). In accordance with the curricula, the communication between the DTE module and DCE module should be used in the RS232 protocol.

Using the ASIREQ artifact from SPIES’ Requirements specification process, students establish functionalities for both modules and the teacher decides the following:

- The DTE module uses a matrix keyboard with 4x4 interrupters and a GLCD for configuration functions. The users can configure each node and visualize the messages sent and received among them, respectively.
- Nodes configuration is established through a set of AT commands sent from DTE module to DCE module, and finally,
- The firmware implementation in each DTE module is performed with a microcontroller

---

\(^2\) The *piconet* concept defines a network which is composed of two or more Bluetooth devices that share a communication channel in the same coverage range.
In a collaborative way, students capture the DreamBlue requirements and follow the SPIES instructions to reflect the three basic representations of a system: functional, structural (or static), and dynamic. This constructionist exercise foments the collaboration and knowledge generated through the creation of formal artifacts that can be reused in further modifications. Meaningful learning is obtained through the interaction of ideas and agreements on overall functionality, and phase’ artifacts (as requirements diagrams and use case diagrams) to formalize a common understanding.

![Artwork](image.png)

**Fig. 4.** SPIES artifacts for project planning.

**Fig. 5.** Block diagram of DreamBlue system.
Designing product with students.

In this phase, students examine the interaction between the user and the whole functionality of the embedded system. Our constructionist approach introduces the creation of functional designs (structural diagrams, sequence diagrams, etc.) which enable the creative process and collaboration among students. Figure 6 shows the structure proposed by students after this collaborative design. This structural diagram summarizes a subsystem’s decomposition achieved through an interchange of ideas and feedback. This architecture is reviewed by the teacher to assure the correct use of different disciplines and he/she validates the correctness of the proposed solution by a simulation tool.

Fig. 6. An example of architecture for DreamBlue system.

Product development.

This phase uses the requirements and functionality previously modeled and includes the analysis of hardware components needed to construct a prototype (the phase’s artifact) and test the model constructed in previously phases. At the same time, students discuss the location of components
and obtain a schematic design as shown in Figure 7. The firmware implementation is based on dsPIC30F4013 microcontroller (Microchip firm); this selection corresponds with the functionality determined in the design phase.

![Schematic Design](image)

**Fig. 7. DreamBlue preliminary development.**

**Product integration by students.**

Students integrate all modules and subsystems developed in Product development phase and obtain the tangible artifact called “system prototype”. This prototype is continually validated to ensure its correct performance. Figure 8 shows the final product—the DreamBlue system.

**Product validation with teacher.**

Validation tests on DreamBlue are performed as follows: configuration tests (under different transmission velocities), local name assignations, device sounding test, transmission test between DreamBlue nodes, and coverage test. To determine the DreamBlue’s maximum coverage, students perform range tests during the establishment of the nodes connection. DreamBlue nodes reach a maximum range of 26.25 ft in free space; however, with interference of walls or solid objects among already linked devices, the maximum range decreases at 19.69 ft approximately.
When the connection is interrupted, nodes should be approached at 9.84 ft to recover the connection. A device sounding test was performed on cell phones, PCs and PDA’s.

EXPERIMENTAL RESULTS

Once that the DreamBlue system was developed (as a core tool) under our constructionist approach, a second group of six students proposed improvements and extensions for system’ functionality as a part of the Communications and Computer Networks course. Thus, meaningful learning is reflected through analysis and discussion over the DreamBlue system. Using the core system, students designed a Bluetooth Wireless Temperature Sensor system.

Designing the Wireless Temperature Sensor from Dreamblue System.

The Bluetooth Wireless Temperature Sensor system is designed using SPIES methodology as shown Section 5, but considering the core requirements of the DreamBlue system. Figure 9 shows an example of structural diagram of the new system. The functional, static and dynamic designs enable students to propose a technical design according to SPIES guidelines. The Bluetooth Wireless Temperature Sensor system is constructed as an independent system; but in
consideration of the core tool, the DreamBlue tool. It is important to say that in our constructionist approach, embedded systems are developed to be reused for other groups or courses inside the campus. The schematic diagram for the temperature sensor is shown in Figure 10.

Fig. 9. Example of architecture for Bluetooth Temperature Sensor system.

Finally, Figure 11 shows that students integrate both systems, DreamBlue and Temperature Sensor, to validate their preliminary design (as a replica) over a core system.

Fig. 10. Schematic diagram for Bluetooth Wireless Temperature Sensor system.
Preliminary record of constructionist learning.

The first version of the constructivist approach presented in Section “A Constructivist Approach for Teaching/Learning Embedded Systems at University Level”, has been implemented, tested and evaluated in the learning processes at University level. The collected evaluation data has shown a very high degree of interest and motivation from students and teachers alike, resulting from its use. Students also perceive this approach as very relevant for their learning, as a self-operating application to be integrated in a more global learning strategy that includes also, tutoring (direct contact with the teacher) and peer learning. Teachers agree with these definitions of the constructionist approach. Another result is the definition of a new method and architecture for the implementation of embedded systems. With the data of historical embedded systems we selected eighteen students related with the Communications and Computer Networks course and proceeded to evaluate the results obtained from our constructionist approach, using the time destined to test the quality of the exercises as a measure of success in the defined project objectives. The objective is to improve the quality of exercises in a manner which does not affect
the percentage of approved students. Table 1 shows that these two issues provided greater evidence of the benefits of our constructionist approach. One of them was the notorious reduction of defects in exercises, and the other was the improvement on the percentage of approved students from 57.7% to 89.8% (see Figure 12).

<table>
<thead>
<tr>
<th>Objective</th>
<th>Estimate</th>
<th>Real</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>% defects at delivery</td>
<td>&lt; 5%</td>
<td>3.8%</td>
<td>-24.8%</td>
</tr>
<tr>
<td>Percentage of approved students</td>
<td>&gt; 70%</td>
<td>96.2%</td>
<td>37.4%</td>
</tr>
</tbody>
</table>

Table 1. Objective data.

CONCLUSIONS

Constructionist is an educational theory developed by Seymour Papert from the Technological Institute of Massachusetts. This theory is based on Piaget’s learning theory. Constructionist theory, states that learning is much better when students are engaged in the construction of meaningful artifacts; such as robots, computational programs, electronic systems, machines, etc.

Fig. 12. Improvement of % approved students
In Mexico, the traditional educational system is used extensively. To increase the student’s skills and knowledge, this approach is supported by two fundamental axis: the teacher and the reference books. So, we strongly believe that in a new form of education such an improvement does not need to rely upon a certain didactic technique, or a certain type of infrastructure. Rather, the new scheme of education that our fast-moving environment demands, requires the re-thinking of every process that we develop in our lives, in order to be congruent with the environment and to build a society that our world demands.

In this context, we do not see that infrastructure, such as software tools, will displace the important role of the didactic techniques that professors develop in the learning process. Rather, we see these technologies in education as complementary tools, which facilitate the learning process in the current knowledge-age society in which we live. However, the question that might be raised could be: would it be possible to implement a new form of education in Electronic Sciences with the implementation of a constructionist theory? This work has introduced an alternative approach in learning how to design embedded systems under the constructionist theory. Our approach focuses on: pedagogical and technical contents, which are built into the DreamBlue system, as the main component for obtaining meaningful learning. However, the experiment demonstrated little consideration of issues regarding how the cognitive process is achieved in the mind of the student, or how the individual stores the knowledge acquired.

Based on the results obtained, it is concluded that emerging technologies such as the DreamBlue system provide a unique environment that directly benefits both academics and students as shown in this paper. Our research work in this area sets out to understand the Bluetooth communications protocol and design educational replicas that require a low consumption of energy. Once it has been validated in a large number of educational projects, we will focus on obtaining the best practices to improve the constructionist approach.
REFERENCES


22. Z. Avery, M. Castillo, G. Huiping, G. Jiang, N. Warter-Perez, D. S. Won and J. Dong, *Implementing Collaborative Project-Based Learning using the Tablet PC to enhance...*


36. M. P. Cuéllar and M. C. Pegalajar, *Design and implementation of intelligent systems with LEGO Mindstorms for undergraduate computer engineers*, Computer Applications in Engineering Education, Published online in Wiley Online Library; DOI: 10.1002/cae.20541.


38. J. Sang, *Hands-on laboratory experiments with SOHO networking technologies*, Computer Applications in Engineering Education, Published online in Wiley Online Library; DOI: 10.1002/cae.20503.


44. F. Losilla, P. Sanchez, B. Alvarez and A. Iborra, *An educational tool for wireless sensor networks*, Computer Applications in Engineering Education, Published online in Wiley Online Library; DOI: 10/1002/cae.20439.


