

A Collaborative Management Model for the Learning and Teaching Process (CollMMod-LTP): An Application for Problem Solving and Algorithms

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Abstract

This research aims at improving the management of learning and teaching process (LTP), more specifically observing the students' learning achievement and persistence, and teacher's interventions. To fulfill this purpose a Collaborative Management Model (CollMMod) has been defined during the last four years. In this paper we describe its main components (LTP-goals, LTP-stakeholders, LTP-variables, LTP-instruments, LTP-assessments) and its application in a course about Problem Solving and Algorithms at Universidad Nacional del Comahue using LTP-cognitive-variables. Results from the experience show that: collaborative members engaged in conducting and managing a TLP process may positively influence students' achievement; persistent practice activities where students can detect and correct their errors contribute to improve their achievement. Collected data were statistically analyzed; preliminary results show that there exists a moderate correlation between TLP variable-derived indicators and students' rate of success in final exams.

1. Introduction

Learning is a cognitive process of knowledge and behaviour acquisition [21]. In cognitive science, learning is deemed as a relatively permanent change in be-

haviour, thought, and feelings as a consequence of prior experience. The principle of information acquisition states that there are four sufficient categories of learning known as those of *knowledge*, *behaviors*, *experience*, and *skills* [22]. 'Knowledge and behaviours can be learnt indirectly by inputting abstract information, while experience and skills must be learned directly by hands-on or empirical actions' [22], [23].

The fast development of emerging technologies as an important communication media has introduced new aspects in education such as: distance-education, virtual learning environment (VLE), remote and virtual laboratories, computer-supported collaborative work, etc. Nowadays, the way we conceptualize how knowledge is acquired and produced has changed significantly. Knowledge is not only dependent on individuals, it is increasingly dependent on social and collaborative actions and sharing (wikis, forum, etc.). A shared knowledge that is the product of a social elaboration is more suitable to be adopted by a collective. There are many efforts in studying collaborative work in education but fewer attempts to formulate a collaborative model for managing a Teaching and Learning Process (TLP).

There are many tools for learning management systems which help students to access and share within a suitable context, educational resources that they need for their educational activities. However administration, documentation, tracking, and reporting of training programs and classrooms' are scanty aspects of an educational environment. Many software systems

have been developed focused on learning activities. We think that systems that focus on the Collaborative Management for the Learning and Teaching Process must be developed. These systems must provide the students or groups of students with tools to control and evaluate the development of their own learning processes. These systems must integrate the knowledge of decision maker with the TLP and the students' skill.

Within any educational system or institution, there are many members (and decision makers): students, teachers, tutors and researchers, involved in a process, due to 'education is a process'. So, TLP's management systems should take into account different views according to their members (and their role) and provide features to observe, explain, intervene, and assess.

In this paper we describe the core of a collaborative management model we have been developing while using during the last four years for managing the learning and teaching process in computer science and maths courses at the Universidad Nacional del Comahue. The model has helped teachers and researchers to understand and to intervene during the process, and enabled researchers to break the problems that arise during the process into discrete, manageable units.

The paper is structured as follows: Section 2 describes the CollMMod-LTP through its main components. Section 3 details how the model has been applied to the computer science field. The main model benefits are included in section 4. Related work is described in section 5. Finally section 6 presents conclusions and opportunities for future work.

2. The Main Components of the CollMMod-LTP Model

The Collaborative Management Model is built with the aim to help different stakeholders (or actors) to understand and collaborate within the frame of a LTP. The goal of the CollMMod-LTP model is to improve the effectiveness of teaching-learning process. The model is based on the following premise/rationale:

1. The best LTP is that in which all the stakeholders collaborate. So, the model involves collecting evidence, from various stakeholders following a set of scheduled activities during the time.
2. Will and skill: Students need to have both the will (motivation) and the skill (capability) to be successful learners [10]. Teachers should pay attention not only on how the concepts are introduced but also how to motivate the student to work with these concepts.
3. The importance of error: It is natural to see skill acquisition as the successive elimination of errors [15], and error rate decreases as a function of amount of practice. So, as part of the process we should follow an itinerary of learning through practice, and to accompany students in detecting (error detection), solving errors (error correction) and unlearning errors ('to avoid repeating an incorrect action requires a change in the knowledge that generated that action' [15]). It is important to understand and document which are the more common errors, how students detect and correct their own errors, etc. This will help to improve the process.
4. The CollMMod-LTP model can be applied in any educational action/project (a single course or a set of courses as well).

Stakeholders. We identify the following stakeholders: (a) teacher: A person who teaches / provides education for students; (b) student: A student is a learner, or someone who attends an educational institution; (c) tutor: A qualified teacher (or student) who is responsible for providing an advice and guidance to students in specific topics; for facilitating students in carrying out tutorials; (d) educational researcher: A person who is researching educational subjects; (e) teachers concerned with the persistence of students during the time through a LTP.

2.1 Activities

This section describes the main activities of the CollMMod-LTP model. Fig. 1 depicts them using UML diagrams whereas Fig. 2 shows the core data produced.

- 1st Activity: Define the TLP goals or competences. Behind any teaching and learning process should be a educational goal or intent, there should be expected competences to obtain in the subjects, there is at least the identification of learning outcomes. These goals or competences are not present in cognitive and non-cognitive context of the students at the beginning of the TLP but are expected to appear/arise during the process and to obtain as an outcome at the end of the process. That is the reason why any process of education has something of virtual (virtual as Lvy [13] considers: not opposite to the real but to the actual). A TLP always has an actualization intent: that TLP goal or competences which is virtual (real in potency) at the beginning of the

process should become actual at the end of the TLP process. This activity is related to the definition of TLP goals or competences.

- 2nd Activity: According to the TLP goals or competences, define a set of TLP variables. Sometimes goals and competence are intangible. Sometimes there are no connection between the content of a course and the way goals and competences will be obtained. Within CollMMod-LTP we should break the TLP goal/competence down into discrete, manageable variables. The variables plays the role of this manageable units from which we will evaluate the TLP goal. The settlement of a set of fundamental variables will help to monitor the TLP process. The variables should be defined as a product of collective construction of different actors, as product of a general consensus. We distinguish two kinds of TLP variables: cognitive and non-cognitive variables. Both are important to contribute to the student's skill and will respectively.
- 3rd Activity: Instrument Application. We consider 'educational instruments' to those devices that help to transform the practice. The TLP, as well as many acts of communications, is mediated by objects (notes, tutorials, slides, exercises, etc.). Instruments can be any good quality task such as activities, exercises, tests, multiple-choice tests, wikis, etc. The design of the educational instrument is crucial, due to the fact the 'tasks' had been identified as a factor that influences student's cognitive engagement and the learning process [3], [10]. It is costly in time and effort to develop an educational instrument, and there is no possibility to run many instruments during a TLP process, so its definition should include a precise intent (usually a subgoal of TLPgoal, see Fig. 2) and it should be carefully designed to fulfill its purpose. The core of the CollMMod-TLP model assume that these instruments are designed, applied and assessed constantly during the process. There exists a micro-cyclical process in this activity. So, the application of the CollMMod-LTP model must contain a set of LTP instruments which will be applied between short period of time within the LTP. The decomposition of a matter in smaller units and the suitable selection of the instrument's content are essential to the model implementation. Students should be motivated to work with the instruments during the time, they should be conscious that educational instruments will help them to be more prepared for tests and to study during the process.

Students should understand that it is impossible to study only the days before the exams, because learning is a process and requires maturation.

Each educational instrument should be assess according to the variables defined in the previous activity. The assessment will use a defined category to rate the instrument performed by the student regarding a variable. The category should be ordinal. All the actors should comprehend its purpose and use it in the same way, in such a way each actor can undertake her/his own lecture of the assessment.

3.1 Subactivity: Define a TLP instrument. When a particular TLP instrument is defined, it should take into account many aspects: (a) when the instrument will be applied within the TLP, (b) how it will be applied within the TLP, (c) a pilot case of the instrument must be run previous to its implementation. It is important that the student should perform a practical work before the instrument is run, but this is not mandatory due to the fact instrument can also be considered as an instance of the first approach to a new introduced concept. Care should be taken not to expose the students prematurely to any concept. Instrument should be perceived as a facilitator and not as an obstacle.

3.2 Subactivity: Assess the implemented instrument and collect the data. When a particular instrument is used in practice, each student should perform the activities defined in the instrument. We call 'instrument instance' to any instrument that was completed by a subject (see Fig. 2). A teacher should assess each instrument instance according to the assessment category previously described. Once the instrument instance is assessed it should be returned and explained to the student. This is the time of error detection and error correction. A devolution of the whole activity should be presented to the group of students, identifying common errors and pattern errors. An error/solution that are socially shared contributes to establish common vocabularies and strategies [9]. The assessment from all instrument instances (instrument-subject pairs) provides the LTP actors of an snapshot of how the instrument's subgoal was conducted. At the same time, the collected data for a particular instrument increases the dataset describing the process, where variables constitute cross-cutting/overlapping indicators between them. The collected data should be available to all the TLP actors through collaborative tools.

3.3 Subactivity: Explanation, Interpretation, Intervention. Probably the worst part of a model's implementation is its maintenance, more in a effort-consuming model like CollMMod-LST, but this model shows many

benefits: from the collected data many explanations of the process can arise, shared view of actors can be supported, difficulties on group of students can be identified, and actions can be undertaken in advance (interventions).

4th Activity: LTP Assessment. This activity involves a deep evaluation of the TLP. After the evaluation is performed, a new TLP could start. The activity involves a macro-cyclical process. As a product of the model application, it is likely that LTP variables or the assessment category for variables need to be re-defined, however, it is important to undertake model redefinitions once a complete process has finished (for instance, once a course -where CollMMod-TLP process is applied- has finished). This activity involves the evaluation of TLP goals defined at the beginning of the process. Do the TLP goals obtained at the end of the TLP had correctly applied?

3. Model Application

In this section we describe a case study we run to validate the model in practice.

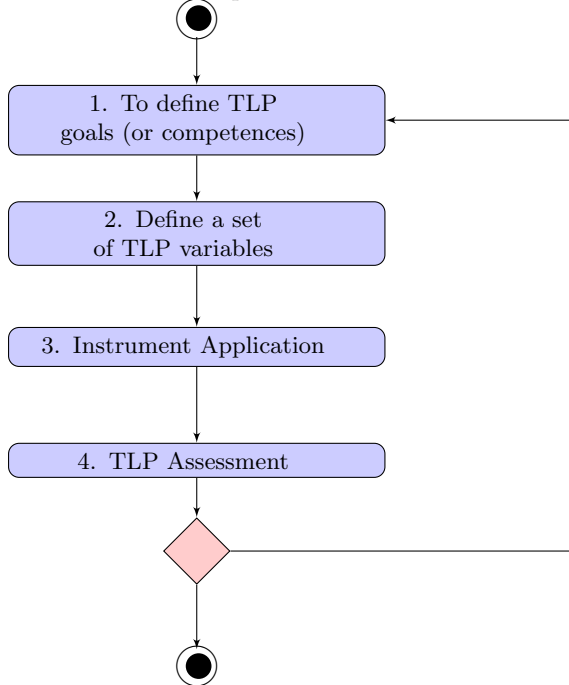


Figure 1. Main Activities of MGC-TLP Model

This model was performed during the last four years in the 'Problem Solving and Algorithms' undergraduate course at the Comahue University. The course is mainly concerned with problem solving using phases, problem representations and strategies; the four-phase

process of problem solving by Polya [16]; the definition and representation of algorithms for class' problem solving using different levels of abstraction and refinement -mainly focusing on semantics rather than sintaxis-, and JAVA implementation. The course is taught in the first semester of the first year for three different study programmes. This course has a high rate of desertion and repeating. Although desertion is close related with lower scored' test, in many cases, students do not profit of all the instances to approve the course. In other cases, some of them desert of the course even when they had not disapproved any tests. We summarize in the following the main components of the CollMMod-LTP model:

Stakeholders. The staff of 'Problem Solving and Algorithm' is composed of one professor, two professor assistants and seven assistants. There are two student tutors, and three teachers working specifically in persistence/retention of students and dealing with individual- or group- problems.

Goal. The goal pursued for applying the CollMMod-LTP is: 'To administrate and manage the LTP in the 'Problem Solving and Algorithm' course, in order to perform suitable interventions and increase the rate of student's persistence.

Variable Selection. At this stage, only cognitive variables were defined in this model application, we plan to include non-cognitive variables as a future work. The variable selection combines topics of the four main stages in problem solving of Polya [16] (understanding the problem, devising a plan, carrying out the plan, looking back) and the proposal of Barnes, Fincher and Thompson [1] which define a Polya-based approach for problem solution (Understanding, Designing, Writing and Reviewing) in a programming context. Table 1 details the six defined variables (named from A to F) which are used to assess all the instrument performed by any student. So, each instrument instance is assessed six times. For each assessment one of three linguistic labels (G, good; G-, not so good; X, bad) is used for each variable.

The application of the CollMMod-TLP during the last four years had evolved till now in which we use one educational instrument each week, during the four weeks before the course test. The same week the course test is evaluated, no educational instrument is used. We motive the student to take part of the instrument.

Assess the implemented instrument and collect the data. During the last four years 9-10 educational instruments (average) were defined for each course. The instrument consists of an exercise which includes a problem description with a set of requests. The activities vary from identification of income and

Table 1. TLP Variables selection for 'Problem Solving and Algorithm'

Variable	Problem Solving	Interpretation
A. Data Identification	Interpretation	The income/outcome data (used to solve a problem) has been identified?
B. Maths Solution	Interpretation	Is the problem solution correct from a mathematical point of view?
C. Variable Manipulation	Design	Are the variables (its declaration, creation, type and operations) accordingly used?
D. Control Structure and Data Dealing	Design	Are the control structures (sequence/alternative/repetitive) correctly used?
E. Programming language Aspects	Implementation	Is the implementation coherent to the design?
F. Testing	Retrospective Vision	Was the retrospective vision correctly applied?

outcomes variables, algorithm design to Java implementation. The population of each course is between 150-250 students in the first semester and 50-100 in the second semester. In average, the instruments were used between 1-2 weeks, so approximately 15000 assessment are performed in the first semester, 6000 in the second one. The collected data, a knowledge database, was available to all the actors through collaborative tools. Teachers are the main actors which profit of the data. Secondly, tutors and teachers working with student's persistence.

Table 2. Spearman Correlation between variables-derived indicators and scored tests

ρ SPEARMAN	Efficiency & Scored Test	Efficacy & Scored Test
1st. Test	0.4896	0.6001
2nd. Test	0.4415	0.3914

LTP Assessment. The main utility of the instrument's assessment was to perform interventions during the process. In 2011, we also performed an empirical study to analyze whether two variable-derived indicators are correlated with scored tests. We defined two variable-derived indicators: (a) efficiency rate = quantity of correct answers/quantity of answered questions; (b) efficacy rate= weighting of variables per exercise / maximum score per exercise. The correlation between each indicator and the scored tests are shown in table 2.

Table 2 shows that there is empirical evidence of a moderate and significant correlation. This empirical evidence can be read in the following way: the

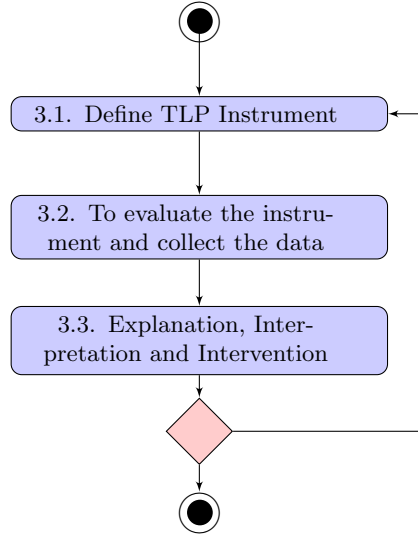


Figure 2. Refinement of the Application of TLP Instrument Activity

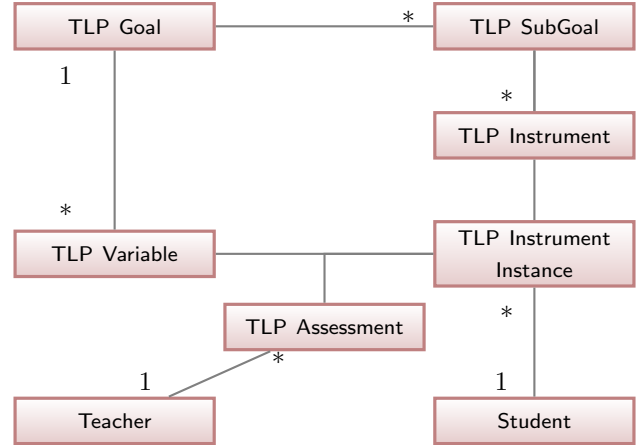


Figure 3. Core Data of CollMMod-TLP Model

greater the indicator value obtained in the instrument's application period, the greater the score test. So, we can conclude that the instrument application period is useful to prepare the student during the LTP for the evaluation period.

4 CollMMod-LST Model's Benefits for LST Actors

The major benefits for LST Actors are:

- For Teachers: CollMMod-LST provides the following advantages: (a) Teachers can improve their practice because they have the possibility to monitor the learning process and intervene on it when

it is necessary; (b) the availability of a collaborative tool to plan the TLP, for obtaining explanations and for assessing the whole process is a suitable way to manage and to document the teacher skills.

- For Students: (a) As Ohlsson recommends 'Learners must be aware of their errors to learn from them' (Ohlsson). So, errors constitute a major source of information for the learner while practicing an unfamiliar task. The instruments which are assessed by teachers allow to students to have a feedback of their errors. (b) Information about the assessment of each variable for each instrument is available for students, in that way the student can realize of his/her progress and achievements, during the time.
- For Tutors: (a) The detection of individual or collective problems of students is one of the major concern of tutor's competence. The availability of the information about the progress of students according to a set of TLP variables could give the tutors a plausible explanation of the problems they detect, (b) Tutorials which tutors bring, can be adapted according to the concepts that students should reinforce.
- For Teachers working with student's persistence: (a) Students having low assessment of instrument instances are potential candidates to participate in workshops carried out by teachers working with persistence, (b) Students that desert prematurely can be detected and invited to a special class, and to have special reinserction, (c) data should be collected, and interviews should be run to detect the main problem of this group of students.
- For Researchers: (a) Researchers and Teachers could share and define complemented TLP goals. Teachers can help researchers to analyze and empirically validate their hypotheses whereas researchers can contribute with teachers in implementing actions according to the more advanced theories, (b) Larger set of data is available for research analysis.

5 Related Work

There are different main strands to our work: models of TLP; explicative models of student's retention at universities, collaborative models. The three kinds of models 'are considered pertinent to the development of' the model presented in this paper.

1. Dix [6] describes different models of TLP: Carroll [4], Proctor [17], Cruickshank [5], Gage and Berliner [8], Huitt [11], Laosa[12]. CollMMod-TLP Instrumentation' Application is related with the Perseverance Time of Carroll model, to promote an environment supported in context and over time, where time student is willing to learn.....; learning outcomes are a result of the interactions of teaching and learning contexts [2].
2. Donoso and Shiefelbein propose in [7] five different categories to classify different student's desertion and retention models where predictor variables are defined. The categories are: psychological, sociological, economic, organizational and interactions-based approaches. Our model can be related with organizational and sociological approaches. In organizational one, desertion is focused on university's characteristics, having special role the quality in teaching and the student's experience in classrooms. The development and frequency of positive interactions between pair (between students and teachers) are important aspects of organizational and sociological approaches. The last two mentioned aspects, which are also relevant in the academic and social system mentioned in Tinto's model [18], [19] are underlying bases of the CollMMod-TLP.
3. Computer-Supported Collaborative work: Waheed et al. [20] distinguish collaborative learning platforms from teacher development collaborative platforms. In their article several Collaborative Web-based Learning System are detailed as the major environment for obtaining a 'maximum learning'. Conley et al. [20] report a research linking 'the development of a collaborative community of educators to enhance teaching and learning effectiveness'.

6. Conclusions

Within an education system, the fact that all the actors be engaged in conducting and managing a TLP process, influence positively student's achievement. Teachers involved with the definition of a TLP-goals, TLP-variables, TLP-instruments and TLP-assessment are better prepared to explain, to intervene the process and to modify their own practice. We are conscious that a student's achievement is the product of many factors (those relating to their academic environment, those relating to the teacher and those relating to the student [14]) and we partially model a narrow aspect of the student's achievement. The monitoring

students' performance frequently is considered as an important aspect of student achievement [14]. We plan to extend the model to include more detailed information and building a fine-grained model. The core of the model consists of: The collective definition of TLC goals or competence, and for each of them the definition of TLC variables, to develop instruments for collecting feedback of the process, to processing the information using the variables according to an agreed category, reporting results for students and doing interventions in practice. In this paper we describe the application of the model in the 'Problem Solving and Algorithm' course. After analyzing the collected data and conducting correlation coefficient between variable-derived indicators (efficiency and efficacy) and scored tests, we obtained a moderate and significant correlation. This shows that an important aspect of student's learning achievement is influenced by the efficiency and efficacy indicators derived from the TLC cognitive variables. Our future work will consist of continue validating the method and the refinement of the method activities (some activities are likely to be refined in new UML activity diagrams).

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