Decision making in the assessment of project-based learning

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Abstract—The Project-based learning is an active learning method, based on student's group work, in order to develop skills, and to acquire knowledge. The development of ICT has enabled the implementation of processes of this educational approach. Indeed, the assessment process is a fundamental process in the learning cycle, and represents a means of regulation and control for tutors and learners. However, the assessment process requires points of decision-making, at the individual and the group level. Our approach in this paper is to treat the decision making through (Analytical Hierarchical process) hierarchical analysis method, for the formative assessment. The Analytic Hierarchy Process structures the assessment criteria and enables an optimization of the decision.

Keywords—Project-based learning, assessment, business process, decision-making, analytical hierarchy process.

I. INTRODUCTION

WITH technological development, new forms of group work have emerged, particularly in the field of distance education (e-learning). The e-Learning has seen many changes, and has improved teaching conditions, while crossing the temporal and spatial constraints.

Most learning platforms are more interested in management of educational content, rather than the process of distance education. This problem is accentuated in a social constructivist pedagogy, which promotes group work [16] and sharing of knowledge.

The project-based learning is characterised by a social and collective nature [1], which promotes the negotiation, the criticism of others, and the group decision making. This arouses a division of labour, and planning tasks, in agreement with the project actors, leading an affective investment and motivation [2].

The decision in a pedagogical project occurs in all stages of the project: project selection, the choice of material, planning and evaluation.

The student is subject of evaluation during the project, to verify the objectives formulated by evaluation criteria. Thus, the evaluation process generates the points of decision-making, individual and collective.

In the context of our study, we are interested in formative assessment, in purpose of the regulation of the learning process

Several methods deal with the decision-making group. Our proposal is based on the AHP method [3], which structures the evaluation criteria in a hierarchical analysis.

The evaluation criteria concern the deliverables during a project, such as a report written collaboratively by the group members [22]. In the course of collaborative writing, students perform tasks in a group, which generates traces of the activities constituting the evaluation criteria.

A deliverable is produced at each stage of the project. The Learners will be formatively assessed by their pairs, in order to regulate the collaborative writing of deliverable.

The validation of deliverables is made by a decision-making of learners, based on the AHP method using the evaluation criteria.

In this paper, we propose the implementation of the Analytic Hierarchy Process for the assessment of deliverables in educational project.

In the first section we will discuss the state of the art of project-based learning approach, and the process it contains.

Afterwards in the second section, we will study the process of evaluating online in this context of learning, and modelling the various sub processes of evaluation by business processes [8].

The modelling of sub process of assessment by a business process will identify the decision points made by the individual and the group.

The third section will be devoted to the hierarchical analysis, and its application to the assessment process of deliverables, for individual or group.

To illustrate our proposal, we have implemented the AHP method, for the collaborative report [14], as deliverable in a project context.

In the fifth section, we presented the general principle of a summative evaluation at the end of the project.

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

II. THE PROJECT-BASED LEARNING

A. Definition

The Project-based learning [1] is a learning approach that

presents some aspects of sustainable learning skills, such as group work, communication, critical thinking, and decision-making. This method of learning develops transversal and discipline skills.

The project gives learners the opportunity to work in a group for a period of time, as opposed to individual instruction.

A project exposes students to other points of view from which they can learn and accomplish their tasks properly.

The projects provide the opportunity for the development of interpersonal skills and group work, such as communication, planning and time management. These skills are prized by graduates in the workplace.

Indeed, a learning project is considered as a set of processes. The online assessment is a fundamental process of distance learning.

B. The Assessment Process in a Project-Based Learning

The Pedagogy by project is a teaching method in which the project is the key element.

During a project, a learner performs collaborative and individual tasks that involve collaboration and communication.

Students choose a project, perform it, and justify the learning acquired through production, in front of the teacher and peers. In order to compare the project objectives with learning outcomes, a summative assessment of the work done by tutor is needed throughout the project.

However during the project, the learners should be able to evaluate their performance, outcomes, and accept criticism and approval of their colleague. Indeed, the formative evaluation made by peers can assist and guide the learner.
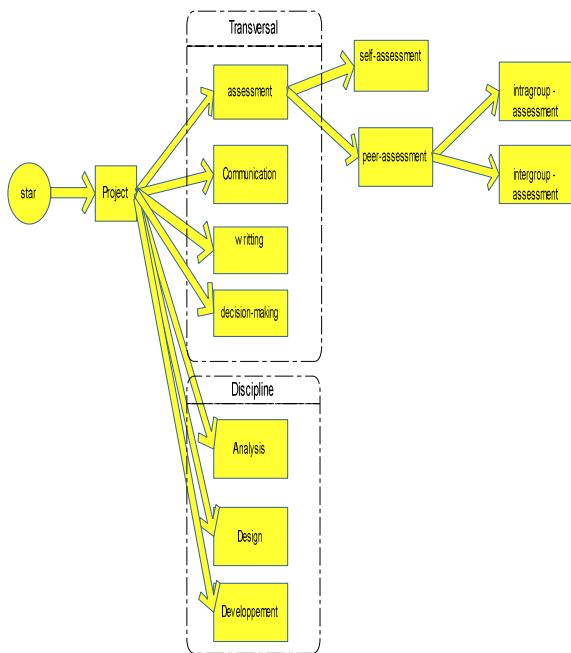

Fig. 1 the assessment process of a project

The evaluation process of learning takes many forms [12]: an assessment inter-group, intra-group, self-assessment of group members, and assessment by the tutor.

The evaluation process (Fig.1) in the context of learning, has a transversal nature, spread throughout the project.

This process consists of two sub-processes, the peer-assessment and the self-assessment [11].

The peer-assessment and self-assessment process are employed in formative manner.

The peer assessment process is divided in two sub-processes, the intra-group assessment and the inter-group assessment.

C. The self-assessment sub-process

The self-assessment process [17] consists in assessing the learners by themselves. This sub-process is modelled [4] by a business process [8] (Figure 2).
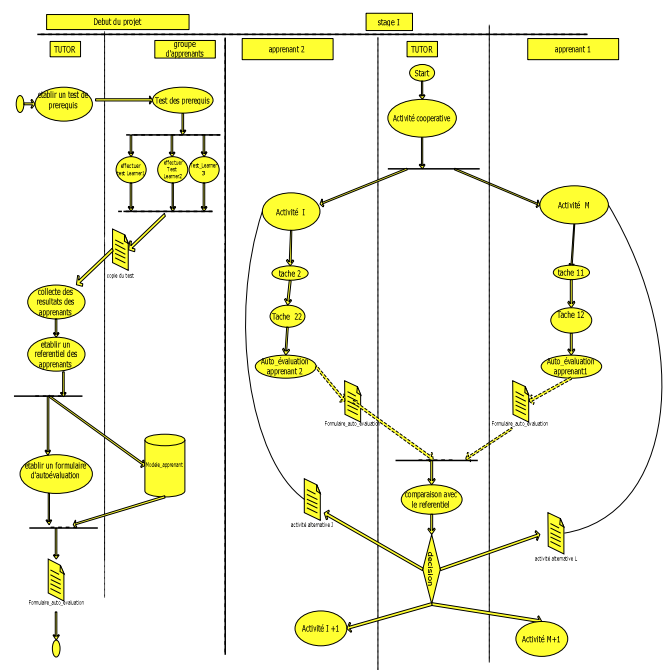

Fig. 2 The Self-assessment sub-process

At the beginning of the project, the tutor starts a prerequisite test of the group. The learner carries out the test individually, and then they send the test to the tutor.

The tutor collects the results, and implements a learner profile, then stores these results in a learner model.

This classification of learner profiles, allows a comparison of the test results, and the referential of learning.

There are also self-assessment tests set up, as tools for learners during the project. These self-assessment tests cover all levels of granularity of the project (process, activity ...).

Thus, in a stage of the project, the tutor assigns a cooperative activity to a group of learners. The cooperative activities are considered as a sub-process which consists of parallel individual activities. These activities consist of tasks assigned to students.

After completing the tasks, learners respond to a self-assessment test, which emphasises the path of learning during the project.

Following a comparison with the repository performance, set at the beginning of the project, the system takes a decision by the AHP method to guide the routing of the learning activities.

The system guides the student towards an alternative activity, or moves to the next activity.

D. The Peer-Assessment Sub-process

Each cooperative task of a learning group will be formally evaluated [18] by a group of assessors who will conduct the next step (Figure 3).

The assessor group will be also assessed by another assessors group, which will continue the project [10].

Members of the assessor group perform the assessment in using the rubric of inter-group, and then they assemble the

results into a single form of the assessed group.

This activity is done by mutual agreement between the members through a discussion and negotiation (unstructured process).

The feedback will then be sent to the assessed group [5], for a review and necessary corrections.

After receiving the feedback, a discussion (unstructured process) is initiated to measure the weaknesses of cooperative work and undertake the necessary corrections.

The evaluation of cooperative work will be done by peers, who will evaluate the work of colleagues in an intra-group evaluation.

In this case, each member will review the work of his colleagues, and will give his assessments [6] in the rubric of intra-group evaluation.

These appreciations will be used to review individual activities, by each group member.

Each member takes a decision in function of the values assigned to the evaluation criteria in the peer evaluation form.

The member of the group assessed, proceeds to a correction of its task, or sends his individual work to the group.

A new report from the cooperative activity will be prepared and sent to a new inter-group reassessment.

This step can be repeated as long as there are revisions from the assessor group.

After that all the necessary corrections, the group decided to submit work for a final assessment by the tutor.

The decision in the case of inter-group evaluation or intra-group will be conducted by the AHP [3] method.

At the end of each level, the tutor will evaluate in turn, and assigns a score in combination with the assessor group.

In the same way the tutor assess the project as a whole, comparing the results with the objectives, and assign a final score to the group.

The final score of the project will be measured by the distance between the objectives fixed of the project, and the results of productions. Hence the tutor takes a decision of the project success.

III. THE DECISION-MAKING PROCESS IN THE FORMATIVE EVALUATION OF THE PROJECT

In this section, we present the process of decision making, during a formative assessment of a project.

When making decision, many interests are involved, which generates a set of criteria supported to achieve a goal. The process of decision-making is based on a set of methods (AHP, ELECTRE…).

In our case we opted for the AHP method [3], for decision making. The AHP method is characterized by hierarchical analysis of evaluation criteria, such as indicators [18].

During a project, groups of students are asked to make choices in the evaluation process, either individually or in groups.
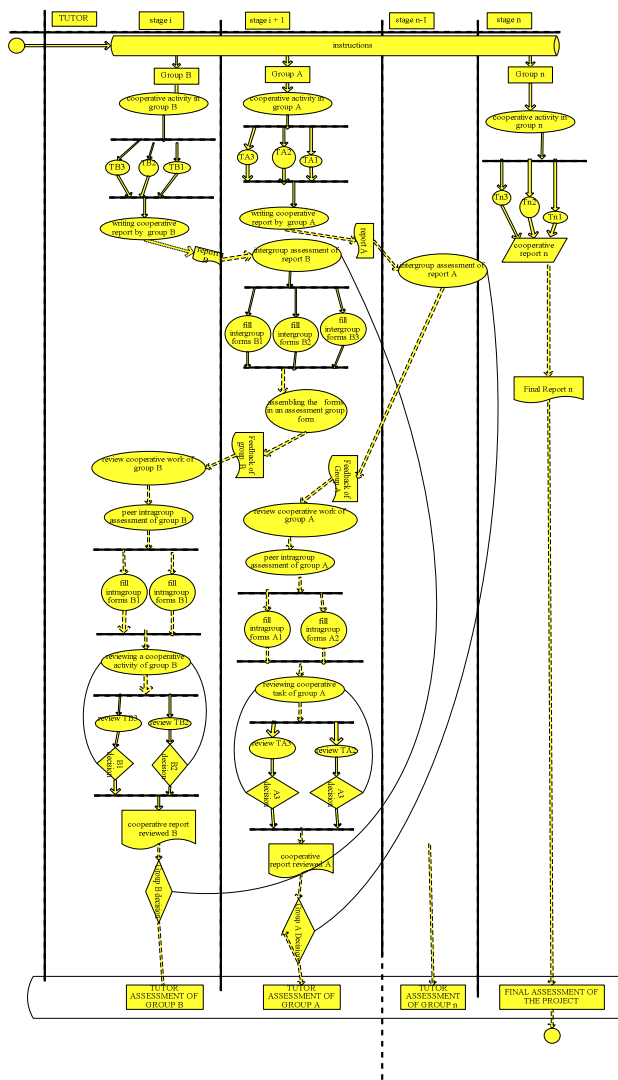

Fig. 3 the peer-assessment sub-process

A. *the AHP process in the formative evaluation a pedagogical project*

The evaluation during project relates to several types of collaborative activities.

In our case study we will be limited to written reports.

At each step i of the project, the group delivers a report written, in collaborative manner, for an evaluation by the group that will perform the step i +1.

The assessment of the written report will be made through evaluation forms at the end of each stage of the project.

Evaluation forms are of two types: form inter-group evaluation and intra-group.

When a group evaluates another, the assessor group fills the inter-group evaluation form, and responds to evaluation criteria.

The intra-group form is filled by members of the same group to evaluate their peers.

When writing the report, learners use the transversal skills, (spelling, grammar, semantics etc ...), and discipline (field of the project).

Thus collaborative writing is characterized by three aspects: the group's production, the writing process, and the individual and collective skills [30].

Concerning the evaluation of the group's production, the written text is analyzed to measure the syntax, grammar, and semantics.

We define the writing process through three phases: planning, writing and review.

During the planning phase, learners read the instructions of tutors, generate new ideas, and discuss the lexical and grammatical choices.

Then learners pass to the writing phase to structure ideas, and interpret the Tables and the graphs in format of written text.

The contribution of learners during the writing phase generates new ideas (scaffolding) and builds a vocabulary, while co-constructing the written text.

The review phase is used to send feedback from learners to others and to allow the structuring of ideas and grammatical accuracy.

In addition, the individual and collective skills are being tested during the collaborative writing, such as the attitude of the learners, and the level of the language used.

The three aspects of collaborative writing will form the evaluation criteria of the written report. The form of inter-group evaluation includes assessment criteria of the group.

The evaluation criteria are the indicators of the group listed in the Table I.

According to Table I, we note that there is a hierarchy of criteria, which will be organized by the AHP process, which will be detailed in the next section.

Table I: The group assessment criteria

The group criteria	Process	Interpretation of tables and figures, that carry relevant information on the subject, in synthesized way.
		Resources: learners are involved in the search for information by various means
		Structuring the essay: logical and organizing ideas
		Group members clarify the arguments, ideas, and conclusions.
		Checking references: cited in accordance with the Template Guide.
		The learners contribute to the development of the chosen concept, and to problem solving.
		Learners describe the theories, methodologies and procedures for implementation.
		Selection of resources related to the topic: resource quality, accessibility.
		Coherence of arguments
		Workload: distribution of workloads adequately between learners
	Written report	Spelling error
		Grammatical error
		Learners have achieved the objectives of the current stage of the project
		Learners contribute to the development of the chosen concept, and problem solving.
		Learners validate the results of the study project.
	skills	Group cohesion: the paragraphs are set homogeneously, and the links between the paragraphs are coherent and logical.
		attitude and team spirit
		Collective scaffolding: learners co-construct new knowledge
		Quality of knowledge

In the same way, the evaluation criteria are structured according to the AHP process for intra group evaluation.

In another strand, the intra-group assessment will be based on individual assessment criteria listed in Table II.

The forms of inter-group and intra-group evaluation will be analyzed in the decision making process, which we will detail in the next chapter.

Table II: The assessment criteria of a learner

Individual criteria of a learner	Process	Look for resources: learners are engaged in seeking information in different ways.
		A learner fulfils the task adequately
		The learner contributes to the development of the chosen concept, and the problem solving.
		Learners describe the theories, methodologies and procedures implementation
		Selection of resources related to the topic: resource quality, accessibility.
		Time Management: perform the tasks within deadlines
	Product	Spelling error of the lexicon
		Grammatical error
		The vocabulary level employed by the learner.
		Quality of information and data clarified in the written text
	skills	assiduity and attendance at meetings
		respect des échéances
		Communication
		Reflexion: This criterion related to critical thinking, looking for consultancy, and explaining the ideas to the peers.
		Cooperation and contribution: chat (number of messages sent, number of unread messages).

In the same way, the evaluation criteria are structured according to the AHP process for intra-group evaluation [20].

The forms of inter-group and intra-group evaluation, will be analyzed in the decision making process, which we will detail in the next chapter.

B. Decision making in inter-group assessment:

A group is subject to a formative evaluation throughout a project stage (Figure. 3).

The assessor group will fill a form of inter-group evaluation by answering the criteria of evaluation of assessed group.

Following to the answers of assessor group, the assessed group (decision makers) will take a decision in group, either for to confirm the report or to return a new assessment.

The decision of the assessed group is based on AHP decision-making process detailed in Figure. 4.
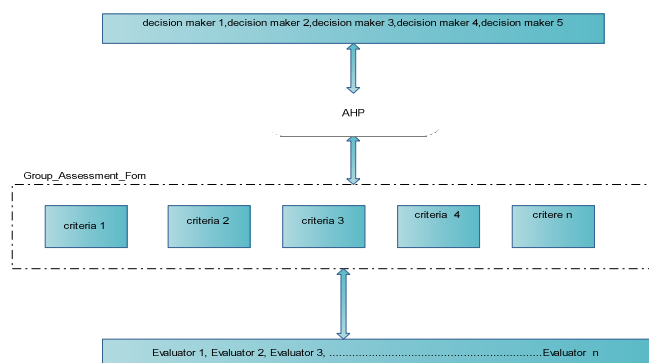

Fig. 4 application of AHP decision making in inter-group assessment

Each member of the assessor group, fills the evaluation form by answering the inter-group evaluation criteria previously established (Table III). Each assessed group member will receive the evaluation form.

Table III: Evaluation form received by each member of the assessed group

criteria	criteria_1	criteria_2	criteria_3	criteria_4	criteria_n
évaluator_1	Val11	Val12	Val13	Val14	Val15
évaluator_2	Val21	Val22	Val23	Val24	Val25
évaluator_3	Val31	Val32	Val33	Val34	Val35
évaluator_4	Val41	Val42	Val43	Val44	Val45
évaluator_n	Valn1	Valn2	Valn3	Valn4	Valn5

Each decision maker Di (group member assessed), assigns values to the inter-group evaluation criteria, according to the importance attributed.

The values construct the comparison matrix, and are situated in the scale of Saaty [9]. Saaty's scale is a rating scale

Table IV: Comparison matrix of criteria

	criteria_1	criteria_2	criteria_3	criteria_4	criteria_n
criteria_1	1	a	b	c	d
criteria_2	1/a	1	e	f	g
criteria_3	1/b	1/c	1	h	i
criteria_4	1/c	1/f	1/h	1	j
criteria_n	1/d	1/g	1/i	1/j	1

that includes values from 1 to 9.

Then we calculate the eigenvector starting from the comparison matrix of criteria (Table IV). This vector is composed of weight of the evaluation criteria.

Calculating the weight vector requires normalization of

comparison matrix.

The elements are normalized by dividing by the sum of columns of the matrix of comparison (Table V).

Table V: Comparison matrix of criteria

	Criteria_1	Criteria_2	Criteria_3	Criteria_4	Criteria_n
Crtr_1	1	a	b	c	d
Crtr_2	1/a	1	e	f	g
Crtr_3	1/b	1/c	1	h	i
Crtr_4	1/c	1/f	1/h	1	j
Crtr_n	1/d	1/g	1/i	1/j	1
Sum of column	$\sum Crtr\underline{1}$	$\sum Crtr\underline{2}$	$\sum Crtr\underline{3}$	$\sum Crt\underline{4}$	$\sum Crt\underline{m}$

The weight of criteria is determined by dividing the sum of a line by the number of criteria (Table VI).

Table VI: Tthe eigenvector of the criteria

Critèria	VP_Ci
Criteria 1	$\sum Crtr\_1 / n$
Criteria 2	$\sum Crtr\_2 / n$
Criteria 3	$\sum Crtr\_3 / n$
Criteria 4	$\sum Crtr\_4 / n$
Criteria n	$\sum Crtr\_n / n$

In the second step, the comparison matrixes of assessors are calculated with respect to each criterion.

Thus, for each criteria Ci, the decision maker assigns values to different alternatives of the assessors (criteria values).

For each criteria Ci, we establish a comparison matrix, of the different values assigned in the evaluation forms by the assessors, then the vector of priorities [VP-Ci_assessor_j] is calculated (Table VII):

Table VII : The comparison matrix for criteria Ci

criteria Ci	assessor_1	assessor_2	VP_Ci_assessor_j
assessor_1	1	Vali1/Vali2	VP_Ci_assessor_1
assessor_2	Vali2/Val1	1	VP_Ci_assessor_2
assessor_i	Vali/Val1	Vali/Val2	VP_Ci_assessor_i

In the third step, we synthesize for each decision maker Di, by multiplying the eigenvector of criteria [VP_Ci] , by the matrix formed of the eigenvector of evaluators, relative to a criteria [VP_Ci_assessor_i], using the following formula (1) :

$$[assessor\_j] = \sum_j \sum_i [VP\_{ci}] \times [VP\_{ci\_assessor\_j}] \quad (1)$$

In general, for each decision maker, the eigenvector of the evaluators [VP_assessor_j] is calculated, and classified in a rank:

As a result, we have the eigenvector of the decision maker Di (Table VII), represented by the synthesis vector [Wsi], which classifies different evaluators.

Table VIII: the eigenvector of evaluators for decision maker Di

$$[Vp_{assessor}] = [Vp_{assessor\_1}], [Vp_{assessor\_2}], \ldots, [Vp_{assessor\_n}]$$
X

	Criteria_1	Criteria_2	Criteria_n
Assessor_1	W_C1_Assessor_1	W_C1_Assessor_1	W_Cn_Assessor_1
Assessor_2	W_C1_Assessor_2	W_C2_Assessor_2	W_Cn_Assessor_2
Assessor_n	W_C1_Assessor_n	W_C2_Assessor_n	W_Cn_Assessor_n

=

	VP_assessor	Rang
assessor 1	VP_assessor_1	R1
assessor 2	VP_assessor_2	R2
assessor 3	VP_assessor_3	R3
assessor 4	VP_assessor_4	R4
assessor n	VP_assessor_n	Rn

The steps previously described will be repeated for each decision maker. We find the following final eigenvector (Table IX):

Table IX: the final eigenvector

	Ws	Rang
évaluateur 1	Ws1	R1
évaluateur 2	Ws2	R2
évaluateur 3	Ws3	R3
évaluateur 4	Ws4	R4
évaluateur n	Wsn	Rn

As a result, we will calculate the final weight of the decision makers, by means of consistency indices [15].

For each decision maker Di, is calculated the indices of consistency for comparison matrices, criteria / criteria, and for all matrices assessors / criteria Ci.

The coefficient of consistency is defined by CR = CI / RI, with consistency index CI.

The consistency index is calculated by (mean coherence - n) / n-1, with n is the number of parameters, and the consistency average is the average of coherences eigenvector of the weights of the matrix.

The average consistency is calculated by the multiplication of each column of the comparison matrix non-normalized by the weight of the associated criterion. Then, we then assess the consistency, by dividing the sum of lines by the weight of criteria of the line. RI is the random index depending on the number of criteria, measured from random index Table [9]. After having calculated individually vectors for decision-makers by the AHP method (Table X), the final ranking of the evaluators is calculated by aggregating the vectors of priorities for each decision maker.

We note the two main modes of aggregation vectors priorities [13]. The first is the aggregation of individual judgments (AIJ) calculated from the arithmetic mean. The second is the aggregation of individual priorities (AIP) calculated from the geometric mean.

The most common approach is the aggregation of individual priorities vectors, by the geometric mean of the various vectors of properties of decision-makers [19].

The formula (2) for the geometric mean of the group is given as follows:

Table X: the final weight of deciders (assessed)

	Decider_1	Decider_2	Decider_n
Criteria/criteria			
Assessor / criteria_C1			
Assessor / criteria_C2			
Assessor / criteria_Cn			
$\sum CR$			
$\dfrac{1}{\sum CR}$			
Normalisation of CR			
Final weights of deciders (assessed)			
The normalisation of CR is performed by dividing each $\dfrac{1}{\sum CR}$ by the sum of the lines $\sum \dfrac{1}{\sum CR}$			

$$z_i^G = \prod_{k=1}^{j} \left[z_i(k) \right]^{a_k}$$

(2)

j: number of deciders (assessed).

$z_i(k)$: The priority of the alternative i for the decider k.

a_k : The final weight of the assessed (decider) k in the group G.

z_i^G : The priority value of the group aggregation.

In conclusion, for each evaluator, the final weight is calculated and the classification of his assessment form, as in the Table XI below.

Thus the assessed group makes a final decision, based on the decision of the high ranked evaluator (it means, the highest ranked evaluation form, among the forms sent by the evaluators).

As a result, the group compares the values of selected evaluation forms, and the thresholds set at the beginning of the project of the various evaluation criteria.

Table XI: the final weight of the assessors

	assessor_1	assessor_2	assessor_n
Final weight			
rank			

After this comparison, the evaluated group makes a decision for a new sending for correction, or submission to a final rating by the tutor.

C. Decision making in intra-group assessment:

In that case each student receives the intra-group evaluation form by the peers.

As well, the student responds to criteria in the individual evaluation forms (Fig.2) and sends to its peers in the group. The evaluation criteria in this case are individual evaluation criteria.

This is a particular case of inter-group evaluation, because the learner alone decides the choice of the most appropriate form.

The stages of this process are carried out in the same manner as discussed in inter-group evaluation, except that the assessed will take the individual decision.

The first step is to establish a comparison matrix of criteria.

In the second step, the comparison matrices of evaluators in function of each criterion are calculated.

Thus, for each criterion Ci, the decision maker assigns values to different alternatives of evaluators.

For a given criteria Ci, we calculate the comparison matrix, and the corresponding vector of priorities (Table II), then the vector is verified by calculating the consistency index

coefficients. It follows the calculation of the weight of each evaluator (Table III) for evaluation criteria.

The resulting priority vector, gives different weights of evaluators, with their ranking position for each criterion.

The classification provides us with the relevant assessment form, which allows the learner to choose correction, then the submission to the group to contribute to collaborative working relationship.

D. Decision-making in self-assessment

The self-assessment is carried out by the learner, which performs individual activity, then fills out a self-evaluation form (Figure. 2).

Following values of responses to the evaluation criteria, the tutor compared with a reference value of criteria drawn up by the pre-test at the beginning of the project.

The tutor takes the decision to move the learner to another activity, or continue its ordinary path.

IV. THE DECISION-MAKING PROCESS IN THE SUMMATIVE EVALUATION OF PROJECT

The summative evaluation aims to assess the level of skills and knowledge acquired by the students in a group project.

Thus, the summative evaluation concerns the measurement of indicators at the end of the project [23].

The trace based system implements the evaluation criteria and aggregates the indicators identified in the formative evaluation.

The aggregation of indicator values during the formative evaluation provides a final value for measuring learner's indicators.

The measures develop a grid value of the skills and knowledge of learner and group throughout the project.

The calculating of the gap between indicators measured at the end of the project, and the values of the indicators referred to in the beginning of the project, used to compare results and project objectives.

The comparison is made by calculating the Euclidean distance between the values of the indicators.

V. CONCLUSION

The decision-making is involved in all stages of the educational project: the choice of the project, material, planning, scenario and the evaluation.

This work has been established in a perspective to provide the authors and the learners, a method to make a decision, within assessment process in a pedagogical project.
The evaluation process takes two aspects: a formative and summative evaluation.
Our approach treats the individual and collective decision during a formative evaluation by the AHP method.
We used the AHP method in a formative assessment of the collaborative written report.

The formative assessment has two forms: the intra-group assessment, and inter-group.

During this process, students take individual and collective decisions, to make the necessary corrections in agreement with the assessment criteria.

At the end of the project, summative evaluation is elaborated by calculating the difference between the values of the indicators to be achieved, and the indicators values at the end of the project.

Among the limitations of the success of an educational project, we cite the heterogeneity of the group, which generates a low group consensus.

In perspective of this work, we will define the indicator of a group consensus to evaluate the group homogeneity. Therefore it assesses the success of the project.

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