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Science-Focused Theme Based Learning in Middle School

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Abstract

Today's educational requirements focus on preparing students for the 21st century climate of change and innovation, where skills such as creativity and flexible thinking are increasingly valued. The literature is full of educational approaches intended to replace traditional methods. However, bringing these progressive ideas to schools is no light matter. Many teachers are reluctant to change their teaching methods and more profoundly, schools in general are not designed, and not directed towards implementing such new ideas. An essential factor for sustainable change in schools is an infrastructure, including a local leadership that will support its implementation and long-term operation.
Project-Based Learning (PBL) is an educational approach in which students acquire knowledge and skills by investigating complex questions and real-world problems. PBL requires teachers to shift from being a presenter of knowledge, to being a promoter of learning. We present here a program aimed at developing and implementing multidisciplinary, science-focused Theme Based Learning (TBL) using PBL pedagogical tools in regular middle schools, whilst working with the general state syllabi.
The program is a three years process. It starts with teachers of the 7th grade classes and grows to the 8th and the 9th grades in the subsequent years. Teachers of all disciplines engage in a year-long professional development course, and a leading group of discipline coordinators and science teachers steer the process in monthly meetings with our experts. Since we aim at creating a meaningful learning experience for students, as well as a language affiliated to all disciplines, the management, and the leading group of teachers, determine an organizing axis and a set of three related themes for each grade. The themes have to be consistent with the school's agenda and with the science syllabus. Teachers of each discipline link the themes to phenomena encountered by students in their daily life and are related to scientific, curricular subjects.
We will describe our experience in implementing such an intensive program in middle school, including both the challenges and successes and providing current feedback from teachers.
Keywords: PBL, project, Teachers, Science, Junior High School, Multi-disciplinary

Background

The changing nature of learning and the skills expected from 21st century school graduates, requires the adjustment of teaching methods in general and particularly in scientific education [1]. *Project Based Learning* (PBL) is a proverbial educational method, enabling teachers to embrace the differences between students and express a wide range of learning abilities. Over the years, many studies examined its effectiveness on various aspects of learning at school. Their results were inconclusive, and some of them doubted the effectiveness of PBL on learning processes [2]. In a comprehensive cross-sectional study, Hung examined the reason behind these conflicting results, he indicated that most studies merely discussed both ends of the teaching process - the theoretical perception and the learning outcomes of the students - without discussing the implementation processes.
The implementation of full scale PBL, especially in heterogeneous schools and classes, is a continuous, complex and time-consuming process. The school management and staff have to be fully committed, and teachers are required to adopt a variety of new teaching methods [3].
In order to actually shape the practice in classroom, the teaching methods should combine three main elements [4]:

- Multiple-drafts - Give students many chances to improve, and give teachers excellent means for individual evaluation of the processes the students has undergone.
- Feedback - judgment is not exclusive to the teacher. Students give each other feedback, thus learning from the work of their classmates while exercising the skills of giving and receiving feedback in a structured and guided manner that does not threaten or undermine.
- A public event - An event celebrating the process and presenting the products to the community. Students' awareness that their project will be displayed outside their classrooms enhances their

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motivation and commitment. The public event also strengthen the connection between the school and its community.

This article describes implementation of *Theme Based Learning* (TBL) based on teaching methods accentuated in PBL approaches. The TBL program we describe is developed at the Davidson Institute of Science Education [5]. It is designed to be implemented in schools with heterogeneous classes, while adapting to the school's agenda and environment, training teachers and providing ongoing support.

Method - Theme Based Learning (TBL)

The learning experience of each grade springs from an organizing issue and a set of related themes. The themes connect the science curriculum with students' everyday experiences, and the curricula of other subject matters (figure 1). The process continues throughout the 7^{th}-9^{th} grades, connecting multiple disciplines with the students' daily life. Science studies are at the center, while pedagogical support is given the teachers of the various disciplines as full partners in the process.

Organizing axis	**Transformations**		
Themes	**From singular to plural**	**Energy**	**Growing-up**
Examples for links students' everyday experiences	How do we build relationships? What types of relationships are we in? Is it better to be alone or in a group?	How do energy snacks vitalize us? Where does electricity come from? What is an energy crisis?	What changes do we undergo when growing up?
Connection with the science curriculum	• Pure substance vs. mixtures • Chemical elements and compounds • Chemical reactions	• The concept of energy. • Types of energy and transformation between them. • Sources of energy.	• Reproductive systems • Fetal development • Cellular differentiation

Figure 1: An example of an organizing axis referring to three themes. The chosen themes are interdisciplinary, relevant to the children's lives and support the science curriculum. Teachers of other disciplines add the appropriate links to their curricula during the preparation stage.

This process is demanding and very challenging, especially in the first year of operation. School stuff must be prepared and fully commit to the program. School preparation involves the mobilization of the management and staff of teachers and their willingness to participate in the program. A supportive infrastructure must be available for such a change: learning hours must be allocated in the school timetable, enabling work in small groups. An appropriate working space must be dedicated, equipped with a simple but essential means of creating products.

Implementation of the TBL program in school includes one *introduction stage*, taking place before the first year of implementation, and *enactment stages* repeating each year of operation (figure 1).

Introduction stage - towards the first year of implementation:

- Meeting with the management and science teachers at the school to discuss the annual organizing axis and suitable themes. The themes are chosen according to the science curriculum. The theme should be interesting for teachers, relevant to students, concerning the community (school, neighborhood or city) or a challenge from the outside world (society, current events, etc.).
- A summer course in which the school's management present the organizing axis and themes, and science education experts provide all teachers with the pedagogical principles and the minimum scientific background required for the first theme. This enables teachers of the non-scientific disciplines to choose the aspects in their curriculum linked to the broad context of the first theme and the scientific subjects. At the end of the summer course, the teachers experience

an accelerated but complete PBL process, including presentation of their products and giving/receiving peer feedback.

Enactment stages - throughout the school year

Throughout the school year, teachers and leading teams participate in a process of continuous tutoring. The process includes three main interrelated components:

Sessions for all school teachers: Sessions for all school teachers under the guidance of a scientific education expert. The main objectives of these sessions are learning and experiencing the scientific principles necessary for the selected theme, guiding the teachers in the process of implementation and preparation for the public events.

Sessions for leading teams: Tutoring meetings of the expert with the leading teams (disciplines' coordinators and/or science teachers). The purpose of the meetings is to highlight the scientific principles and to assist in linking them to the various disciplines' curricula.

Continuous school work without the expert: Disciplinary teaching, self-preparation of teachers, working on projects in small groups of students and preparing for the public events.

The following figure schematically describes the optimal TBL implementation model in school:

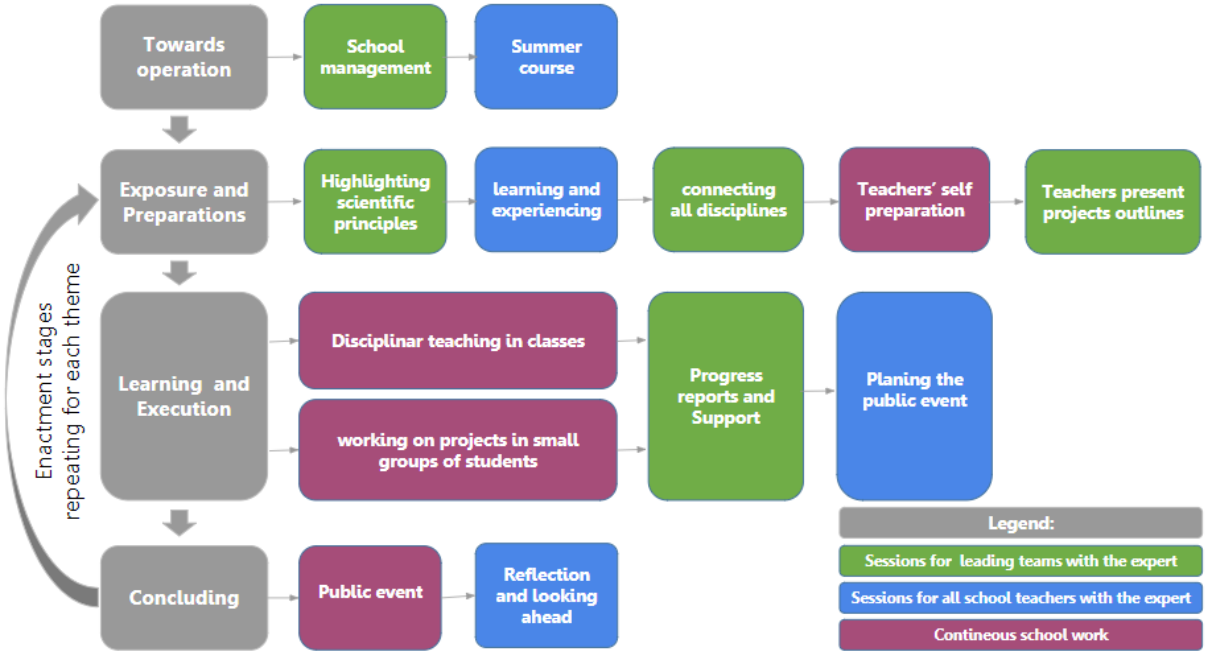

Figure 2: A scheme describing the TBL implementation model in school. The first stage of introduction, followed by the stages of enactment that include exposure and preparation, learning and execution, and concluding, that is repeated for each theme.

Results

The program is in its second year as a pilot, and we develop and draw conclusions while implementing it. Therefore, we do not yet have quantitative assessment data. In the reflections written following the introduction and the first year of implementation, the teachers describe a challenging and complex process, but one that was also rewarding and significant to their professional development:

Teachers gain confidence with time

"At the beginning … the change is not simple because suddenly we are talking about scientific subjects and planning educational units that contain science, and ... I was uncomfortable, afraid of failure … and sometimes frustrated. Although I started with negative emotions … by the middle of the year... everything has changed: lesson planning, students at the center, collaboration with students, interest in scientific subjects and amazing products. I won an excellent and dominant experience."

"At the beginning ... I encountered a lot of difficulties and uncertainty. This raised a lot of question marks among the teachers in the group; there was a sense of fear and confusion and

a kind of pressure … but gradually things became clearer by the beginning of the second session … and especially when we implemented the subject. "

Significant contribution to students

"I feel that this way of learning encourages students more than the traditional way."
“Students are an active part of the learning process; they have the opportunity to seek information and not just accept it."
"The group work every week allows students to feel comfortable and free. They also participated in the lesson in a different and much more efficient way than they do in regular classes."

Improving teachers-students relations

"The best part of working with small groups was getting to know my students on a personal level, which of course affected the teacher-student relationships positively."
" This learning process has enriched me as a teacher, enabling me to get to know each one of my students better, his abilities, his aspirations, his motivation, his responsibility, his strengths and weaknesses ..."

Professional development of teachers

"I personally acquired new skills and learned a lot, so that the various learning processes helped me develop my professionalism. Today I can certainly shape the learning environment in the classroom according to my students' issues."
"The course was very effective, enlightening the complexity of the curriculum, required learning various teaching methods and trying them out, which meant many hours of preparation."
"The project was interesting and challenging ... I learned to be more creative and to teach in diverse methods in order to advance the learning process..."
"The PBL lesson gave me a great boost and encouragement to deal with the many difficulties."

Obstacles and challenges:

"The performance was not easy as most of the students were very weak."
"One of the difficulties we encountered was meeting the deadlines because we were in the middle of exams period, but we were happy when we managed to meet the deadlines and achieving the desired goal through diligence, persistence, cooperation and proper division of roles”.

Summary

The process of implementing the TBL program described in this article is challenging and requires the full commitment of the school staff. However, improvement in the quality of learning outcomes and the reflections collected from teachers indicate that both students and teachers are greatly benefited by the process. The program is in its pilot stages, requiring comprehensive data collection and analysis, along with continued implementation and assimilation. The program’s success is measured, among other things, by its suitability for implementation in schools with heterogeneous classes and not solely in private schools or excellence classes.
Additionally, the multidisciplinary approach and connection to the students' lives enable both teachers and students to experience science as an integral part of daily life and to develop the skills required in the 21st century, including creativity, collaboration, and flexibility. We attach great importance to the choice and commitment of the school management, to the teamwork of staff, and to the continuous support in the first years within the school as a unit of change.

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