Project-based learning modeling language

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Abstract

The evolution of ICT promotes researchers in e-learning to integrate in the author system, the ability to design custom learning paths, tailored to the needs of users in e-learning platforms. The scenario of learning activities is one of techniques available to teachers, in order to customise and to adapt learning paths. The authors of educational scenarios can choose from several educational approaches, which change the learning environment.

Our case study is based on project-based learning, as a method of collaborative work of a group. In this educational framework, a scenarisation of collaborative learning activities in the context of group work presents several challenges for researchers. The Modelling languages of learning scenarios such as EML (Educational modelling language) are criticized by their abstraction and their difficulty to be used by teachers.

To avoid these constraints, we propose in this paper a meta-model that will describe a modelling language. The modelling language is used as an author tool, to formalise an activities scenario in online educational project.

Our meta-modelling approach is based on the notion of process, and the implementation of the Framework of activity theory. To illustrate our proposal, we have implemented the evaluation process, as instantiation of the proposed meta-model. The assessment process during a project requires points of decision making. The decision is addressed through the hierarchical analysis method (AHP).

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1. Introduction

The technological development has emerged new forms of group work, particularly in the field of distance education (e-learning). E-learning has seen many changes, and has improved teaching conditions, even with temporal and spatial constraints. Most learning platforms are interested in management of educational content, rather than the process of distance education. This limitation is emphasised in a social constructivist pedagogy, which promotes group work and sharing of knowledge, like in a project-pedagogy.

This pedagogy is characterized by a social and collective nature (Louise), which promotes the negotiation, the critical of others, the group work, and the collaborative learning. All Those characteristics arouse a division of labour, and planning tasks, in agreement with the project actors, leading an affective investment and a motivation (Capra & Arpin, 2002). Therefore, the project is considered a collaborative learning process in terms of stages, and activities structured and unstructured, defined by the tutor.

The existing EML modelling languages (Koper, 2002) do not respond to the inherent characteristics of this current educational. The EML languages are criticized for complexity, abstraction, and generality, for a course designer. Hence, the idea is to model the learning process, using a language dedicated to the project approach.

Our proposal is based on the modelling of a learning process based on the UML meta-model.

The meta-model describes two different types of processes, the structured and unstructured in a work group (selmin Nurcan, 1998).

Furthermore, we introduce decision points in our meta-model to deal with the problem of decision-making individual and in group. Several methods treat the decision-making by group, whose AHP method (Saaty, 1980), which structures the evaluation criteria by a hierarchical analysis.

In collaborative writing, students perform tasks in the group, which generates traces of activities, constituting the evaluation criteria. The evaluation criteria concern the deliverables during a project, like a report written in collaboration with the group members.

In this article we will discuss, a state of art of collaborative modelling languages (LDL, CPM, etc...), their advantages and disadvantages. The following section will be devoted to the activity theory, which forms the theoretical basis of our work, by a projection in a teaching project. In the fourth section, we discuss our proposal of meta-modelling the processes, and definition of domain concepts.

In the fifth section, we will illustrate the evaluation process, as an instance of meta-model of processes in a project. Then in the sixth section, we will apply the method of group decision-making in an evaluation process.

The final section will highlight the work in progress, and our main perspectives in the context of project-based learning.

2. A Study of modelling languages

Several research studies have been conducted in the field of modeling languages of collaborative activities. In this section we introduce different modelling languages in a collaborative learning environment, and we discover their limits in teaching project. Among these languages, there are CPM (P. Laforcade & T. Nodenot & C. Sallaberry, 2005), LDL (Martel & Vignollet & Ferraris, & David ,2006) and PoEML (Manuel Caeiro Rodriguez,2007):

- CPM (cooperative Problem Based learning Meta-model): CPM is a modelling language which aim the designing of cooperative situations problem-based. The CPM is a UML profile that expresses the learning scenarios. However, the CPM is specific to learning through problem, thus it's not generic to other learning situations. Therefore, the CPM has a weak reusability (EL Kechai, 2008 Villiot-Leclercq, 2007). Further, CPM is for instructional designers who have mastered the UML formalism, which makes it difficult to handle by teachers.
LDL (Learning Design Language): used to model collaborative activities, and express collaborative scenarios. The LDL is based on a meta-model defined for CSCW (Computer supported cooperative work), and an infrastructure to take charge of the operational scenarios: LDI (Learning Design Infrastructure). This language is based on a particular organizational paradigm called participation model (Martel, 1998). However, the LDL is difficult to handle for scenario of a learning situation, due to the concepts of LDL that are not adapted to the project, in addition to the very specific level of decomposition of the project. Therefore, the concepts of LDL are generic in regard to a project-based learning.

PoEML (Perspective oriented EML): This language is an EML organized into several packages according to a meta-model, which separates the modelling of learning units, based on perspectives, and identified aspects. The perspectives are used, for group the elements of the meta-model in subset of models, each with a specific role in the modelling (S. Ouari, 2006). During a project, the PoEML language is difficult to implement, due to the project structure which does not allow the decomposition, according to the aspects and perspectives. The project has a predefined structure, and a specific decomposition.

In sum, the languages listed are either dedicated to specific learning situations (CPM), either difficult to handle by teachers (LDL), or does not support the sequential activities of the project (PoEML).

Our goal is to define a modeling language dedicated to project-based learning, and also treats the decision making.

3. The activity theory

The activity theory incorporates the concepts of intention (the goal), mediation (artefacts), and development (activities). It has experienced three generations of research.

The first was based on the work of Vygotsky and his concept of mediation (Engeström, Y, 1987). From empirical observations, Leontiev (Leontiev, 1978) has structured activity as a set of conscious actions, which themselves consist of a set of operations.

The activity consists of a subject, and an object (in the sense of purpose, it can be physical or mental), which is managed through a process of transformation to get the result (the transformation process is the purpose of the activity). The activity is mediated by physical tools, or cognitive (symbols, language, gestures).

Engeström (Engeström, Y, 1999) has continued the development of the theory by introducing the notions of community (the environment in which the activity takes place), the rules (the constraints governing the exercise of the activity involve the social aspect) and the division of labor (Organization adopted by the community to perform the activity: the distribution of roles, the powers and the other organizational mechanisms).

In this perspective, we have applied the theory of the activity of the second generation to our pedagogical approach. As shown in Fig 1, the components of the Framework are:

- Subject: learner, group of learners.
- Artefacts of the project: educational resources (documents, courses, modules, etc.), technological tools (software, LMS platform, portfolio), cognitive tools (critical thinking, decision making, assessment), and social strategies (group work).
- Rules: meeting hours, planning of tasks, deadlines.
- Division of labour: distribution of roles (tutors, assessors, assessed), and distribution of tasks for each role. The tutor is responsible for assisting, guiding, and facilitating tasks to learners, while learners have the task execution as mission, communication, and information sharing.
- Learning objectives: mastery of language, writing etc...
- Outcome: In a project the outcome relates to the product of a task, or a step or to the entire project. The product can take the shape of a report, oral presentation, or even of an application.
The application of the theory of activity is adapted to the different granularities of the project. It can be applied to the entire project, then to a particular step, and finally to a defined activity.

As shown in Figure 1, the tutor in accordance with the learners proceeds to the assigning roles and the division of tasks. The subject, plays role assigned by the tutor, and uses the project artefacts to carry out the learning objectives.

During the learning process, students perform tasks to achieve the goals, and they produce collaboratively reports and oral presentations. While the rules implemented concern the organization, such as the team formation, the meeting times, and the hours of collaborative work.

4. Meta-Model of learning in a pedagogical project

The working through project, is based on group cooperation, and been the subject of a field of research called computer-supported cooperative work (CSCW) (Grudin 1 Jonathan, 1994).

The expansion of information technology and communications has shown up new modes of cooperation in professional and educational environment.

The keys of success in a work group, is dependent on the simplification and automation of the process, in order to ensure productivity and quality. In the context of the project, there are several modes of group work, synchronous or asynchronous, distributed or localized. The project group works on a common goal in a shared environment (Ellis, C.A. & Gibbs, S.J., 1994).

On one hand, the actors cooperate to carry out individual tasks in a time interval, and lead to an overall goal, on other hand, the other actors work together to achieve a common task in a shared environment.

There are two types of processes in project work (Mark de Boer & Simon Townsend, 2012): structured and unstructured processes.

The structured process or workflow (OVUM, 1991) is a well-defined process, consisting of repetitive procedures performed via a set of predefined tasks, sequenced and coordinated between actors. Each task is implemented by actor with a corresponding role. The actor, who runs the task at a given time, is selected from this group.
The unstructured or ad hoc processes such as groupware (Ellis & Gibbs & Rein, 1991) are occasional processes, which supporting the unpredictable interactions of actors in a group project, during a collaborative work. The order and the exact time of performing tasks are not pre-established in the unstructured processes, and can be changed at runtime. Such processes are characterized by the sharing of information and knowledge.

As part of our research, we propose a meta-model of learning processes in a pedagogical project, in accordance with standards WFMC (consortium standard workflows).

The learning scenarios according to a learning situation, individual, cooperative, and collaborative, are an instance of the meta-model defined.

As shown in Fig.1, we define the package of our meta-model: organization, environment, interaction, subject, and objective.

4.1 The subject package

This package of discusses the organization of group in a project. We cite three main actors of project-based learning: teacher, tutor, and learner.

- Teacher: is the instructional designer of the activity of learning, and defines the specifications together with the learners.
- Learner: is part of a group of learners. The group members are distributed in space, and interact in different times, through project. The learner gains new knowledge and develops new skills.
- Tutor: its role is to follow the individual learning activities and group, to assist learners, and ensure the sharing of workspace. A tutor is qualified as controller, facilitator, and consultant.

Role: A role is a concept that defines organizational intentions, shared by actors, according to the objectives. We define two types of roles: individual role, and group role which is composed of several individual roles. The individual role performs individual task, while collaborative task is performed by group role.

4.2 The environment package

This package handle the environmental aspect of the project, including artefacts, tools used in the project activity.

There are different kinds of resources such as:

- Tools: means the software, the platforms, and the software agents.
- Information: contents and exercises.
- Social: group work, collaborative work.
- Cognitive: critical thinking, decision making.
4.3 The control package

This control package concerns the flow control in a structured process. The collaborative interactions require the use of operators that control the flow, and operators in the tools.

The operators defined in package, have a sequential nature, parallel, and alternative. The sequential operator defines the steps, activities, and tasks sequentially in a structured process.

The operators and-join, and-split, are used to define a parallel flow (synchronization).

The Or-split and join-split, define alternative flows, depending on the parameters of conditions (deadline, the value of the response, etc...).

4.4 The functional package

This package describes the process of composition, in terms of types of processes, activities and tasks.

The process in a project has a disciplinary nature or transversal, in adequacy with the learning objectives.

The transversal processes are spread out throughout the life of the project, such as the evaluation process, communication, writing etc. Each step is composed of process, linked to decision points at runtime.

The decision is taken, during the runtime, by triggering an action in consequence of the learners interaction.

The role concept, takes an individual or collaborative decisions, in a step, at activity level and tasks. Processes are composed of sub-processes, structured and unstructured. Structured process consists of steps, ordered and coordinated.

So, the structured processes are modelled through workflows, defined by an ordered set of steps and activities, submitted for a flow control by the operators (sequential, parallel, alternative).

As an illustration, the planning of work prepared by the tutor is seen as a process, which can be decomposed into sub-processes.

While the unstructured processes, are executed in unpredictable ways by roles, using environmental resources (selmin. N,1998).

The main objective of unstructured process is the sharing of knowledge and information in a workgroup.

The part of the meta-model, which illustrates the functional package, is described below.
4.5 The traceability package

The tracking package (Fig 6) provides indicators used to make decisions, and to produce feedback for learners. The tutors manipulate indicators in order to regulate, assist and facilitate the learning process (Benjeloun & Faddouli & Khalidi & Bennani, 2012). The indicators can be from different levels in accordance with the theory of activity (Leontiev, 1978). Based on our analysis, we have indicators at the project level, composed of indicators at process level.
4.6 The meta-model of project-based learning language:

The aspect of meta-model is shown in fig.7, consisting of five packages, according to the theory of activity. The organizational package describes the organization of project actors, and the roles played during runtime. The functional package expresses the structure of the project, in stages and processes, which correspond to the levels of activity theory.

The interaction package corresponds to the control during a workflow in a structured activity. The environment package illustrates the artefacts, and tools used in a project.

We added the traceability package to the meta-model, structured according to the hierarchy of three levels of activity theory.

Fig 7. The meta-model of the project-based learning
5. Case study: the evaluation process in a pedagogic project

The assessments in a project consist, to compare the project objectives with learning outcomes. Thus, in a project, the assessment takes many forms, such as inter-group evaluation, intra-group, self-evaluation, and evaluation by the tutor.

The evaluation process has a transversal nature, and composed of several sub-processes, structured and unstructured.

5.1 The evaluation process in a pedagogical project

The evaluation process (Fig. 8) in the context of learning, has a transversal nature, spread throughout the project.

This process consists of two sub-processes of peer-assessment, and self-assessment.

- The self-assessment sub-process: The self-assessment in process consists in assessing the learners by them-selves. This sub-process is modelled by a workflow (Fig. 9). At the beginning of the project, the tutor starts a prerequisite test of the group learners. 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. Then a self-assessment test is set up, as tool 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 composed of parallel individual activities. These activities form of tasks assigned to students. After completed the tasks, learners respond to a self-assessment test, which emphasises on the path of learning during the project. Following a comparison with the referential, implemented 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.
The peer-assessment sub-process: when learning by project, group members perform a cooperative task, and will be a subject of formative evaluation throughout a step, by a group of assessor which will continue the next step, such an operation is called inter-group assessment (Fig.10). The assessor group will be also assessed by another assessors group, which will continue the project. Members of the assessor group perform the assessment rubric of the assessed group, and then they assemble the results into a single form. 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, 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 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, after corrections. Consequently, the group performs a new collaborative activity, and sends the outcome for a new inter-group reassessment. This step can be repeated as long as there are reviews from the assessor group. If the assessed group, is satisfied with
his work, he takes a decision not to send the work for inter-group evaluation, but it will be submitted to the tutor assessment. At this level, the tutor will evaluate in turn, and assign a note at work. The final grade will be a combination between the tutor score, and the assessor group score. The decision in the case of inter-group evaluation or intra-group will be conducted by the AHP method.

Fig 10. The peer assessment sub-process
6. The decision-making process in the evaluation of a project

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

When a decision is making, 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 chose the AHP method (Saaty, 1980), for decision making. The AHP method is characterized by hierarchical analysis of evaluation criteria, such as indicators.

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

6.1 The AHP process in the 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 collaborative report written, 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 of the group assessed. While the intra-group evaluation forms, are filled by members of the same group, who answers to the individual criteria of assessment.

When writing the report, learners use the transversal skills, (spelling, grammar, semantics etc ...), and discipline skills (related to the field of the project).so the collaborative writing is characterized by three aspects: the group's production, the writing process, and the individual and collective skills (Neomy storch, 2005).

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, students read the instructions of the tutor 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 other, and to allow the structuring of ideas and the 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 constitute 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 1.

According to Table 1, 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.

In Another strand, the intra-group assessment will be based on individual assessment criteria listed in Table 2.

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

In next section, the forms of inter-group and intra-group evaluation, will be analyzed by the decision making process.
Table 1. The group assessment criteria

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

Table 2. The assessment criteria of a learner

<table>
<thead>
<tr>
<th>Individual criteria of a learner</th>
<th>Process</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Look for resources: learners are engaged in seeking information in different ways.</td>
<td>a learner fulfils a task adequately</td>
<td>The learner contributes to the development of the chosen concept, and the problem solving.</td>
<td>Learners describe the theories, methodologies and procedures implementation</td>
<td>Selection of resources related to the topic: resource quality, accessibility.</td>
<td>Time Management: perform the tasks within deadlines</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spelling error of the lexicon</td>
<td>Grammatical error</td>
<td>The vocabulary level employed by the learner.</td>
<td>Quality of information and data clarified in the written text</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>skills</td>
<td>assiduity and attendance at meetings</td>
<td>Respect of deadlines</td>
<td>Communication</td>
<td>Reflexion: This criterion related to critical thinking, looking for consultancy, and explaining the ideas to the peers.</td>
<td>Cooperation and contribution: number of messages sent, number of unread messages, number of received messages.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.2 Decision making in inter-group assessment

A group is subject to a formative evaluation throughout a project stage (Fig. 10). The assessor group fills 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 for a new assessment. The decision of the assessed group is based on AHP decision-making process detailed in Fig.11.

![Fig. 11. Application of AHP decision making in inter-group assessment](image)

Each member of the assessor group, fills the evaluation form by answering the inter-group evaluation criteria previously established (Table 3). Each assessed group member will receive the evaluation form.

<table>
<thead>
<tr>
<th>criteria</th>
<th>criteria_1</th>
<th>criteria_2</th>
<th>criteria_3</th>
<th>criteria_4</th>
<th>criteria_n</th>
</tr>
</thead>
<tbody>
<tr>
<td>evaluator_1</td>
<td>Val11</td>
<td>Val12</td>
<td>Val13</td>
<td>Val14</td>
<td>Val15</td>
</tr>
<tr>
<td>evaluator_2</td>
<td>Val21</td>
<td>Val22</td>
<td>Val23</td>
<td>Val24</td>
<td>Val25</td>
</tr>
<tr>
<td>evaluator_3</td>
<td>Val31</td>
<td>Val32</td>
<td>Val33</td>
<td>Val34</td>
<td>Val35</td>
</tr>
<tr>
<td>evaluator_4</td>
<td>Val41</td>
<td>Val42</td>
<td>Val43</td>
<td>Val44</td>
<td>Val45</td>
</tr>
<tr>
<td>evaluator_n</td>
<td>Valn1</td>
<td>Valn2</td>
<td>Valn3</td>
<td>Valn4</td>
<td>Valn5</td>
</tr>
</tbody>
</table>

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

The values are used in the construction of comparison matrix, and are situated in the scale of Saaty (Saaty, 1980). Saaty's scale is a rating scale that includes values from 1 to 9.

Then we calculate the eigenvector starting from the comparison matrix of criteria (Table 4). 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 5).
Table 4: Comparison matrix of criteria

<table>
<thead>
<tr>
<th></th>
<th>criteria 1</th>
<th>criteria 2</th>
<th>criteria 3</th>
<th>criteria 4</th>
<th>criteria n</th>
</tr>
</thead>
<tbody>
<tr>
<td>criteria 1</td>
<td>1</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>criteria 2</td>
<td>1/a</td>
<td>1</td>
<td>e</td>
<td>f</td>
<td>g</td>
</tr>
<tr>
<td>criteria 3</td>
<td>1/b</td>
<td>1/c</td>
<td>1</td>
<td>h</td>
<td>i</td>
</tr>
<tr>
<td>criteria 4</td>
<td>1/c</td>
<td>1/f</td>
<td>1/h</td>
<td>1</td>
<td>j</td>
</tr>
<tr>
<td>criteria n</td>
<td>1/d</td>
<td>1/g</td>
<td>1/i</td>
<td>1/j</td>
<td>1</td>
</tr>
</tbody>
</table>

Tab. 5: The matrix of comparison normalised

<table>
<thead>
<tr>
<th></th>
<th>Criteria 1</th>
<th>Criteria 2</th>
<th>Criteria 3</th>
<th>Criteria 4</th>
<th>Criteria n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria 1</td>
<td>1</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>Criteria 2</td>
<td>1/a</td>
<td>1</td>
<td>e</td>
<td>f</td>
<td>g</td>
</tr>
<tr>
<td>Criteria 3</td>
<td>1/b</td>
<td>1/c</td>
<td>1</td>
<td>h</td>
<td>i</td>
</tr>
<tr>
<td>Criteria 4</td>
<td>1/c</td>
<td>1/f</td>
<td>1/h</td>
<td>1</td>
<td>j</td>
</tr>
<tr>
<td>Criteria n</td>
<td>1/d</td>
<td>1/g</td>
<td>1/i</td>
<td>1/j</td>
<td>1</td>
</tr>
</tbody>
</table>

The weight of criteria is determined by dividing the sum of a line by the number of criteria, see table 6 below.

Table 6: The eigenvector of the criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>VP Ci</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria 1</td>
<td>( \sum \text{Crtr}_1 / n )</td>
</tr>
<tr>
<td>Criteria 2</td>
<td>( \sum \text{Crtr}_2 / n )</td>
</tr>
<tr>
<td>Criteria 3</td>
<td>( \sum \text{Crtr}_3 / n )</td>
</tr>
<tr>
<td>Criteria 4</td>
<td>( \sum \text{Crtr}_4 / n )</td>
</tr>
<tr>
<td>Criteria n</td>
<td>( \sum \text{Crtr}_n / n )</td>
</tr>
</tbody>
</table>

In the second step, the comparison matrixes of assessors are calculated with respect to each criteria. Thus, for each criteria Ci, the decision maker assigns values to different alternatives of the assessors (criteria values). Then we establish a comparison matrix, of the different values assigned in the evaluation forms by the assessors, so the vector of priorities [VP-Ci_assessor_j] is calculated (Table 7):
Table 7. The comparison matrix

<table>
<thead>
<tr>
<th>Criteria Ci</th>
<th>assessor 1</th>
<th>assessor 2</th>
<th>assessor 3</th>
<th>assessor 4</th>
<th>assessor 5</th>
<th>VP_Ci_assessor_j</th>
</tr>
</thead>
<tbody>
<tr>
<td>assessor 1</td>
<td>1</td>
<td>Vali1/Vali2</td>
<td>Vali1/Vali3</td>
<td>Vali1/Vali4</td>
<td>Vali1/Vali5</td>
<td>VP_Ci_assessor_1</td>
</tr>
<tr>
<td>assessor 2</td>
<td>Vali2/Vali1</td>
<td>1</td>
<td>Vali2/Vali3</td>
<td>Vali2/Vali4</td>
<td>Vali2/Vali5</td>
<td>VP_Ci_assessor_2</td>
</tr>
<tr>
<td>assessor 3</td>
<td>Vali3/Vali1</td>
<td>Vali3/Vali2</td>
<td>1</td>
<td>Vali3/Vali4</td>
<td>Vali3/Valin</td>
<td>VP_Ci_assessor_3</td>
</tr>
<tr>
<td>assessor 4</td>
<td>Vali2/Vali1</td>
<td>Vali4/Vali2</td>
<td>Vali4/Vali5</td>
<td>1</td>
<td>Vali4/Valn</td>
<td>VP_Ci_assessor_4</td>
</tr>
<tr>
<td>assessor 5</td>
<td>Vali/Vali1</td>
<td>Vali/Vali2</td>
<td>Vali/Vali3</td>
<td>Vali/Vali4</td>
<td>1</td>
<td>VP_Ci_assessor_5</td>
</tr>
</tbody>
</table>

In the third step, we synthesize for each decision maker Di, by multiplying the eigenvector of criteria [VP_Ci] in Table 8, by the matrix formed of the eigenvector of evaluators, relative to a criteria [VP_Ci_assessor_i], using the following formula:

\[
W_{\text{assessor } j} = \sum_{i} \sum_{j} [VP_{ci}] \times [VP_{ci}_{\text{-evaluateur}}]
\]

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

Table 8. The eigenvector of evaluators for decision maker Di

<table>
<thead>
<tr>
<th>[VP_assessor] = [VP_assessor_1, VP_assessor_2, ..., VP_assessor_n]</th>
</tr>
</thead>
</table>

\[
X
\]

As a result, we have the eigenvector of the decision maker Di (Table 8), represented by the synthesis vector [Wsi], which classifies different evaluators. The steps previously described will be repeated for each decision maker. We find the following final eigenvector (table 9):
As a result, we will calculate the final weight of the decision makers, by means of consistency indices. For each decision maker $D_i$, the indices of consistency are calculated for comparison matrices, criteria / criteria, and for all matrices assessors / criteria $C_i$.

The coefficient of consistency is defined by $CR = CI / RI$, with consistency index $CI$. The consistency index is calculated by $(\text{mean coherence} - n) / (n-1)$, 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. We then assess the consistency, by dividing the sum of lines by the weight of criteria of the line (Table 10). $RI$ is the random index depending on the number of criteria, measured from random index table (Saaty, 1980).

### Table 9 The final eigenvector

<table>
<thead>
<tr>
<th>Decider $i$</th>
<th>Decider $i+1$</th>
<th>Decider $i+2$</th>
<th>Decider $n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>priority vector</td>
<td>$W_{si}$</td>
<td>Rang</td>
<td>$W_{si+1}$</td>
</tr>
<tr>
<td>assessor 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor $n$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 10 the final weight of the decision makers

<table>
<thead>
<tr>
<th>Hata! Düzenleme alan kodlarından nesneler oluşturulamaz.</th>
<th>Decider 1</th>
<th>Decider 2</th>
<th>Decider 3</th>
<th>Decider 4</th>
<th>Decider $n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>criteria/criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor/criteria $C_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor/criteria $C_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor/criteria $C_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assessor/criteria $C_n$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$$\sum CR$$

Normalisation of $CR$

Final weights of deciders (assessed)

The normalization of $CR$ is performed by dividing each

$$\sum CR$$

the sum of the lines

$$\sum \left[ \frac{1}{\sum CR} \right]$$
After having calculated individually vectors for decision-makers by the AHP method, 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 [(Forman, E. H. and K. Peniwati, 1998)]. 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 (AIP), by the geometric mean of the various vectors of properties of decision-makers.

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

\[ H_{k} = \left( \prod_{i=1}^{n} p_{ik} \right)^{1/n} \]

- \( j \): number of deciders (assessed).
- \( H_{k} \): The priority of the alternative i for the decider k.
- \( p_{ik} \): The priority value of the group aggregation.
- \( G \): The final weight of the assessed (decider) k in the group G.

In conclusion, for each evaluator, the final weight is calculated, also the classification of his assessment form (table.11).

<table>
<thead>
<tr>
<th>assessor_1</th>
<th>assessor_2</th>
<th>assessor_3</th>
<th>assessor_4</th>
<th>assessor_n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus, the assessed group makes a final decision, based on the decision of the high ranked evaluator (it means that, 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, and stored in the referential. After this comparison the evaluated group, makes a decision for a new correction, or submission to a final rating by the tutor.

6.3 Decision making in intra group evaluation (peer 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 (Fig10) 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 lonely decides (not in group) of the choice of the most appropriate form from his colleagues. The steps 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 criteria, are calculated. Thus, for each criterion \( Ci \), the decision maker assigns values to different alternatives of evaluators.
For a given criteria \( C_i \), we calculate the comparison matrix, and the corresponding vector of priorities (table 2), then the vector is verified by calculating the consistency index of coefficients. It follows by the calculation of the weight of each evaluator (Table 3) 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 either the correction of his activity, or the submission to the group to contribute to collaborative working.

6.4 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 (Fig. 9). 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. Finally, the tutor takes the decision to move the learner to another activity, or continue its ordinary path.

6- Conclusion

This work has been established in a perspective to provide the authors with a modelling language based on the process in a pedagogical project. Our approach is based on modelling the processes of learning in a pedagogical project.

The second generation of the theory of activity has been a great theoretical support, by introducing the social component in project-based learning. The Framework of the theory, allows us to define the concepts of our meta-model, and the relationships between them.

In our meta-model, was introduced the concept of decision making, that is important in a collaborative work. We chose the AHP method for the individual decision and in group.

Our approach is illustrated by the evaluation process, which addresses the evaluation in inter-group, and intra-group. During this process, learners must take individual or group decisions, in order to make the necessary corrections in accordance with the evaluation criteria, or for validate the activity. The process of decision AHP helped us in the evaluation of the collaborative report.

However, the AHP method has limitations such as the choice of weights for the evaluation criteria, which affect the decision for the validation, or the correction of the work.

In perspective of this work, we will evaluate the process of decision making, by creating indicators of the decision performance. The indicators of the process inform the tutor of the pertinence of the decision.

In that purpose, we will use the process mining technique for the decision making.

References


Selmin, N, 1998. Main concepts for cooperative work place analysis, proceedings of the telecooperation conference of the 15 th ifip world computer congress.


