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Flipped classroom for algorithmic teaching based on ontology and bloom's revised taxonomy

Teimzit Amira, Mahnane Lamia, Hafidi Mohamed

LRS Laboratory, University of Annaba, Badji Mokhtar, PO Box 12, Annaba, Algeria

Information

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*Correspondance :

teimzit.amira@gmail.com

Abstract

Today's society requires new skills and competencies, the university has an important role in their acquisition. The educational environment is undergoing profound transformations due to the integration and exploitation of the new Information and Communication Technologies Applied to Education. The use of these technologies in training environments allows new learning approaches to be considered. However, the quality of these approaches depends on their ability to provide learners with pedagogical content adapted to their needs.

This research work concerns the use of ontologies in Computer Environments for Human Learning generally, and in particular the integration of a flipped class learning system in the algorithms teaching to beginners.

The proposed approach consists in implementation of flipped class learning system based on Bloom's revised taxonomy and exploiting an algorithmic. This method allows for the fragmentation of learning sessions into two stages and six phases that improve the transmission of knowledge for better assimilation.

1. Introduction

Nowadays, technology occupies a very large place in the lives of students who already spend a good part of their free time on the Internet to learn or exchange information. This is why higher education institutions can no longer meet the needs of their learners by offering only traditional (lecture) courses in the classroom.

Currently, pedagogical methods are changing and include in their practice e-learning, blended learning and various synchronous, asynchronous or collaborative learning environments that are increasingly becoming an integral part of higher education.

Computer environments for human learning; defined as cooperative learning systems that integrate teachers (or trainers) and learners as actors, and that offer good conditions for interaction through networks between human and

artificial agents, as well as good conditions for access to distributed, human and/or mediated training resources; which are based mainly on computer tools that aim to disseminate knowledge and its acquisition by learners. Thus, the motivation to explain, share and reuse this know (knowledge) is central to the Computer Environment for Human Learning.

In this context, ontologies, which are conceptual systems that allow concepts to be shared and reused through computational semantics, have a key role to play as intelligence amplifiers for knowledge sharing and reuse.

In this work we want to improve algorithmic learning by proposing a system based on the use of ontologies in human learning environments. More specifically, we are attempting through this research to make changes in the teaching method of this module.

Algorithms is a discipline that has long been used naively, as [1] pointed out, without any particular formalism. The algorithm allows the programmer's ideas to be organized and represented with a formalism that can be easily translated into a language that can be understood by the computer. This discipline is often a source of problem for the teacher as well as for the student; the teacher because he must find the appropriate methods to assimilate rather abstract concepts to students who are only in their initiation phase. [2] confirms that the failure or dropout rate for undergraduate introductory programming courses varies between 25 and 80% worldwide.

It is well known that many students find learning algorithms and programming difficult to master [3]. Our university does not give better results, according to the study by [4] which compared the success rate of algorithmic students with other modules taught during the same year. The result obtained showed that a failure rate of 75% in Algorithmic learning was observed over two consecutive years.

Since we assume that a misunderstanding of a basic algorithmic notion or a misinterpretation of it necessarily leads to the realization or design of an erroneous algorithm, trying to mitigate the difficulties encountered by any student in learning the algorithm is our main objective.

We note that all the algorithmic courses, in our university, given in the first year of the L1 MIAS degree are classroom-based. However, in traditional teaching based on lectures in which students must be present and in which the time in class is mainly devoted to the lecture given by the instructor and a short question and answer period, students are required to do the work requested outside the classroom, which, due to poor time management, makes the task difficult to accomplish.

It is for this reason that we have focused on the concept of "Flipped Classroom" as a teaching technique by proposing a flipped model based on Bloom's taxonomy. This Flipped approach integrates a dynamic and engaging face-to-face learning environment and a set of asynchronous online tools that prepare and improve student learning.

The rest of this paper is organized as follows: in section 2, we present a state of the art on related works on the difficulties in algorithmic learning, flipped algorithmic teaching and bloom's taxonomy in flipped classroom. Section 3 is devoted to the presentation of the design and implementation of flipped algorithmic class platform learning. We expose in section 4 the methodology of an experiment. Next, in section 5,

we present the results of an experiment. Finally, we conclude with section 6, which contains the conclusion and the future work.

2. Review of literature

This section we give a review on the difficulties in algorithmic learning, also we presents the flipped classes approach and the importance of using Flipped Classroom for algorithm learning based on Bloom's revised taxonomy.

2.1. Difficulties in Algorithmic learning:

Algorithmic is the science whose object of study is the algorithm. This discipline, at the borderline between mathematics and computer science, is interested in the creation, description and analysis of algorithms.

Knuth (1985) sees algorithmic as the whole computer science.: "For many years I have been convinced that computer science is primarily the study of algorithms. My colleagues don't all agree with me, but it turns out that the source of our disagreement is simply that my definition of algorithms is much broader than theirs : I tend to think of algorithms as encompassing the whole range of concepts dealing with well-defined processes, including the structure of data that is being acted upon as well as the structure of the sequence of operations being performed [...] However, if I had a chance to vote for the name of my own discipline, I would choose to call it Algorithmics." [5]

Learning this discipline is considered as an immense challenge for the majority of undergraduate learners. This difficulty has been studied in many research papers , such as [6], [7], and they showed high dropout rate of first year computer science learners.

Algorithmic thinking is a special problem solving competence, which consists of several abilities, see [8]:

- Analyze given problems
- Specify problems precisely
- Find the basic actions that are adequate to given problems
- Construct correct algorithms to given problems using the basic actions
- Think about all possible special and normal cases of a problem
- Evaluate algorithms (correctness, efficiency, termination)
- Improve the efficiency of algorithms

Futschek and Moschitz have been working on activities where learners can play algorithms, either virtually or by themselves [9] or with

tangible objects [10] Their work focuses on the fact that the concepts of algorithmic thinking must be reduced to natural thinking for beginners. Moreover, that especially for beginners the complexity should be reduced to that level where the concepts of algorithmic thinking can be learned in a natural way [11].

This problem of algorithmic failure is not only a problem for our institution. Several studies on algorithmic learning conducted by different institutions in other countries [12], [13] have converged towards the same conclusion that algorithmic learning is still a source of difficulty not only for students but also for teachers.

These results and our own experience as a student at this university have led us to focus on "how to improve the quality of learners' understanding of algorithmic in our university?" and "What learning strategies should we use to facilitate the understanding of basic concepts and how?"

2.2. Flipped classroom teaching:

In the Flipped Learning model, teachers transfer direct learning from the large group learning space to the individual learning space, using one or more technologies. Teachers record and narrate screencasts of the work they do on their computers, create videos of themselves teaching, or select video lessons from websites such as TED-Ed and Khan Academy. Many educators are beginning to improve their classrooms using this readily available material. Students can access the videos or screencasts whenever and wherever they want (at home, in study hall, on the bus, even in the hospital), as many times as they want, allowing them to come to class better prepared [14].

The "flipped classroom" is a pedagogical approach that reverses the nature of learning activities in the classroom and at home, resulting in a shift in traditional learning roles, a strategic direction that helps higher education meet the expectations of today's students while optimizing instruction and classroom resources. [15]

Lebrun and Lecoq in [16] described the flipped classroom as:

- ✓ A means of increasing personalized interaction and contact between students and teacher.
- ✓ An environment in which the actors change roles: students take responsibility for their own learning under the guidance of the instructor who is no longer the master on the stage "wise on the stage" but the attentive guide on the side.

- ✓ A fertile mix of direct "I teach" transmission with a constructivist or socio-constructivist approach to learning (it is the learners who learn).
- ✓ A class in which students who are absent due to illness or extracurricular activities are not left "behind".
- ✓ A classroom where the content being worked on (the "subject matter") is permanently accessible for review, testing, remediation.
- ✓ A place where students can receive personalized support.

In the vast majority of this research, regardless of discipline and academic or school cycle, a positive impact on academic performance is reported in terms of higher average scores on assessments when the flipped classroom is used ([17]; [18]; [19]; [20]; [21]; [22]; [23]; [24]; [25]; [26]; [27]; [28]; [28]; [30]; [31]; [32]. [33];). It seemed appropriate to point out that in several other articles as recorded ([17]; [18]; [23]; [27]), no statistically significant positive impact on outcomes was recorded. Nevertheless, none of these articles showed a negative impact on academic performance following the implementation of the flipped classroom.

2.3. Flipped Classroom for algorithm learning based on Bloom's revised taxonomy:

In a flipped classroom, what the learner receives at the beginning of the "lesson" is a mass of information organized in the form of a video capsule most commonly used, but it may be other media or an explanation of a notion related to understanding the lesson.

Thus, the complex is approached first in order to analyze it, understand it and then bring production tasks during peer-to-peer classroom activities with a teacher who becomes a guide and accompanist.

By integrating the revised bloom taxonomy into reverse classroom learning, learners will achieve the lower levels of cognitive work (remembering and understanding) outside the classroom to focus on the higher stages of cognitive work (application, analysis, evaluation and creation) during classroom sessions, where there is an atmosphere of competition between their peers and encouragement from their instructor [34].

Table 1: Description of the Bloom's taxonomy steps

Step	Description
Remembering	In this stage, the learners try to recognize and recall the information they receive; they also try to understand the basic

	concepts and principles of the content they have learned.
Understanding	The learners try to demonstrate their understanding, interpret the information and summarize what they have learned.
Applying	The learners practice what they have learned or apply knowledge to the actual situation.
Analyzing	The learners use their critical thinking in solving the problem, debate with friends, compare the answer with peers, and produce a summary. The learners obtain new knowledge and ideas after implementing critical thinking or debate in-group activities. In this level of learning, the learners also produce creative thinking.
Evaluating	Assessment or established peer-review knowledge, judge in relational terms; in this stage, learners are evaluating the whole learning concepts and they could evaluate or make judgment on how far they succeed in learning.
Creating	The learners are able to design, construct and produce something new from what they have learned.

Bloom's Taxonomy classifies diverse domains of learning, from the basic recalling of facts to applying knowledge which generates something new. [35] Every domain has different levels, below is the revised version of Bloom's taxonomy for cognitive learning [36].

2.4. Algorithmic domain Model

Nowadays, there are many suggestions for ontology-based e-learning, or ontology-based instructional design. Here are some examples [37] [38]. From a pedagogical point of view, when a learner understands new concepts, it is important to integrate them as knowledge. Ontologies can make a significant contribution in this respect [39].

Many solutions and researches focus on the use of ontology in modeling personalization and automation of the e-learning environment, including: modeling the learner's profile, assessing behavior, describing knowledge about learning styles, and other issues arising in the context of personalizing e-learning [40].

The domain ontology expresses domain-specific conceptualizations and is intended for several applications in the domain. It provides concepts and relations to cover the vocabularies, activities and theories of these domains.

Today, ontologies are widely used in the field of artificial intelligence, because the use of ontologies offers several advantages: interoperability between systems, data sharing, reuse of domain knowledge, etc. It is this type of ontology that will be useful for defining the targeted objectives of our project.

3. Flipped algorithmic class learning platform

Our hypothesis is that *"the flipped classroom is an effective way to teach algorithmic"*, compared to the traditional model. Given the nature of the module, that requires the acquisition of knowledge and skills, the materials covered in the algorithm courses are dense and for many learners difficult to understand at the rate at which teachers present them. Therefore, from time to time, the learner must stop and think for himself to catch up, but on a traditional conference, such a break is impossible because his need varies from one individual to another. In addition, the content is sequential and closely linked to each other, so if the learner's attention is lost for a while, he or she may not understand most of the course content and waste time attending the conference. Also requires a lot of practice, the latter, it is not well taken care of in traditional teaching as already explained.

The first two problems are solved by video conferences, which are assigned to learners in the reverse class model. The learner can watch the video at a speed that suits him/her, pause it when he/she needs to think about a concept or rewind it if he/she has missed anything.

The solution to the third problem lies in the "in-class" part of the reverse class model, where the learner finds himself in a situation of practice with the teacher and other learners in order to solve a given learning situation (exercise, case study, PBL...).

The present study aims to extend our collective understanding of flipped classroom in three ways:

- First, we tested the possibility to integrate ontology in the representation of algorithmic domain model.
- Second, we tested the feasibility of using an instructional design theory- theory of Bloom's revised taxonomy- to implement flipped classroom.
- Third, we designed and offered flipped classroom for underperforming learners and high ability learners based on learner's learning style and learner's skill level.

- Finally, we compared the effectiveness and learner perceptions in flipped classroom and traditional class.

3.1. Algorithmic Domain Model

Domain module is represented with domain ontology and resource ontology, domain ontology of algorithmic designed in [41] it consists of a set of concepts and relationship between these representative the field of algorithmic concepts, these hierarchies have been represented as follows:

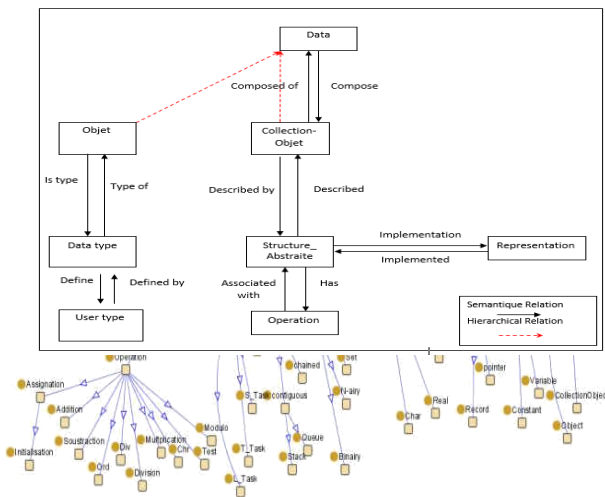


Fig. 1. Binaire relation diagramme of domaine ontology

The codification of our ontology was done using the Protégé 2000 ontology editor of Stamford University.

Fig. 2. Domain ontology

When the teacher integrates the lesson on the system, he must define tags for it, it is the last ones are externalized from the domain ontology. from these tags the system will present a semantic menu to the learner according to the relationships existing in the ontology, this menu will help the learner to see the relationship of the lesson read at this time with the other lessons already read or planned in the next sessions.

3.2. Bloom's taxonomy in flipped classroom of algorithmic:

In 1948, Bloom led a group of educators who set out to classify educational objectives; with the goal of implementing a method of classifying the thinking behaviors necessary for the learning process. This later became a taxonomy that covered three domains: the cognitive domain, the affective domain and the psychomotor domain. In

1956, a manual commonly called "Bloom's Taxonomy" was published.

In 1990, Lorin Anderson, a former student of Bloom's, again convened an assembly to update the taxonomy to make it more relevant to 21st century learners and teachers. The work was difficult, taking six years to finalize, and it was not until 2001 that a new version was published that included minor but important changes. The changes were in three main categories: terminology, structure and orientation. The terminology changes between the two versions appear to be the most visible and confusing differences. [42]

In an effort to improve algorithmic learning, we focused on the concept of the "flipped classroom" as a teaching technique by proposing a flipped model based on Bloom's taxonomy that is deployed in two stages:

- The first stage, called "Out class", provides students with a set of relevant instructional content on algorithms in the first two phases of the taxonomy, which are information retrieval and understanding. This content is in the form of video tapes that review the main points that will be covered in the second stage.

- The second stage called "In Class" consists of applying, analyzing, evaluating and creating an algorithm. In other words, students come to class with what they have learned in the first stage to discuss their learning with their teachers and peers, and to complete the planned activities individually or in groups.

Figure 3 below illustrates the levels of Bloom's revised taxonomy based on the flipped classroom approach.

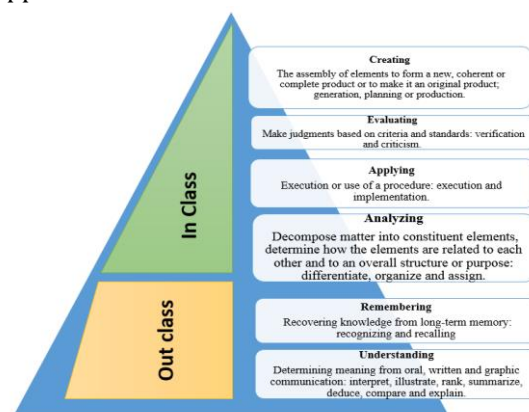


Fig.3. The levels Bloom's revised taxonomy according to the flipped classroom approach.

4. Experimentation

According to our hypothesis that the reverse class will be of great help in learning the algorithmic and will improve the quality of learning and its results, and always based on the fact that the basic concepts are the most important in this module.

We tested this learning approach on students to see the impact of integrating such a method into our academic environment compared to the traditional method.

4.1. Instruments

There were three instruments used in this study presented in the following table.

Table 2. Instruments used in the study

Instrument	Roles of teacher	Analyse
Pre-test and Post-test	- Create a 10-question test to be used as a pre-test and post-test assessment. (The tests included eight multiple choice and two open-ended questions from the content of their lessons.) Mappe each question with lesson objectives to ensure assessment consistency. (The same 10 questions were also used for the post-test implemented at the end of the experiment.)	The reliability analysis showed that the pre-test/post-test created and used in this study was found reliable (10 items; from $\alpha = .71$ to $\alpha = .82$). Even though no long term validity test applied to this instrument due to the time constraint, internal consistency scores showed positive results (10 items; from $\alpha = .69$ to $\alpha = .79$)
Creating Lesson Videos	- Create their lesson plans. Create content videos with different approaches depending on the lesson content.	
learner Survey	- Prepare an 8-questions survey to collect data regarding	- The reliability analysis showed that the learner survey created

	the experiences of the learners. The survey was prepared only for the group of learners that were taught in the flipped model. Create online survey using the Survey Monkey online survey service.	and used in this study was found reliable (8 items; $\alpha = .74$).
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4.2. Progress of the experiment

we conducted an 8-day study on a population of 50 first-year undergraduate students, for the algorithmics course, the experimental group of 26 students took a flipped classroom course and the other control group of 24 students took a traditional course.

Both groups took a pre-test before starting the experiment to find out their initial level and a post-test at the end to assess their level of mastery of the new material.

We also used an online form to collect the opinions of the learners in the flipped classroom. Each of these steps will be described in detail in the following paragraphs.

5. Results

5.1. Pre-test

Firstly, all learners were divided into two groups according to their scores of prior knowledge assessment. Before one-way ANOVA, the homogeneity of variance assumption ($F=0.516$, $p=0.476 > 0.05$) was tested. The result indicated that the homogeneity assumption was not violated. The results of the one-way ANOVA are presented in Table 3.

Table 3. Basic statistics for the two groups in pre-test

	Control			Experimental			P-value/F-test
	N	M	SD	N	M	SD	
Pre test	24	52.19	14.7	26	48.61	19.91	0.476/0.516

5.2. Post-test

Table 4 shows that the experimental group has significant impact on the post-test scores of the assessment ($F=8.562$, $p=0.005 < 0.05$), meaning that in the experimental group, learner level of prior knowledge has a significant impact on their learning effectiveness. Furthermore, the

experimental groups have significantly better learning effectiveness than control groups.

Table 4. Basic statistics for the two groups in post-test

	Control			Experimental			P-value/F-test
	N	M	SD	N	M	SD	
Post-test	24	58,9	17	26	73,56	18,46	0.005/8.562

5.3. Survey to learners and Evaluation

In this section, we will present the survey in which learners specifically evaluate the flipped classroom approach. Table 5 shows the questionnaire results of this study. Overall, most of the learners (87.5%) found that flipped classroom was more engaging than traditional classroom, and preferred learning at their own pace. In addition, many learners (70.8%) liked watching instructional videos, and recognized that flipped classroom provided more chances for peer communication. The follow table present the 10 questions of the form:

Table 5: 10 questions of the experimental group Suestionaire

Nbr	Statements
1	The flipped classroom is more engaging than traditional classroom instruction
2	I like watching the lessons on video
3	I prefer a video-recording of the lesson to a traditional teacher-led lesson
4	I like to self-pace myself through the course
5	I like taking my quizzes online by using online learning platform
6	The flipped classroom gives me more chances to communicate with other learners.
7	I am more motivated to learn in the Flipped Classroom
8	The flipped classroom has improved my learning of algorithmic
9	I liked the navigation between tags in the lesson
10	The tags helped me to understand the relationship between the notions of the course

This figure show the results of learner evaluations of the flipped classroom experience

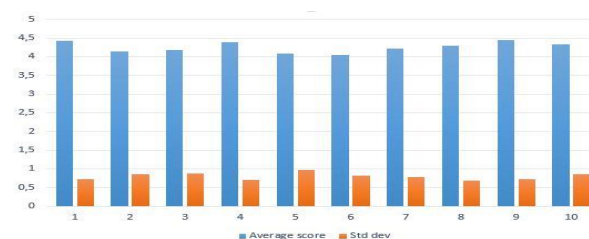


Fig. 4. Results of learner evaluations of the flipped classroom experience

Learners' answers to the open-ended questions of the questionnaire and interviews were analyzed by theme and organized into several categories.

Firstly, learners mentioned the benefits of the flipped classroom, such as the ability to learn at their own pace and autonomy in learning: "Learners are free to choose whether or not they want to watch the videos for review" (learner 10), "We can decide on our own learning progress" (learner 9). In the same way, learners' perceptions of the flipped classroom were mostly positive. Some learners even asked the teacher to provide them with more examples and exercises, as well as to extend the duration of the lessons: "It would be better to give more examples and advanced application problems" (learner 15), "We can stay even after 6pm (end of lesson)" (learner 20).

Secondly, the majority of learners reported that the classroom discussion made it easier for them to learn. They also enjoyed communicating with their peers in their learning. For example, "learners mainly discussed the solution in class, which facilitated our communication and learning" (learner 18).

Thirdly, although many learners liked the fact that they could receive more help from the teacher during school hours, a number of them indicated that they could not get immediate help for their out-of-class learning. Some learners asked for a place to ask the teacher questions: "We cannot get instant feedback when we have problems at home" (learner 17); "You can provide a place where learners can ask questions during the out-of-class session" (learner 12).

Finally, a lot of learners have shown that navigation by semantic tags has helped them to better understand the relationship between several notions, which before could not assimilate them. "I didn't know that the notions of the course were related to each other and that even if we learned them in separate lessons" (Learner 6); "the tags helped me to link the lessons I was reading with the one I had already acquired and animated my curiosity to wait for the one I didn't know yet" (Lerner 1).

6. Conclusion and future works

Our work focuses on the teaching of algorithms which, since its inception, has been a difficult subject for the teacher to teach and complex for the learner to assimilate. This is due to the intrinsic characteristics of the subject and the way in which teachers (the majority) understand its foundations. These difficulties make it very difficult to design a serious game for the algorithmic.

The development of a Computer environments for human learning based on the modeling domain model using ontologies to ensure functionalities related to competency management, pedagogical resource management and training quality management using the reverse class approach.

It incorporates multimedia pedagogical processes and monitors learners' activities. The aim is to allow the learner to consult the pedagogical contents online, carry out exercises, transmit assignments to his teacher and also allow communication between the learner and the teacher can be individual or in a group.

The difference compared to traditional teaching comes from the fact that knowledge is not transmitted by a teacher but is individually appropriate by the students.

It also changes the roles of teachers. They advise and support students and support learning processes. They ensure that students do not leave a topic with misconceptions. They ask open-ended questions rather than passing on knowledge.

All the more so since the integration of learning situations by class allows the development of desirable skills and attributes in learners.

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