A MODEL OF PROJECT-BASED STRATEGY FOR EDUCATION IN TECHNOLOGY TO 10TH AND 11TH GRADES IN COLOMBIAN SCHOOLS

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Abstract

In our current world citizens involve diverse technological products and services in their daily activities, however they have a limited knowledge about the production, functioning and impact of technology. In this sense, education plays a relevant role for the development of the competencies related with decision taking and critical thinking about technology. In 2008, the Ministry of National Education (MNE) of Colombia published a document in which the main orientations for education in technology for elementary and secondary schools are presented. However, teachers usually do not include these orientations in technology assignment curriculum design, making it a subjective process that is highly dependent of the experience and teacher opinions. As a solution, in this paper an educational strategy design for the formation of competences in technology, based on the model of Project-Based Learning (PBL) and focused on solve a context problem of the students is described. The structure of this strategy is composed of phases and stages that take into account the educational community characterization from a data collection, which is chronologically and sequentially organized in order to achieve the learning objectives in technology. In order to build, evaluate and validate this educational strategy, a collaborative work with technology teachers from some EI was developed, considering the relevance of previous teacher experience for the definition of the strategy components. Currently, the proposed strategy is being implemented in five EI in Colombia and with the aim to evaluate the impact of this strategy in the student development of technology competences, different tools will be applied to qualitatively and quantitatively measure the progress in these competences.

Keywords: technology education, Project Based Learning, educational projects, competences.

1 INTRODUCTION

In recent years, technology education has taken relevance in schools due to its importance in the development of several competences required for citizens nowadays. For instance, this can be evidenced in activities that require access to computer systems, the use of sophisticated transportation systems and the purchase or use of technological products. In order to develop these competences, organizations worldwide have proposed documents that guide the instructional design process for the inclusion of technology education in the EI [1].

In some countries, educational strategies have been developed in order to include technology education in classrooms according to the regulatory curriculum proposals defined by governmental agencies. In United States, for example, some methodologies have been used to carry out collaborative projects by students themselves or under guidance of experts from different knowledge areas on a "*hands on projects*" approach [2]. Another strategy oriented to reach technological literacy in citizens of this country is called "*how things work*" [3], in which technological competences development is proposed through inquiry based learning about the operation of artifacts and systems in their environment.

In 2008, the MNE of Colombia published the document "*Be competent in technology: a requirement for development*" [4], in which the main elements that should be considered for elementary and secondary education are presented. Although some orientations for their implementation in the EI are given, the process of instructional design in technology is still highly subjective and weakly applicable in the EI context. This situation leads teachers to take into account few or none of the elements described in this document and the instructional design mainly depends on teacher point of view and his academic orientation. To counteract this situation, some elementary and secondary institutions of

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the country have proposed different approaches based on PBL have been proposed. Nevertheless, these initiatives were short time experiences and their continuity has not been reported [5].

This paper describes a solution for the problem presented above through the design, construction and adaptation of an educational strategy focused on the development of technological competences and based on a PBL approach. The second section presents a short description of the elements considered for the instructional design in technology and the variables involved in this process. Section 3 describes the construction of the proposed structure, the elements that were considered and several possibilities for its use by teachers. The fourth section shows the adaptation of the initial structure and the results obtained when it was adjusted for a particular case. Lastly, the results and conclusions section is presented as well as some suggestions for replicating the experience in other EI and possibilities for future work.

2 INSTRUCTIONAL DESIGN FOR TECHNOLOGY EDUCATION

According to MNE, the curriculum is defined as: "the set of criteria, study plans, programs, methodologies and processes that contribute to the integral education and construction of the national, regional and local culture identity, also including human, academic and physical resources for implementing policies and carry out the institutional educational project". In this regard, it is clear that in order to achieve its objectives, the curriculum considers particular aspects of each EI context in which it will be implemented. Given these characteristics, it is important to understand that curriculum design for each EI involves a set of activities oriented to characterize the institutional population, its interests and resources, as well as governmental interests and projections regarding different educational levels.

In the Colombian case, the MNE has presented a set of documents that have been constructed for the orientation of technology education process. The most recent and currently in use document is "Be competent in technology: a requirement for development", in which the main terms related with technology are described [2]. Additionally, it describes the educational objectives of each school grade and their organization in a hierarchical structure. As can be seen in Fig. 1, the superior level consists of four components in which technology education is divided: *Nature and evolution of technology, Appropriation and use of technology, Solving problems with technology* and *Technology and society*.

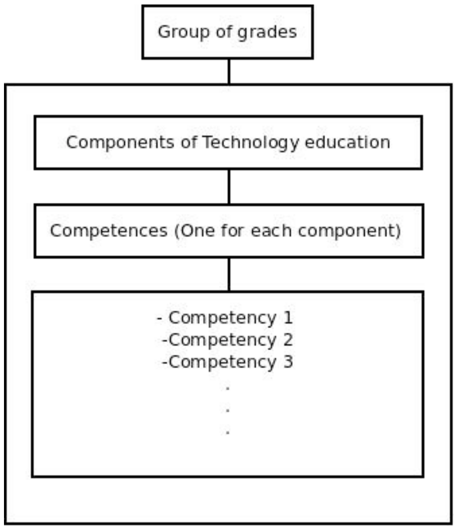

Fig. 1 Hierarchical structure of technology education components, competences and competencies proposed by MNE.

For each of these components, it is proposed a particular competence that describes the expected goal to be developed by the student in his educational process. Additionally, the achievement of each competence is related to the compliance of a set of competencies. Although these competencies have been defined by MNE, it is also possible that teachers adjust them according to the particular characteristics of their EI and the population involved.

Once the more relevant aspects for each of educational level are described through components, competences and competencies, the MNE document suggests teachers some elements to consider for their implementation in class. Despite of these suggestions, it has been observed that many teachers do not take into account neither the proposed structure nor its details. This is due to different factors: teachers do not completely know the orientations, or consider that there are not a defined guidance that explain how to involve or contextualize them in their EI. Under these circumstances, the process of instructional design in technology area is subjective and strongly depends on teacher considerations according to his formation area and experience. As a result, the possibilities of technological competence development in students is significantly reduced.

In order to reduce the subjectivity in the design process, we propose a model that involves the PBL approach and considers particular characteristics of each educational community and EI. This model, showed in Fig. 2, is organized in five phases each of which is divided in different stages focused to achieve the proposed objectives. Likewise, for an adequate adaptation of the model for each EI, four variables are used to characterize the particular population: *students learning styles, family perception about technology, students and teachers education on technology, available resources in EI* and *Institutional Educational Project (IEP)*.

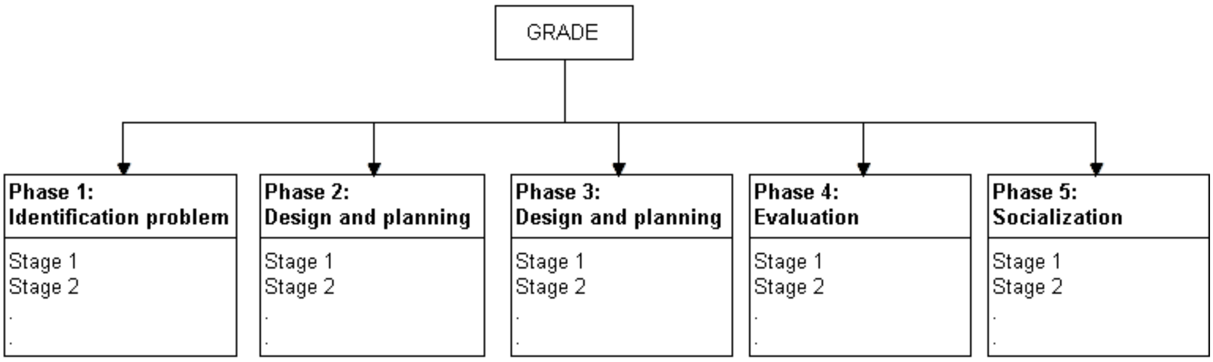

Fig. 2 General strategy structure.

The description of these information variables and their importance for instructional design in technology education is presented below.

3 CONSIDERED VARIABLES IN STRATEGY INSTRUCTIONAL DESIGN

Instructional design is defined as the set of strategies that allow developing a learning process focused on particular interests and needs of the students, taking into account the learning objectives on the educational activities development [6]. To effectively involve the interests and needs of the students on the instructional design process for technology education, we proposed four variables that characterize the involved community. These variables were chosen considering the availability of information and its impact on student learning process [7].

The first of these variables is related to students learning styles, and it is important because allows us to recognize student preferences about the form in which the information should be presented and organized, as well as the kind of activities that should be developed. In this work, the Felder - Silverman learning styles approach is used [8], in which four main groups of styles are described: *visual - verbal, sensing - intuitive, sequential - global* and *active - reflective*. To obtain this information, the use of Felder - Soloman learning styles test is proposed [9].

The second variable is related to the educational community preferences about technology formative process and shows the competences that community considers pertinent, based on those proposed by the MNE. To obtain this information, the implementation of both interviews with technology teachers and surveys for students and parents is proposed. The third variable is the resource characterization for technology area on each EI, which is very important because it affects directly the kind of classroom activities and technology school projects that students can make. This characterization will be made through surveys and interviews with students, teachers and parents.

The last information variable is related to the IEP in which main characteristics of EI are described. Some of these characteristics are: pedagogical model, educational emphasis, educational areas offered and academic and community agreements. The most relevant information for the variable is the EI emphasis, which allows us to guide the process of project selection to link it adequately with the learning objectives.

Once the methodology to collect this information has been defined and the results of the characterization process has been obtained, each element of the strategy model can be adapted for each institutional context. On the next section the proposed strategy construction process and the main characteristics of its implementation are described.

4 CONSTRUCTION OF THE PROPOSED STRATEGY

The proposed teaching - learning strategy model is based on the model proposed in [5], in which nine phases are described for a school project. On this case, these phases were grouped on five main phases that involves the principal elements of a school project. Furthermore, these five phases have a parallel with the creative thinking spiral proposed by Mitchell Resnick [10], in which a set of phases are established for educational activity design based on the student experiences. According to this, the structure of the proposed strategy is as shown in Fig. 3, divided on different stages that seek to accomplish the PBL methodology and provide a clear and concrete orientation for teachers about didactic objectives and strategies to be implemented in class.

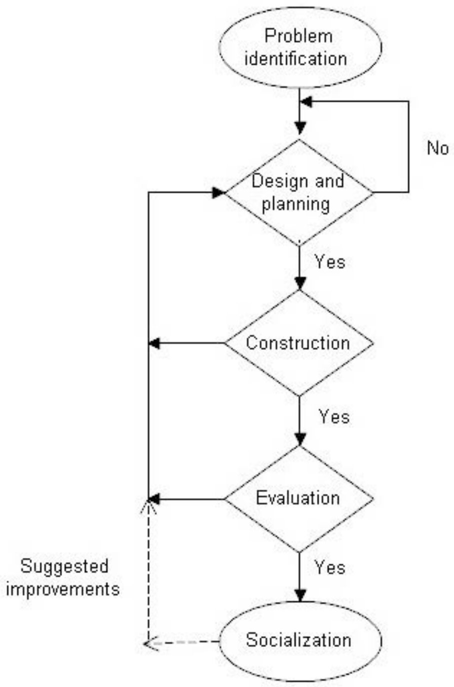

Fig. 3 Flowchart of strategy phases

This strategy has as main characteristic the possibility of adaptation to each EI context, taking as reference the information variables previously mentioned. Each phase is composed by different stages and activities that can be developed according to the involved variables, which allows us to customize its structure according to the EI community characteristics. Likewise, the purpose is to encourage the technological competences development and follow up the student process during the educational strategy execution. Following subsections present the five phases of the strategy and their stages.

4.1 Phase 1: Problem identification

This phase aims to motivate students on the PBL methodology characteristics. Students are led from the identification of a problem observed from their environment to the process of searching and selecting a solution taking into account the requirements and key aspects given by the teacher and other students. In this phase is fundamental to give clarity about the activities and the role of each member on the collaborative team to accomplish the objectives. Four stages characterize this phase:

- Stage 1 has as goal to motivate students on scholar project making, present the working methodology and the available resources on the EI, and preliminarily define the problem to solve.

- On stage 2 students will define the problem to solve, the project phases according to the particular needs of their project and the roles and responsibilities of each member of the team.
- On stage 3 students formulate and analyse different solution alternatives and then choose the best possible solution.
- On stage 4 students organize and present information for their project according to the previous stages. Teachers will evaluate this presentation and give them a feedback.

4.2 Phase 2: Design and planning

After defining the problem, its possible solution and the student role, the next phase is design and planning. This phase comprise four stages in which teachers organize the activities to develop during the project and define the required resources for their execution.

- On stage 1 a set of criteria is presented to the students in order to help them on the selection of materials or resources for their project.
- On stage 2, the previous knowledge of students is considered to classify the concepts involved on the project. These concepts must be consulted and organized for a justification of their selection.
- On stage 3 the teacher will describe the fundamental criteria for the design of a timetable of activities. Considering these criteria, students must construct and present the advances of the project.
- On stage 4 the teacher will present the available computer assisted design tools, simulators and relevant software according to each project. With this information, students can make the program design, drawings, models or diagrams.

4.3 Phase 3: execution or implementation

On this phase, students prepare the materials and resources needed for the execution of the project in order to begin the construction and perform functioning tests. This phase is divided into three stages:

- Stage 1 consists on material or algorithm preparation according to the requirements of the project.
- Stage 2 begins with the assembly of pieces or the organization of programing algorithms. This stage consists on the construction of the product considering the designs obtained on previous phases.
- On stage 3, performance tests are conducted for all the systems included in the project. As product of this phase, students will present the built solution according to the proposed design.

4.4 Phase 4: Evaluation and improvement

On this phase it is determined whether the proposed solution meets the objective or whether it should be reviewed. It involves three stages:

- Stage 1: product performance evaluation based on teacher orientations.
- Stage 2: performance tests based on evaluation parameters previously established.
- Stage 3: suggestions and improvements implementation according to the results obtained on the previous stage, focused not only in performance but also in aesthetic and security aspects.

4.5 Phase 5: Socialization

On the last phase, students present the result of their work to the community using different mass media. This process allows them to obtain suggestions to improve their project and to open possibilities to present it in other events. This phase consists in three stages:

- On stage 1 student consider suggestions obtained in fourth stage in order to improve their product and obtain a final version of it.
- Stage 2 consists on the preparation of audiovisual resources with the aim to present the project to the community. On this stage students are oriented about the use of particular resources and strategies for the presentation.

- On stage 3 the project is presented to the educational community of each EI. However, it is possible to open other participation scenarios out of the school and with other type of audience interested on the topic.

We propose to implement this strategy on 10th and 11th grades of some institutions in Colombia, on a weekly session of two hours approximately during a school year. This is equivalent to 34 classes on each year, in which the teacher can define the necessary time for each stage according to the project main characteristics. Likewise, teacher can select the specific competencies and the particular content design that will be used during each class. The next section shows an example of the implementation of this strategy on one EI in Colombia.

5 STRATEGY ADAPTATION EXAMPLE OF A STUDY CASE

Once the structure that describes the proposed strategy was designed, it was presented to teachers with experience on instructional model construction in the technology area. During this revision, we observed some elements that hinder the strategy implementation and others that were not explicitly defined. Hence, we obtain suggestions that allow us to make the strategy more adaptable to different EI contexts.

In order to obtain a first version of the of the strategy adaptation to a particular EI context, the *Instituto Pedagógico Arturo Ramírez Montúfar (IPARM)* was used as a case of study. We collected information related to each variable on this school in Bogota using surveys and interviews for students and parents. The obtained information allowed us to prioritize technology competences and competencies to include on the strategy design. Then, the Felder-Soloman learning styles test was applied on 10th and 11th grade students (see section 3). The obtained results show different levels that characterize the influence of each style on the students and aids on the construction of activities and methodology to implement.

Table 1 - Case study characterization variables

VARIABLE		**CHARACTERIZATION**
IEP - Institutional emphasis		Formation of integral people with high capacity in knowledge, competencies and behavior field, with high level of autonomy, clear ethical, spiritual and social values, capable to assume solidary and community commitment in the construction of fair, equitable, inclusive and participatory society.
Available resources		Tools for virtual information handling, tools for information access, tools for material handling.
Prioritized competences		Solving problem with technology - Technology and society
Learning styles	**Active - Reflexive**	*In Balance (58%), more Active (26%), more reflexive (12%)* and *a lot more active (5%)*
	Sensing - Intuitive	*In Balance (65%), more Sentient (16%), more Intuitive (14%)* and *a lot more Sentient (5%)*
	Visual - Verbal	*In Balance (42%), more Visual (33%)* and *more Verbal (5%)*
	Sequential - Global	*In balance (63%), more Sequential (33%)* and *a lot more Sequential (5%)*

Parallel to this, the information about the available resources on EI and the IEP emphasis was collected and analyzed in order to guide the activities and project selection. This information was obtained through technology teacher's interviews and the IEP document of the institution. The obtained information for these variables is described on Table 1.

Considering this information, the strategy model was adapted for this EI characteristics and a first version was obtained. This first version was used as a start point to define the specific activities and the didactic methodology to develop on each particular stage of the general project according to the community needs and interests.

6 CONCLUSIONS AND FUTURE WORK

As a result of the development of the proposed strategy, we observed the importance of linking the information obtained through the selected variables with the classroom activity design process. In this regard, once teachers reviewed the structure model, it was evident its potential to be adapted and implemented on different educational contexts. In addition, this project structure allows reducing the subjectivity on the classroom activity design process, because it provides information to teachers and tools to make decisions about the educational activities that are pertinent to their EI context.

In the near future it is expected to implement the proposed structure within various EI in Colombia. Additionally we consider assessing its impact on the development of technology competences in students and assessing its adaptability to different EI contexts. This process will allow us identifying the EI characteristics were the strategy should be used, as well as analyzing its possibilities to be used on other school grades for technology education. Furthermore, the evaluation results will allow to feedback the strategy and make the necessary changes for future implementations, contributing to the possible redefinition of the orientations for technology education proposed by the MNE. Finally, there is an interest to automate the strategy adaptation process to facilitate the model construction based on the collected information of the EI were the strategy can be implemented.

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