The optimization by ant algorithm for a project-based learning

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Abstract: - The research and development of ICT plays an effective role in distance learning. Several electronic platforms have been created, and have to confront various pedagogic currents including teaching by project. the Project-based teaching is a pedagogical approach that puts the learner at the center of all learning, and develops their skills and knowledge.
During the project, students are required to make decisions regarding the solutions of the posed problems.These decisions generates conflicts between students due to heterogeneity in the group and a level difference between the learners' profiles.
To overcome this problem, this paper develops a new approach based on the ant algorithm, for adapting the learning path to different learner profiles. The basic idea is to associate the adequate learning activities at the level of homogeneity and at the cognitive level of learners.

Key-Words: -the project-based learning, adaptation, heterogeneity, cognitive degree, ant colony optimisation

1 Introduction

As With technology development, new forms of group work have emerged, particularly in the field of distance education (e-learning).

The e-Learning has experienced many changes, a

Most learning platforms are more interested in the management of the educational content rather than the distance learning process.

This problem is increased in the social constructivist theory, which advocated the teamwork, and knowledge sharing.

Among the socio-constructivist streams, is cited the pedagogy by project [1]. The Project-based learning is characterized by a collaborative learning, a social character, which promotes the negotiation, the sharing of knowledge, the criticism of others, and the decision-making in groups.

However, the steps and activities of the learning project [2], are defined sequentially manner, which makes the predefined learning path.

Furthermore, the level of skill and knowledge varies from one learner to another, generating a heterogeneous group of learners during a collaborative activity and can doom the project to failure.

In a collaborative activity, learners are required to take decisions to solve a given problem [15]. The group decision making is measured by the degree of heterogeneity of the group[3].

The tutor intervenes to overcome this problem of heterogeneity in a situation of decision making by measuring a cognitive divergence indicator of the group of learners [16].

the cognitive divergence indicator [17] measures the degree of understanding of the assessment criteria used in the decision making.

Each member of the group of learners draws a cognitive map of the evaluation criteria, and the tutor measures the degree of divergence for each criterion.

When an evaluation criterion has a degree of divergence, the tutor intervenes to provide documentation in order to assimilate the evaluation criteria, or propose adequate evaluation criteria to cognitive levels of learners.

However, this task is difficult in the case of a position of decision making with multiple criteria and a large number of learners. In this context, the meta heuristic may be most appropriate for the adaptation approach.

The adapatation approaches of learning paths , lends itself to the use of meta heuristics such as the case of optimization by ant algorithms[4]. The ant colony optimization is an effective technique in the field of combinatorial optimization. The ant colony algorithm is a method that processes uncertainty of a problem and built a path with a maximum adaptation.

This technique allows learners to find the learning content that best fits the characteristics and personal goals of the learners.

In this paper, we propose a method based on optimization by ant colonies to provide a personalized learning path in a context of educational project for learning groups.

This article is structured as follows:

In the first section we will approach a state of the art of the approach of project-based teaching. Later in the second section, we will study the optimization by ant algorithm.

Then we will define the third section a dynamic learning project adapted for groups, and describe the application of ant algorithm in this context in the fourth section.

In the fifth section, we will implement our proposal to choose the optimal learning path in a project-based teaching.

The last section will highlight the work in progress, and our main perspectives.

2 The project-based learning

The project-based learning is a learning approach that presents some aspects of sustainable learning skills for learners, such as teamwork, communication, critical thinking, and decision making [5].

This method of learning develops the disciplinary and transversal skills of learners. The skills are individual and collaborative.

The project gives learners the opportunity to work in groups for a period of time, the opposite of individual teaching.

the group project exposes learners to other views, and confronts ideas that can accomplish their tasks properly.

The project group provides the opportunity to exhibit interpersonal skills and group work skills such as planning and time management. These highly prized skills in the workplace.

The project consists of a set of steps, and each step presents an ordered set of individual and collaborative learning activities [6].

the individual activities are performed by a learner who is subject to an evaluation by quiz or by an exercise, while the collaborative activities require the support of all members of the group and are subject to evaluation [7]. Indeed, all groups of learners face similar collaborative activities, and study the same educational content.

However, each group member has different skills and knowledge of its peers, which can generate motivation. A lack of motivation is an abundant factor in an educational project [14].

Therefore, the tutor must intervene to redirect the group to collaborative activities, appropriate to cognitive levels of the participants. Accordingly, the adaptation of the educational project becomes essential in a learning process to meet the learners' requirements.

Our approach is to model the educational project adapted to the levels of members of the group of learners to facilitate the project-based learning.

The path adapted to a project allows time savings, reduces isolation of learners, and fights abandonment.Thus, the groups of learners are dynamically oriented towards activities which are not necessarily consecutive.

The project is modelled as a directed graph where each node presents a learning activity. Each activity contains the tasks to be made by the group of learners and the educational objects to be manipulate. The educational objects contain concepts, objects, image, and audio.

The nodes in the graph are connected by a dependency relationship, such that each activity is a prerequisite for the next activity. At the end of each activity, learners have to solve the problem by choosing a solution among the alternatives proposed by the tutor.

3 The decision making in a project-based learning

In a pedagogical project, the process of decision making [28] is a fundamental process [27] in a learner path. Decision making in a group, is made by means of consensus, vote, compromise, geometric mean.

The AHP method [19] is a method that treats the collective decision-making. The AHP method provides a mechanism for expressing the preferences and goals of the participants, and to generate a solution that takes into account individual participant evaluations.

This method develops communication and understanding between decision makers, which opens the way for convergence of preferences, and builds a consensus so that a solution of minimal conflict is generated [20].

In a project, the collaborative decision-making between learners [7], involves a set of alternative solutions, a set of evaluation criteria, and a group of learners makers.

In theory, solving the multi criteria decision-making MCDA [21], is based on the aggregation of individual solutions by assigning different weights to the evaluation criteria.

Each learner solves the problem of decision individually to get a set of individual solutions, and in the second stage the individual solutions are aggregated using the rules of collective choice, or an algorithm to obtain a group solution.

In the case of educational project, learners are confronted to problem solving, so they gives their opinions, discusses and criticize their peers.

Alternatives are assigned values by the members individually, and in groups.

At start of project, learners are organized to discuss the conception of the project. Then they make the choice of material, the E-learning platform, and documents to be consulted.

The learning scenario is proposed by the tutor, which assigns educational activities (courses, exercise, quiz, etc ...) in order to solve the problems of the project.

Learners collaborate and decide on the delegation and orientation of activities, and the choice of appropriate solutions.

Each group decides on the strategy for performing the necessary tasks of the project, either individually or collaboratively. In our context, we will study the decision of the group, to choose the optimized solution to a problem.

In all stages, the tutor provides the group a set of tasks to execute. Learners carry out assigned tasks, according to an advance planning. Then the tutor performs an evaluation the group's work.

The tutor provides a set of solutions, and learners give preference values for each solution. The AHP process [19], allows aggregating the priorities of solutions to provide a collaborative solution of the group. This collaborative decision is only efficient if the group find a consensus among its members.

3.1 The heterogeneity degree

The Consensus or homogeneity [3] [22] is an opinion or position achieved by a group of individuals acting as a whole, generally considered an agreement. On the other hand, dissent is the opposite of consensus.

In a consensus, individuals who want to react by actions want to hear the opponent views, and not impose a decision, and follow conversations that will benefit everyone.

Indicators [23] play a key role in any learning process, including in an e-learning system. The calculation of indicators allows measuring the success of the educational project, by comparing the reached values with those listed at the beginning of the project.

In our case study, we measure the homogeneity indicator [7] [10] within a project group during a decision-making. The decision-making of a group of learners used to find an optimized solution. The measurement of the indicator is based on the information theory [24], and known as the Shannon entropy.

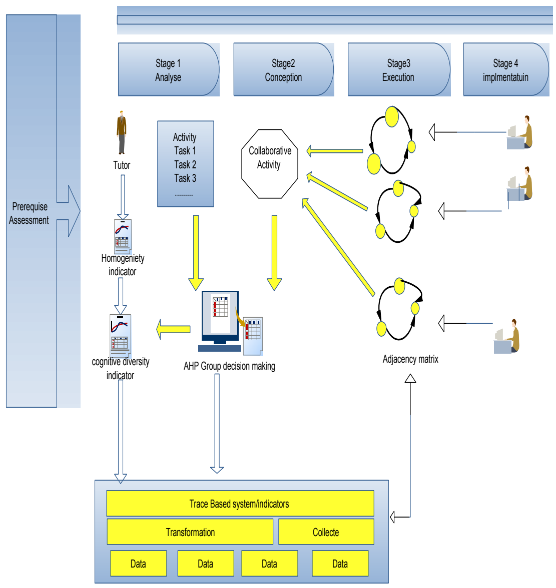

Fig. 1 the indicators measured in project-based learni

3.2 The cognitive divergence

At each decision situation on a project, the students have to understand the problem before making a decision. The understanding of the study field depends on the cognitive level of each group member [25] [26].

The indicators [23] play a major role in an educational project. The calculation of indicators allows having a view of the progress of the learner pedagogical scenario, by making a comparison between the values reached and the values fixed as a goal early in the project.

In our case, we chose to measure the cognitive differences of learners during a decision-making in an educational project [22].

The Shannon entropy [24] quantifies the distribution of the differences between values in a community. In the discipline of biology [26], the entropy of Shannon concerns the identity of species in a sample of a community of many species.

In a collective decision, learners must assign weights to the evaluation criteria, which constitute an input for the AHP method [19]. Our approach consists of asking learners to build individual cognitive maps. The cognitive map is composed of domain concepts which are the subject of the study. The tutor proposes a list of concepts (evaluation criteria) to learners, and asks them to draw arcs of influence. The values of influence arcs are selected on a Likert scale [25].

4 The learning scenario in a project-based learning

During a static educational project, activity (i, j) of the phase i is the prerequisite for activity (i, j + 1) of the i phase.

So a group of learners passes from phase 1 to phase 2, after completing all the activities of Phase 1 (Fig.1).

Also a group can not take new steps without executing all activities successfully. The success of an activity depends on the group decision of the solution the problem posed.

Thus, the group of learners is subject to all the project's collaborative activities even if his cognitive level allows crossing certain activities.

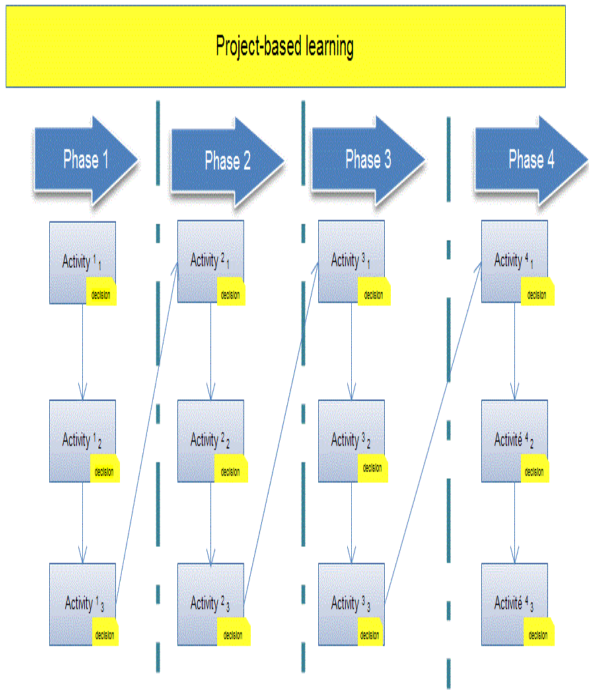

Fig.1 the learning paths in an educational project

In order to ensure that the group carries out activities appropriate to the level of knowledge and competence of learners, we propose a dynamic educational project.

This flexibility allows learners a redirection towards activities, based on the score of tests after the end of each activity. According to the value of the test, the tutor proposes the learner adequate activity.

In case of the test score is higher than the threshold required for the next activity, the tutor proposes an activity with a threshold that meets the needs of learners (Fig.2).

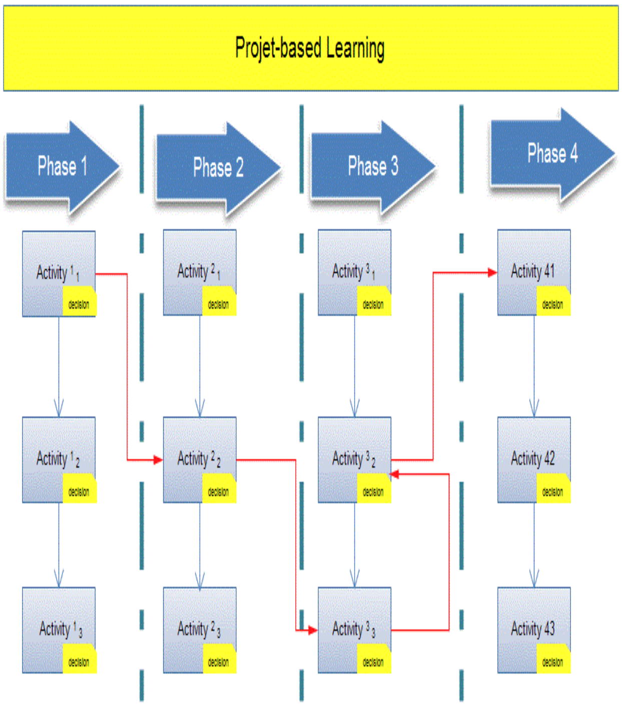

Fig.2 the learning paths in an dynamic educational project

At the end of each activity, the group has to take a decision to choose the appropriate solution to the problem addressed. Depending on the solution chosen, the tutor assigns a score to the group.

When the group of learners has achieved a higher score to the pre threshold required of all the current stage activities, the tutor suggests starting the activities of the next phase of the project, and so on up to the next step.

This work is tedious for the tutor within the framework of a large project with multiple activities, and in the presence of a large number of learners.

Therefore, we will model the pedagogical project as a graph. The nodes of the graph constitute the collaborative learning activities, and the links between nodes present the relationships among those activities.

The implementation of the ACO algorithm proves to be an appropriate way to adapt the learning scenario in an educational project.

4 The ant algorithm

The students express the need for an interactive system that meets their needs in terms of adapted content, the evaluation of learner's knowledge, and feedback on the cognitive level required for the educational content.

During the pedagogical scenariothe learners realize the activities proposed by the tutor in order to achieve the project objectives.

However, each group of learners can lead a different educational path to reach the same educational objective successfully, by carrying out the adequate activities with to the level of members.

learners are able to collaboratively find the most relevant educational paths for effective learning.

Thus, our approach is to use ant colonies [29] to determine the optimal learning path for learning groups [8].

The ant colonies algorithm [9] is based on the collaborative work of ants. Ants live in a nest, and have to find a source of food to bring provisions to the nest.Thus the purpose is to determine the optimized path by depositing pheromones on crossed paths.

The ants deposit the same amount of pheromones on their paths to mark the best path to be taken by the other members of the colony. Thus, the optimized path will receive more pheromone per unit.

In addition, the amount of pheromone on each path will decrease due to evaporation phenomenon. the paths with a low amount of pheromones will disappear favoring paths with high amount of pheromones.

The ants build a solution by computing the probability of selecting a node among others, subject to no longer go to a previously visited node.

The choice of transition from a node i to node j is randomly according to a probability calculated by the equation:

$$p_{i,j}^{k} = \frac{(\tau_{i,j})^{\alpha}(\eta_{i,j})^{\beta}}{\sum_{l \in J_k} (\tau_{i,l})^{\alpha}(\eta_{i,l})^{\beta}} \quad (1)$$

η: Local heuristic information such as distance, time, cost.

τ : Pheromone quantity deposed in the arc.

α, β: Fixed factors regulating.

After a full turn, ants release an amount of pheromones which updates the path traversed according to the formula:

$$\tau_{i,j}(t+1) = (1-\rho)\tau_{i,j}(t) + \sum_{k=1}^{m} \Delta\tau_{i,j}^{k}(t) \quad (2)$$

m: Number of ants who crossed the arc between the nodes i and j.

$0 \langle \rho \langle 1$: Evaporation factor.

$\tau_{i,j}(t+1)$: Quantity of pheromones linking the arc between the nodes i and j at the instance t+1.

At the end of each turn, the amount of deposited pheromones on the arcs is updated by the formula (1).

The amount of pheromone in the path will decrease by the evaporation factor, which eliminates the non-optimal paths.

The evaporation phenomenon is described by equation (3):

$$\forall \tau_i(t) \leftarrow (1-\rho)\times\tau_i(t) \quad (3)$$

Next, each ant retraces the path followed, and deposits an amount of pheromone on each crossing connection. The update of pheromone is defined by:

$$\tau_{i,j}(t) \leftarrow \tau_{i,j}(t) + \sum_{k=1}^{m} \Delta\tau_{i,j}^{k}(t) \quad (4)$$

When the amount of pheromone is updated, the number of ants crossing the arc between node i and j, reflects the amount of pheromone deposited on a path between two nodes, therefore the importance of a path relative to others.

In conclusion, the best path contains the highest amount of pheromones deposited by ants. the edges of the path composing the path form the entire path [10].

5 The ant algorithm approach for a project-based learning

The pedagogical project is modeled by a graph (Fig.2). The node A_i^m of the graph presents the learning activity at the stage m, and the link $L_{i,j}^m$ presents a shifting of the learners between the activities i and j in the same stage m.

The graph consists of m steps, and each stage includes a set of activities. Each activity has a weight assigned by the tutor who relates the importance of the activity compared to other activities.

The activity performed by the student consists of reading a text, perform an exercise, visualizing a demo, read a document, explain a concept, and studying a theory, etc [11].

At the end of each activity, the group of learners is subject to an assessment, and must take a collective decision. The solution is associated with a score that reflects the level of the group of learners.

Comparing the score of the group to the pre required threshold of the other activities, the system offers an adequate activity to the learner, unlike the traditional system that provides the following activity in order.

When the learner threshold's exceeds all thresholds of the activities of the current step, the group moves to the next step. This mechanism reflects our approach of adapting the educational project.

In a dynamic pedagogical project, the student passes from one activity to another based on their test score at the end of each activity by comparing it with the threshold of the next activity, and so on up the end of step.

This approach consumes in terms of time and complexity, and do not allow to encourage the activities which record the learner's success record values, and avoid activities or learners failed.

To this end, we propose the use of ant algorithms for having the most optimal path of learning. The students take a variety of learning paths based on the results of the learning activities in each project stage.

Thus, we can predict the results of learners in terms of paths followed by learners during the learning scenario. The ant colony optimization seems appropriate to address this issue.

The amount of pheromone on each edge depends on the number activities performed successfully. The amount increases if successful, and decreases in case of failures.

Therefore, the amount of pheromone in the arc $(A_i^m \rightarrow A_j^m)$ depends on two factors: the number of learners who successfully completed the activity A_i^m, and achieved the threshold prerequisites of the activity A_j^m in the same step m.

The arcs interpret navigation of the learners between different learning activities. The graph consists of n activities, and each activity is associated with a step of the project.

The selection procedure will allow selecting a path based on the high value of the fitness function of the arc.

The fitness function is defined by :

$$f(A_i^m, A_j^m) = (\frac{H+D}{2}) \bullet (W+S+F)(i,j) \quad (5)$$

H : Heterogeneity degree of a learner's group performing the activity A_i^m [16].

D: cognitive Divergence degree of learner's group performing the activity A_i^m [17].

S : Number of students who success in the activity A_i^m and the score is higher than the threshold of the activity A_j^m in the step m.

F: Number of learners who failed in the activity A_i^m, or the score is less than the threshold of the activity in the step m.

The tutor assigns to each arc linking the activity A_i^m to A_j^m, a weight to express the degree of importance.

This function measure the fitness value of the arc (A_i^m, A_j^m) linking the node A_i^m to the node A_j^m.

The arc is selected in function of the weight assigned by the tutor, the value of success, the heterogeneity of values [16] and cognitive divergence [17] the group of learners.

The heterogeneity of the group is an indicator calculated from the decision of the members of the group.

Thus the probability of selection is given by The Following formula:

$$p(A_i^m, A_j^m) = \frac{f(A_i^m, A_j^m)}{\sum_{l \in E} f(A_i^m, A_l^m)} \quad (6)$$

As a result, the probability of choosing an arc is strictly proportional to its fitness value.

we propose an ant algorithm applied to an educational project translated as follows:

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Step 1 : [initialisation]

Enrolment of m learners in the E-learning platform

Choice of project

Assignment of learners to projects

Step 2 : Building of optimal learning path in a project

start of the project

For e=1 to m steps

For i=1 to n activities

For k=1 to e learners

Perform the activiy i

Take the test (quizzes, question / answers, etc ...)

If ((value_test=value_success) and (value_test>treshhold_of_next_activity))

Then

Calculate the probability of moving to activity j int the step p by the selection formula:

$$p(A_i^p, A_j^p) = \frac{f(A_i^p, A_j^p)}{\sum_{l \in E} f(A_i^p, A_l^p)}$$

end if

Loop

Updating the path linking the activity I and activity j i in step e by the formula:

$$\tau_{i,j}^p(t+1) = \rho\tau_{i,j}^p(t) + \sum_{k=1}^{m} \Delta\tau_{i,j}^{k,p}(t)$$

Loop

Choosing the best path having the largest amount of pheromones

Loop

End of the project

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6 Conclusion

In this article, we opted for the use of ant algorithms for the design of a dynamic educational project.

A dynamic pedagogical project is a learning method that ensures for each member of the group, a learning scenario adapted to his level of knowledge and skills.

The article discusses the state of art, and proposes a dynamic method of learning based on ant algorithm.

This approach is able to determine the optimal path for learners and propose appropriate level activities learners.

The learners need to make decisions to choose the best solution for the subject.

The optimized path is based on the two indicators measured in a group of learners in an educational project.

Therefore, we implement an algorithm based on indicators: Cognitive heterogeneity and divergence in the calculation of the fitness function.

However this work is limited by the choice of the parameters of the fitness function, that do not support all features of the learner profile.

A learner has several inherent characteristics including cognitive.

Each learner profile is different from its peers in the group, which is reflected in the group's decision.

In perspective of this work, we will define a global formula of fitness function by taking over the learner profile of all the members of the group.

On the other hand, we will exploit other meta-heuristics algorithms, in order to compare between the various optimization solutions obtained.

The most effective algorithm in results will be chosen to optimize the route of the group of learners.

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