MISNA: Modeling and Identification of the Situations of Needs for Assistance in ILE

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For the majority of assistance systems in online learning, the design and the implementation of an intervention strategy are among the most prominent obstacles, and introducing an adequate assistance in the good time is not an easy task. In this research paper, we proposed an active assistance approach that allows calculating during the learning process, revealing indicators of the learners' difficulties. This approach is based on IMAC model that defines and models the assistance situation using a trace indicator with its calculation rule, an intervention modality, an Aspect, and a Category of assistance situation. An operational prototype was developed to evaluate and to implement this approach containing a learning environment, an assistance editor, a collector of traces and our detector of the situations of assistance needs. In order to evaluate our proposal, we conducted field experiments in the domain of professional PowerPoint presentations. The impact of the information provided by revealing indicators, both on assistance system intervention and learner activity, was analyzed. The results suggest that the revealing indicators improve the effects of the proactive interventions and have a positive impact on learners' reactions

Povzetek: Predstavljena je nova metoda aktivne pomoči, testirana na pomoči snovalcem prezentacije v PowerPointu, ki se uči sproti.

1 Introduction

In the field of ILE (Interactive Learning Environments), the importance of help notion and help systems is commonly admitted and it makes a subject of the abundant literature revolving around five major research areas [25]. First, the problematic concerns the problem identification encountered by the learners [29]. A second line of research, the help requests that have formulated by the learners [31]. Third, the design and the characterization of help proposed to the learner [28]. The fourth axis covers research in the construction of learner's profiles and the integration of this profile in the formulation process of the help [37]. Finally, the evaluation as a fifth axis, which is additional research domain, allows validating the proposed help and evolving its place in the environment.

Nevertheless, despite all these efforts, the help system remains generally ignored or rarely consulted by users. Either because of irrelevant intervention following an interruption during the task, or fear to lost time [6]. For these reasons, it seemed very interesting to think about the design of an intervention strategy. This strategy take account the specific needs of each learner like: his learning strategy, his preferences, his objectives and his experiences, in order to provide an adequate assistance with a proactive or a reactive intervention.

Our work focuses on the characterization of this intervention strategy and the determination of its components, with the stakes related to the identification of conditions and intervention criteria, on the one hand, and on the other hand, the stakes related to the proposal of a personalized assistance approach for calculating, during the learning process, the revealing indicators of the difficulties encountered by learners.

Our proposal is based on the collect of an interaction traces according to a predefined formalism which describes the concepts and relationships manipulated by the learners in ILE. These traces can be considered as a source of knowledge that the system can use in order to provide individualized assistance for learners. It involves analyzing the traces left by the learners during their activities for calculating the revealing indicators of the difficulties situations that require the proactive assistance interventions. Besides, these revelations can be used to enrich the content of the assistance system for adapting to the new situations not anticipated during the design phase.

The article is organized as follows: Section 2 presents the problematic and the research questions of our work. Section 3 presents the related works. Section 4 presents our approach and our system architecture with the theoretical foundations. It details the IMAC model we have proposed to represent the assistance situations, the classification of revealing indicators, the proposed indicators with their formulas and the treatment process of indicator calculate. We present in Section 5 our environment called Modeling and identifying the situations of Needs for assistance (MISNA). In Section 6, we discuss the relationships between the assistance situation and learners' traces through an experiment, conducted with 40 students, to validate our assumption about deducing difficult situations from learners' interactions. In Section 7, we present our results and discussion. The case study, in Section 8 and finally Section 9 concludes and future perspectives.

2 Problematic

This work aims to develop an active and personalized assistance system, capable of identifying the learners in difficult situations and providing the appropriate assistance.

How to improve the acceptability of the assistance system? How to raise its effective use by learners? and, How to favor the learners' persistence? This is the general problematic of our work. For this, we focus on the analysis of the interaction learners' traces on one hand and on the positive influence of proactive interventions on learners' motivation, on the other hand. Therefore, many research questions arise:

RQ1: *Which difficult situation nature is appropriate to web-based learning systems?*

RQ2: *How to model the assistance situations and the difficulty notion?*

RQ3: *On which criteria we take the initiative for proposing a proactive assistance?*

RQ4: *Is it possible to reveal automatically information about difficult situations from interaction traces and how can be achieved?*

3 Related works

Much effort has been made in an assistance system domain, in order to offer an adapted and personalized assistance to ILE's learners. For instance, we can mention the works offering the interfaces that "give and take advice" in interaction with the users [20]. The web browser Letizia gives advices and proposes assistance to the user, the user can accept, ignore or reject the proposal. The works aiming to help in the classification of electronic messages [13], in the use of design tools [15] or help in the navigation on complex websites [33]. Although this works use the interactions user-environment stored in memory, in order to propose to the users the action suggestions, the classification techniques for organizing messages, and take a reasoning-based rule in order to complete a design case. However, these assistants are based on pre-defined strategies that prevent them to develop for adapting to the new situations that are not anticipated by their designers, so they are based on a specific model for a specific application.

However, the generic adaptive assistants are designed for adapting to users in individual way to one or more needs, whether explicit or not. According to [21], the generic assistants are based on the help individualistic approach in the generalization process for automation. These tools are applicable to various fields of knowledge, to various host systems (assisted system) as described in [7]. This generic assistant is made up of a task model, an user and a group model, as well as a set of assistance interventions allowing to respond to the user's needs by providing appropriate assistance. Generic adaptive tools exploit the knowledge they have on users for adapting their behavior and for adapting to other users have the same case of difficulties [30].

There are also, the assistance systems that use the learning traces. These systems allow analyzing natively or externally the produced traces [3]. For example, the Pixed project [16] reuses learner's interaction traces in order to help them to find their way. This system is an application of the Musette approach (Modelling USEs and Tasks for Tracing Experience) to ILE. This approach consists of exploiting the interaction traces to aim the activity analysis needs and equally the help to the user. An External, a trace analyzer will allow finding in the database traces a similar episodes to an explain task signature. In [26], the authors provide an approach for collecting and exploiting communication traces of a forum to provide the help to the learners, tutors, teachers and researchers during and after their activities. His proposal focuses on two points: (1) the tracing communication activities and (2) the tool proposal allowing the tutors and the learners to analyze and to visualize, in real-time, the obtained traces. The Tool proposed by [5] is also a work concerning the assistance systems based on traces, this system proposed eighty indicators (the individual indicators, the group indicators and the general indicators) whose aim is to provide a direct assistance to the users (including the learners working in collaboration) to activate their metacognitive processes, allowing them to regulate their activities and offer to teachers the possibility to identify the situations and the difficulties that require the regulatory interventions.

However, most of these systems don't provide individualized and adapted assistance in real time assistance to the learner. They integrate a traditional pedagogical approach (behavioral) based on the prescriptive and the specific models for a specific application instead of adopting the recent didactic approaches (Constructivism and Social-Constructivism), which are based on the open models to provide a realistic environments rather than pre-determined learning sequences [2].

Thus, these different systems are generally based on the idea that learners (or users) are self-regulating, which means that they manage their learning independently. For this, they provide assistance only at the request of the student. Nevertheless, several studies have shown that most learners do not know that they are in a difficult situation and whether they know it; they prefer to use the training in order to acquire the necessary knowledge, or they ask their colleagues. Consequently, the help systems are usually ignored or rarely consulted [6].

In this paper, we focus on the development of active assistance system capable of providing a spontaneous assistance (that is to say, relevant and well-timed) to ILE's learners, either to their request or at the system's decision. For this, we focus on the tools based on the sharing and reuse of experience, which aims to find the right system intervention dosage according to the learners' needs.

4 Approach

To be useful and effective, an assistance system must be capable of providing to the learner the necessary assistance at the exact moment, when he really needs it. In order to determine this moment, it is necessary to identify the difficulties that the learner will encounter during his learning and as it is not possible to predict all difficulties at the time of system design [14] it is conceivable to calculate a revealing indicators of these difficulties during the learning sessions from learners' interaction traces.

However, it is necessary, above all, to define correctly, the key concepts of our approach:

- **Learning difficulty:** According to Perraudeau [30]: Learning difficulty is an ordinary time of learning that is not to punish, but to take as an activity indicator of the learner." This difficulty is individual or social source; the personal one is revealed in the complex relations between the development of thought and the knowledge to acquire. However, the social one is revealed in the relations of the learner with others through two dimensions: one macro-social (family, culture) and the other micro-social (relationships with other students, teachers and the learning context). In this Research paper, we interest in the kind of difficulties that have their origin in the mobilization of the thinking operations and the procedures implemented, like discovery or research complex tasks and to micro-social difficulties.
- **Assistance situation:** the assistance situation is a formalism of assistance specification, formulated by a couple of a problematic situation and an assistance proposal.
- **Problematic situation:** in literature, the problematic situation is a general learning strategy, when the teacher confronts the students with an important problem. In our system, the problematic situation is a learning situation proposed by the teacher with his a prevention problem.
- **Assistance proposal:** is an assistance action made by assistance designer for responding to learner's needs. The assistance actions in ILE are realized by a set of assistance means like: message, example, and change the interface of ILE.

In order to deduce the assistance situation automatically by the learning indicators in ILE, we need first to specify which assistance situation is appropriate to web-based learning systems and by which indicators we can be detected. The following sub-sections provide some answers, describing our approach, explained in Figure 1.

4.1 Difficult situation modeling

Our assistance characterization is based on a formalism which models the assistance situations in couple form problematic situation and assistance proposal (explained in Figure 2). The problematic situation appears with a model that specifies the learning moments when the learner needs assistance by a set of characteristics: a Trace indicator, a modality of intervention, an Aspect

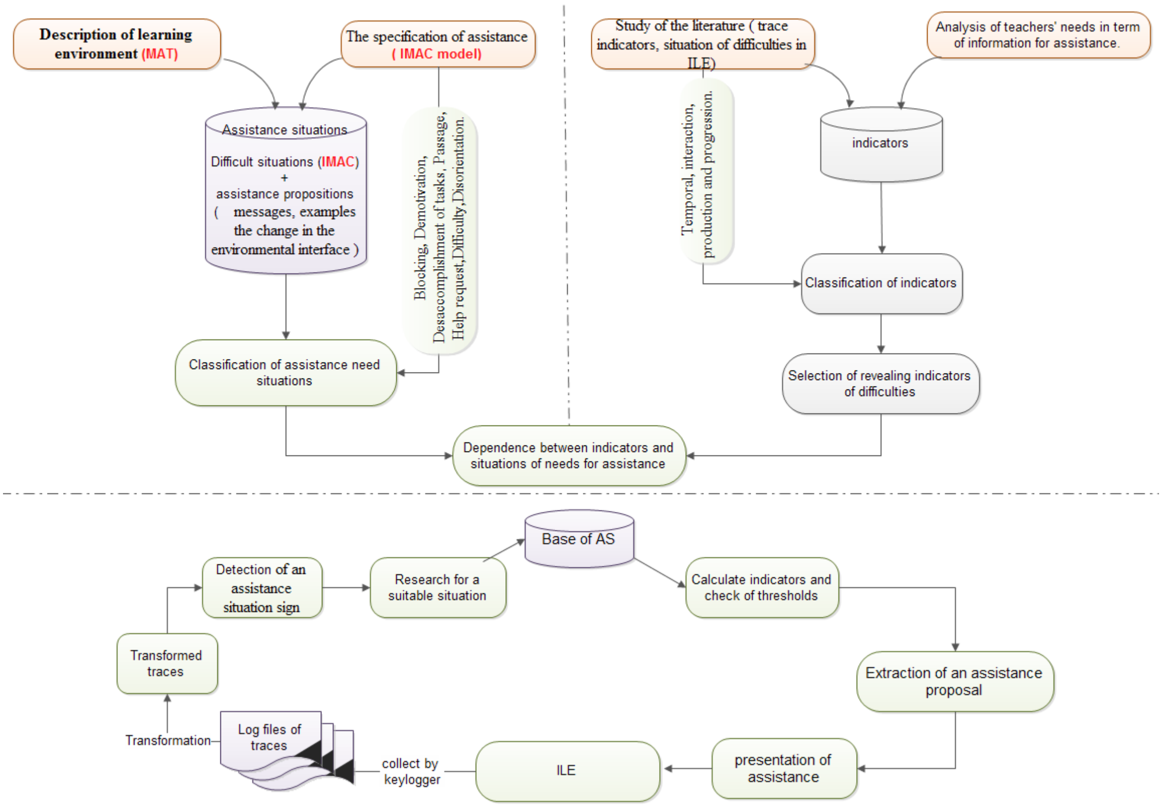

Figure 1: Architecture of the Assistance System.

and a Category. The assistance proposal is defined by assistance means associated to component of learning environment.

4.1.1 IMAC model (indicator, modality, aspect and category)

IMAC is based on four components: the trace indicator that reveals the learner difficulties, the modality for specifying the form of intervention, the aspect that determines the assistance dimension and the category that indicates the kind of situation.

a. Learning Indicators

In order to assist the learner's activity and to determine the conditions of the proactive interventions, the revealing indicators of learners' difficulties are offered. To calculate these indicators, we use the transformed traces (traces collected after processing, defined later). Each indicator is defined by a calculation rule and an acceptability domain of values allows identifying the critical situation that may be an assistance situation. The assistance system intervenes, if the indicator' value is in its domain of values. For example: the inactivity time indicator above to a threshold (defined by an expert) can be an assistance situation' indicator of blocking kind. If a learner clicks on many areas of the interface for a relatively long time, it could mean that he is looking for something, he is lost or he is disoriented.

b. Intervention Modalities

In the field of the learning environment, two style of intervention exist: proactive and reactive, *a* proactive style when the tutor or the assistant intervenes spontaneously beside the learner and a reactive style when the tutor or assistant only react to the learner's request. However, the assistant can decide to intervene proactively throughout of training or in specific times. This intervention can be systematic or opportune.

In the present work, we are particularly interested in the proactive modality to anticipate the difficulties encountered by the learners, and consequently to reduce the perturbations that could be associated there.

Thus, we have identified three types of assistance according to three intervention modalities:

- A reactive assistance that represents the learner' request to his assistant or his peers and vice versa, enabling them to advance in their task.
- A proactive assistance that represents the means and strategies provided by the upstream assistant and before any use of actors, in order to mediate this process. The proactive assistance may be systematic or *opportune*.
  - In a **systematic** proactive assistance, the assistant decides to intervene in a proactive organized manner when, for example, at the end of a stage, the assistant provides significant information for the rest of the activity.
  - In an **opportune** proactive assistance, a trigger sign (a particular committed error, an irrelevant choice, etc.) is the opportunity for the assistant intervenes, for example, in order to orient the learner towards more efficient learning strategies. In this system, the release sign is a trace indicator.

c. Aspect

The problematic situation can be characterized by an Aspect or a dimension, which determines the content which brings. Many researches are focused on this characterization, such as the authors in [34], when they are interested in the didactic dimension of the help. In [26], the authors are looked for the cognitive dimension, while the author in [37] is interested in the technological dimension.

Thus, on the basis of the help dimensions' topology proposed by author in [18], we associated to the assistance needs situation seven aspects:

- ***Cognitive Aspect:*** we connect to the cognitive aspect, every critical situations when its content focuses on the comprehension and appropriation activity. For

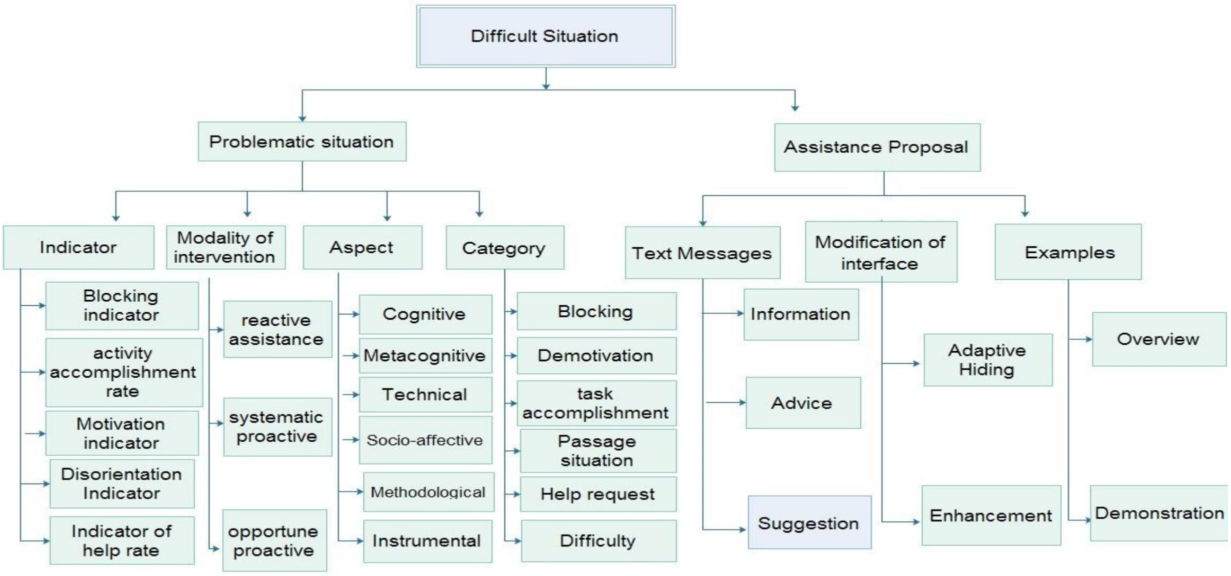

Figure 2: The IMAC model.

example, the analysis of the tackled problem, the confrontation of views and the incitement to apply concretely the discovered concepts, the blocking in theoretical learning and memorizing or reasoning difficulty.

- ***Metacognitive Aspect:*** In this aspect, we group every critical situation comprises the problems on the new knowledge construction activities, which need a metacognitive reflection.
- ***Organizational Aspect:*** for the organizational aspect, we adjust every critical situation comprise on the organization of students' work in a different category, qualified according to the authors of "organizational", "regulative" or "managerial" [32] such as, the situations of time management problems that facilitate the planning of activities, in order to respect the deadlines.
- ***Technical Aspect:*** We attach to the technical aspect every situation related to the technique such as: point out a technical problem or a malfunction on the machine, a connection problem, the problems related to the use of Training software: ask how to run or to work particular software.
- ***Socio-affective Aspect*:** it groups the assistance situations intended to support the socio-affective assistance of social order, such as, the difficult situations to set up the positive relationships between the users (learner and teacher), the contact problems and the situations of collaboration and communication problems.
- ***Methodological Aspect:*** for this aspect, we are very interested on the main methodological problems situations that encounter the learners. For instance: the problems of the learning resources management, the research of the methods and the approaches to achieve some activities.
- ***Instrumental Aspect:*** a situation is called instrumental, when the learner searches the minimum information that him lacks to succeed the task by his own means [27]. We can determine this kind of situations via a mastery goal indicator, when the learner looks to develop his skills. Also, different authors such as, the authors in [35] show, that more the learner pursues a mastery goal, more he searches the instrumental help and so he is in an assistance situation.

d. Categories of Assistance Situations

The aim of assistance systems in general, is to respond to a particular need, specific to each learner of the learning system that is in a situation of exchange in foreign language, of blocking or interrogation facing to many choices that are available to him [25].

We tried to generalize these situations that are related to a specific domain, in order to establish this topology.

- ***Blocking situation***: We detect a blocking situation when, after a more or a less fruitful period of trial, a learner still fails to progress. Therefore, his behavior is characterized by a refusal, a provisional and an apparent inability to pursue the learning and to react to a situation (GDP Larousse).
- ***Demotivation situation***: according to the author in [41] "the students in learning difficulty have often motivational problems. Their difficulties to learn, their many failures and their image in the eyes of other students bring many of them to demotivate and to loss all interests to learn in a school context". According to this principle, we can reveal a difficult situation through the value of the motivation indicator where, according to the same author, "the students that have learning difficulties are more likely to have a low motivation or a fragile motivation than the others". That is to say, if the motivation indicator value is low, the learner is in a difficult situation.
- ***Situation of task accomplishment***: in the training session, the learner must learn, improve and develop his knowledge and his skills from the professional tasks that are the well-defined units of work. Each unit is divided into an organized sequence of steps for the tasks of the procedure kind or the guidelines that have to be applied for the tasks based on principles, like "to organize a conference". Therefore, the learner can be blocked in a stage or in a guideline that prevents him to accomplish his task correctly and to achieve the course's goal.
- ***Passage situation*:** the content of the online training can include the learning resources, the interactive online lessons, the electronic simulations and the work tools. These various components put the learner in a confusing situation, where he is not capable to select the optimal methodology of navigation and he will not be able to answer a sequence of questions: Which path, I will choose? ", "What component, I will consult? ", "what do I have to do now? "," What is the next step". In this case, the assistant should intervene in order to provide to the learner guidelines for achieving his learning goal.
- ***Help request:*** in the learning sessions, the learner reacts according to the context and the tasks; ask a question about the detention, the steps that follow, the time that he is allotted and the organizational succession. Through these questions the learner looks for steps to be followed in order to realize the job he has to do [18].
- ***Difficulty:*** being in a situation of learning difficulty means having problems at level of perception, understanding and (or) use of concepts. These problems cause a delays in a development and (or) difficulties with one or all of These aspects: organization in reasoning, attention, memory, reasoning, coordination, communication, reading, writing, spelling, calculation, social skills and emotional maturity.
- ***Disorientation:*** to be disoriented in terms of progression in the learning system, means having difficulties for: identifying his position in the structure of information, reconstruct the path which has brought him to this node, discern the possible choices which available to him, select a destination and generate a path to a node which he knows his

existence [12]. In [11] the authors defined the disorientation by the difficulty to extract the information in order to realize a task or perform the treatments on content such as the understanding, the selection or the learning.

4.2 Indicators identification

In order to provide to ILE's learners a proactive and a personalized assistance, the revealing indicators of their difficulties have been proposed. The revealing indicators are triggering conditions of the assistance, which through their values, the system detects whether the learner in a situation that needs help or not. The calculation of these indicators is based on the analysis of learners' interaction traces with ILE.

For identifying these indicators, we acted on a studied of state of the art on learning indicators, digital traces, as well as the assistance in ILE, on the one hand. On the other hand, we made a survey (on needs of online assistance) with several teachers, for exploiting their experiments to determine some parameters allowing identifying signs and characteristics of the difficult situations encountered by the learners during a learning sessions.

In order to provide generic indicators, we asked the teachers to answer a set of question on (observed actions, training time, number of sent messages, rate of individual production, forum participations, percentage of activity realization, etc.) which necessary for obtaining global view on learning situations. As a result, in the 13 responses collected, we identified a set of indicators that have been classified according to three dimensions: time indicators "The temporal aspect", indicators on the learners' interactions "interaction aspect "and indicators of learners' production "The aspect of production and progression".

4.2.1 The temporal aspect

The training time remains always an important factor, to indicate the learner's progress. In psychometrics, many studies have demonstrated its utility as an easiness indicator with which the learner complete a task [21];[38];[40];[43]as a task's difficulty indicator [17] ;[23] ;[44], and also as a motivation indicator in ILE [1] ;[7].[8].

In order to detect the assistance situations, we considered that is very important to define the following temporal data:

- The real-time of training in active session.
- The inactivity time: This parameter can be an indicator of blocking cases.
- The time spent for passing of task to another: this parameter can be an indicator of possible disorientation.

4.2.2 The interaction aspect

To achieve relevant assistance, the system must analyze the learners' interactions. For this reason, we have taken in consideration four types of interaction: cognitive interactions, social interactions, interactions of navigation inside and outside the ILE (action on machine files or free navigation on the web).

➢ ***Cognitive Interactions:*** this type of parameters gives some information about learner and his handling method of objects and pedagogical resources available in learning environment. From this information, the

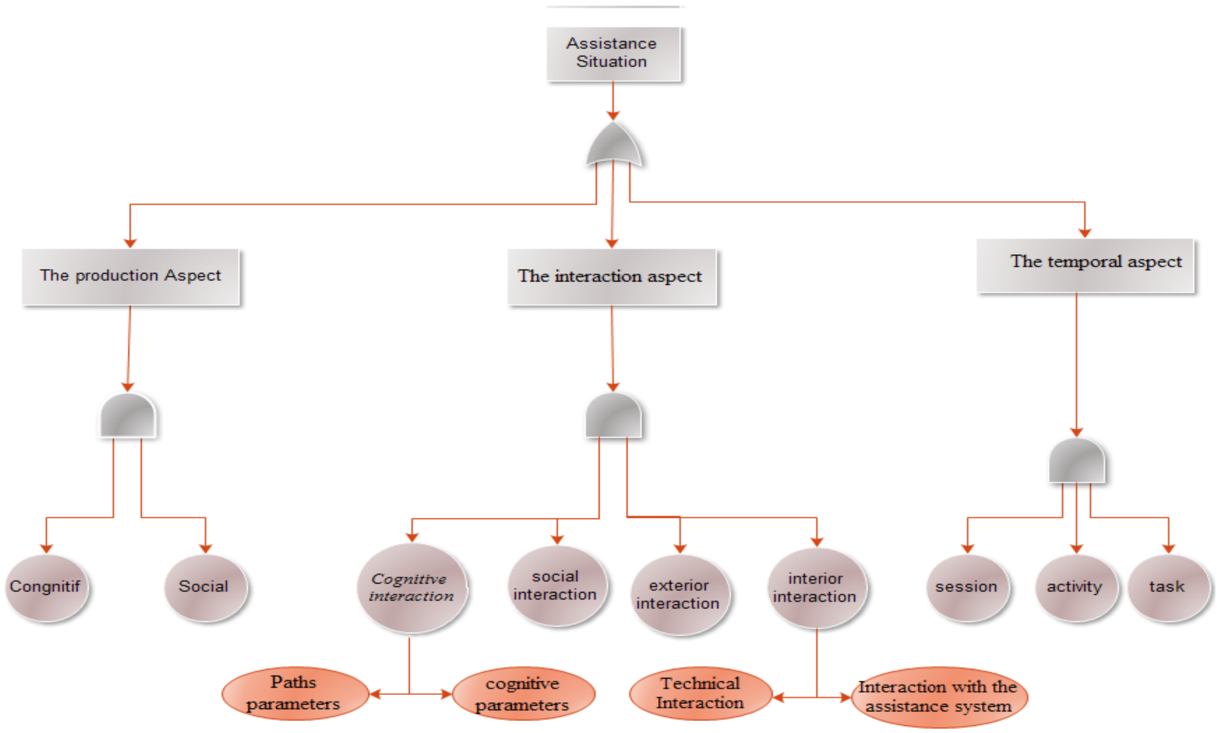

Figure 3: Indicators Classification.

assistance system can comprehend the learners' objectives. Two subtypes are distinguished:

- Information about the use and the handling of resources called the Paths parameters. For example, a learner in ILE can manipulate pedagogical objects through the access to its content, to certain of its technical components that can be buttons, scrollbars (scrollbar), and a menu. And can to navigate to a learning object to another. This kind of parameters may allow the assistance system to define the critical moments in relation to the environment functions (for example: as the learner clicks the button X)
- Information about the knowledge manipulated by learners, we call them cognitive parameters. These parameters allow the personalization of assistance according to information related to the acquisition strategy of knowledge, of expertise and of problem resolution adopted by the learner.

➢ ***Social Interaction:*** the social parameters inform about learners' communicative interactions with the other participants (tutors- teacher and peers) by communication tools (email, forum ... etc.). For example, a learner uses the forum in order to get some information about the course, seeking the help of his tutor or his teacher. This type of parameters allows the assistance system for detecting some situations of help request through the semantic proximity indicator between sent mails, consulted forums and the course content.

➢ ***Navigation interactions inside the environment**:* this type of parameters gives information about the use and the handling of tools and about system functions. We distinguish two subtypes:

- *Technical interaction*: These parameters provide information about any technical problems that may encounter the learners during the use of resources or tools of ILE.
- *Interaction with the assistance system*: Through the collection of this information, the system can define the practical difficulties that learner may meet during learning sessions. For example: according to the search keywords used by the learner during his interaction with the assistance system.

➢ ***Navigation interactions outside the environment**:* Some studies as well as the authors in [6], they have shown that most users, when they encounter difficulties, they prefer, either to use the training for acquiring the preliminary knowledge necessary to the software use or to call for other participants through communication technologies (mails, discussion forums). Consequently, we aim to analyze the learners' interaction and navigation traces outside the ILE during the learning session in order to identify these difficulties situations.

The idea is to save these interactions and to consider them as a source of knowledge that the system can use to detect assistance situations on one hand and to construct and to update the contents of the help, on another hand.

4.2.3 Production and progression aspect

During the training sessions, the learner discovers the software at the same time while he tries to accomplish his learning task, hi is thus facing to double difficulties: learn to use the software functionalities and to apply his knowledge and skills. In order to detect this type of difficulties, the system should calculate some indicators such as, progress indicator in the course, proportion indicator for learner's productions, the progress rate indicator, indicator of success and completion for each activity and task, indicator of percentage and realization level of the activity.

These indicators can be classified into two types: cognitive and social.

- Cognitive: we link to the cognitive type, every indicator that gives to the system the ability to obtain the information about the personal progress of the learner and on the realization percentage of his activities.
- Social: The calculation of this type of indicators offers to the system the information about the collective production of the learners and about the global progressions of the groups.

To understand the process allowing to calculate these indicators and to deduct the situations of assistance needs, our solution is explained in the next section.

4.3 Revealing indicators of difficulties

In order to make our assistance approach applicable for ILE, we were interested in proposing indicators that can be produced from learner's actions trace. Our approach aims at exploring the possibility of deducing the difficulties encountered by the learner based traces interaction.

According to the classification of indicators and the category of assistance situation, we proposed five indicators with their thresholds and their formulas. For the selection of these thresholds, we have made several adjustments to the calculation of each indicator based on preliminary test, in order to estimate the appropriate values. However, our system offers the ability for assistance designers to change these thresholds. The selected thresholds shown in Table 1.

	Inactivity maximal threshold	Semantic similarity threshold	Threshold for the Accomplishment
Selected value	3mn	0,3	50%

Table 1: The value of thresholds.

▪ **Blocking Indicator**: This indicator can be measured by the calculation of the inactivity time during the learning session. However, it is not always easy to distinguish the inactivity time for actual working time (real time learning) [4]. For this, we are oriented towards the analysis of the navigation interactions outside the learning session. This allows knowing, if the learner tries to accomplish his task, or on the contrary, he wants to change it or abandon it completely.

In order to inform whether the learner is more active or not, we have used an indicator of interactivity rate that takes into account the number, the type and the handling duration of action.

$$\boldsymbol{R_{int}} = \frac{\sum_{i=1}^{n} \boldsymbol{numbre\ of\ actions}}{\sum_{j=1}^{m} \boldsymbol{numbre\ of\ page\ concepts}} \ldots\ldots\ldots.(\mathbf{1})$$

N: number of actions performed by the learner on the page and m: number of page concepts.

If the rate of interactivity tends to 0, this means that the number of learner’s actions on the content of the task is relatively low, which implies that the learner is inactive, so he is in a blocking situation requiring an intervention of assistance. However, if the number of learner’s actions on the content of the task is relatively high, the rate of interactivity tends to 1 or more, which implies that the learner is active. In this case, the system will start the calculation of another indicator: the indicator of semantic similarity between the content of the task and the content of the pages visited by the learner during the learning session. This indicator was inspired from the work of [4] who studied the semantic similarity between the courses and pages visited during the learner navigations [19].

Sim(c_i,p_i): the semantic similarity between the studied course and the visited page. It is calculated by using the following formula [4]:

$$\boldsymbol{Sim(q,d)} = \frac{\sum_i \boldsymbol{q_i \times d_j \times sim(i,j)}}{\sum_i \sum_k \boldsymbol{qi \times d_k}} \ldots\ldots\ldots.(\mathbf{2})$$

With:

- I is concept of the document q (the course);
- J is the concept of document d (page having the maximum similarity with i);
- K represents the concept of the document d;
- q_i And d_j are the weight of the concepts i and j in documents q and d;

Sim (i, j) is the semantic similarity between concepts i and j, calculated by the Lin’s formula [19].

$$\mathbf{Sim(i,j)} = \frac{\mathbf{2.IC(lcs(i,j))}}{\mathbf{IC(i)+IC(j)}} \ldots\ldots\ldots.(\mathbf{3})$$

Where IC determines the information content of a concept and LCS finds the lowest common subsuming concept of concepts i and j.

If the semantic similarity is relatively high, it means that, the learner has consulted other content having the same subject of task, either in order to learn more or to explore new perspectives. Here, we estimate that this learner is inherently active and therefore is not blocked. But if semantic similarity is very low, it means that the learner has changed his task or abandoned according to waste of motivation facing the difficulties encountered. In this case, the learner may be in a blocking or abandonment situation.

▪ **Indicator of Activity Accomplishment rate:** The educational structure of a course in ILE is divided into modules, activities and tasks. In order to calculate our indicator of accomplishment, we used the principle of Despres [9], where each task is a feasible entity in all or nothing, that is to say, which can take only two states: "accomplished" or "not accomplished." Thus, for each task, we must associate a weight and a coefficient. The task weight sum of the same activity must be equal to 1. Therefore, the percentage of activity accomplishment is calculated according to the weight of the tasks that the learner has accomplished.

$$\boldsymbol{R_{\mathrm{Accomplishment}}} = \mathbf{100} \times \sum_{i}^{n} \boldsymbol{Pi} \ldots\ldots\ldots.(\mathbf{4})$$

With Pi: the weight of tasks, n: the number of completed tasks.

- If $\boldsymbol{R_{\mathrm{Accomplishment}}}$ ≥ 50%, we estimate that the learner has completed his tasks, he does not need a help and if he needs, he asks the assistance.
- If $\boldsymbol{R_{\mathrm{Accomplishment}}}$<50%, we estimate that the learner is in a difficult situation and he needs a help to accomplish his tasks.

▪ **Motivation Indicators:** Three types of indicators are defined in the literature in order to measure learners’ motivation: the indicator of interest and pleasure to accomplish a learning activity, the indicator of cognitive engagement, and the perseverance indicator [41].

❖ **Indicator of Interest**: it is very difficult to measure the learner’s interest. However, in our case, we have use only the rate of concentration to calculate the interest. This indicator can be measured by comparing between the activity developed outside the training content and the activity performed on the platform or the course and depending the recorded periods of inactivity.

$$\mathbf{I_{interest}} = \frac{\sum_{i=1}^{n} \mathbf{sim(Ci,Pi)}}{\mathbf{N}} \ldots\ldots\ldots.(\mathbf{5})$$

With: Ci: the performed concept of task; Pi: the page visited during the performing of task; N: number of pages visited.

This indicator was used by author in [39] to determine the types of motivation and by authors in [4] to determine learning styles. But it will be borrowed here to determine the difficult situations. However, this indicator can have three values:

- *Low interest*: if its value tends to 0, the semantic similarity between the proposed task and the content of visited pages is very low. This means, that the learner has a low interest to the proposed task and consequently, he is not motivated. In this case, we assume that he is in a difficult situation.

- *Medium*: If its value is equal to 1, this means that the learner has consulted only the content offered in training. This means, that he was not interested essentially by the activity itself, but he accomplishes it, because it is imposed. In this case, the learner is not in a difficult situation.
- *Interested*: If its value is greater than 1, the learner consults other contents that are semantically close to the content of the proposed task. This means, that he has consulted these contents voluntarily and by interest. In this case, it seems that he is motivated and thus is not in a difficult situation.

- **Indicator of Cognitive Engagement degree:** To calculate this indicator, we based on the principle of Rolland [44] that reflects the cognitive engagement by the fact that a student or learner will navigate in depth on web sites. In other words, he will examine all aspects of these sites and not only the images or the sound effects. Moreover, we consider that all concepts are characterized by a depth measuring their distance from the root.

$$\mathbf{D}_{\mathbf{Cog-eng}} = \frac{\sum_{\mathbf{i}} \mathbf{Di} * \mathbf{depth(ci)}}{\sum_{\mathbf{i}} \mathbf{Di}} \ldots\ldots\ldots. (\mathbf{6})$$

With depth (ci): the depth of the *concept Ci and Di:* Di: the consultation time of concept Ci.

This indicator can have three values:

- ***Weak:*** if the learner consults the learning environment superficially, that is to say the learner examines only home pages or images and sound effects.
- ***Average***: the learner uses an intermediate navigation strategy.
- ***Strong***: If the learner's navigation strategy is more in depth. In other words, the student consults and examines the concepts of great depth.

- **Perseverance Indicator:** the perseverance is one of the indicators that seem more relevant to measure learning motivation in distance education, than the interest and pleasure to accomplish the task. According to the author in [44], we may be interested in sound or visual effects of a website and take pleasure in "surfing" on its contents without actually learn. This perseverance is manifested by the time that the student devotes to accomplish a task or an activity and the number of times that he repeats it [44].For this, an indicator of correspondence rate between the realization real time of the activity and the time spent by the learner for performing this activity with a component for repetition, has been defined.

$$\mathbf{R_C} = \mathbf{D_{réal}} / \mathbf{T_{effect}} * \mathbf{N_{rep}} \ \ldots\ldots\ldots. (7)$$

Where:

- R_C is the indicator of "correspondence Rate"
- $D_{réal}$ is the realization period.
- T_{effect} is the effective realization time defined by the teacher or the course designer
- N_{rep} is the number of repetition

The different scenarios:

- ***Scenario 1*:** If R_C> 1, this means that the learner spends more time for doing his activity. In this case, we assume that the learner has persevered to accomplish his task despite the obstacles and difficulties that he encountered.
- ***Scenario 2*:** If R_C<1, and the accomplishment rate indicator inferior than 50%, this means that the learner spends less time to perform his activity. At this point, we assume that perseverance of the learner to accomplish his activity is very low and he is considered as not motivated. We assume that these indicators are factors of dropping out in learning and so, we are in difficulty situation.
- ***Scenario 3*:** If $R_C \leq 1$ and accomplishment rate indicator is superior to 50%, it means that the learner is able for doing his activity in the effective time. In this case, we assume that the learner's persistence and motivation tend to average, which implies that the learner is in a normal learning situation.

- **Disorientation Indicator:** The ILE can be considered a problem space when each movement or interaction is a revealing of the learner's cognitive activity type (understanding, disorientation, information confrontation, etc.). In this meaning, the authors in [33] proposed four variables for revealing the disoriented learner:
  - Redundancy (red): This variable measures the number of nodes opened more than once by the learner during the learning phase.
  - The number of additional readings (read-addi): the learner can ask for additional reading to understand the concept in progress. If the request is repeated several times, this means that there is a problem.
  - The number of additional solutions (solu-addi): the number of times that the learner answers questions he has already given a solution, then he can continue his work.
  - The number of returns to a previous part (ret): The problem arises if the learner has acquired concepts and he asks, subsequently, to return to these concepts.

We take these variables and we add another to define our disorientation indicator:

The Number of Clicks (nb-clicks): the problem arises if the learner clicks on many concepts or areas of the screen for a relatively long time. This may be a sign that he is looking for something or he is lost in the learning environment.

We consider as a disorientation indicator, the sum of the values taken by these variables:

$$I_{dis} = \mathbf{red + read{-}add + solu{-}addi + ret + nb{-}clicks} \ldots\ldots\ldots(8)$$

The different scenarios:

- ***Scenario 1*****:** When the values of these variables are low, it means that the learner is well oriented in the environment.
- ***Scenario 2*****:** If a variable value is high, it does not necessarily mean that the learner is disoriented, but, it can rather confirm a learning style.
- ***Scenario 3*****:** when several variables are characterized by high values, this indicates disorientation in the environment.

- **Indicator of Help rate:** During the learning session, the learner can seek help, in order to get out of a blocking situation. Depending on the nature of this solicitation, we can determine: the disorientation of the learner, his navigational difficulties in the learning environment, his apprehensions to go into details... etc. And we can also detect its failure signs (personal, technical, skills...).

$$\mathbf{R_{Help}} = \frac{\sum_j \mathbf{Hj}}{\sum_i \mathbf{Ci}} \ldots\ldots\ldots.(9)$$

With Hj: the number of call for help and Ci: the number of task concept**.**

4.4 Indicators calculation

To calculate the five revealing indicators, we propose, a treatment process composed of two steps: collection of traces and transformation.

- **Collection of interactions' Traces:** three approaches are available to perform the collection of traces [4]: user-centered design approaches, server-centric approaches and specific software-based approaches. Each approach has some advantages and disadvantages. In order to have a complete perception of all learners' activities and the information about his inactivity time during learning sessions, we have opted for the user-centric collection approach through a program installed on the learner's machine. Therefore, we have used an existing keylogger. Among the collection software available in the free version, we have chosen MiniKey; it allows saving all the actions of the learner on his machine, whether made inside or outside the ILE in real time.

However, the traces generated by this tool are primitive and difficult to exploit as such and required a transformation and a modelization. Moreover, it must undergo a pre-treatment process to eliminate the noise (not found pages, URLs wrong)

- **Transformation and formalization of traces:** Generally, the traces collected by the keylogger software are digital traces that contain rich information about user's behavior. However, the collected traces quantity is usually huge and the traces are very detailed which makes the interpretation process difficult on the analyst side [24]. A transformation mechanism is necessary for obtaining an adequate volume of traces at the right level of granularity that makes the interpretation process easier. This transformation process is based on some methods: cleaning (To eliminate the noise), filtering (To extract relevant tracks according the objective of the analysis) and traces structuring (to structure and to model the tracks of interaction).

Our aim is to use the traces of learners' experiences in order to calculate the revealing indicators of difficulties and in the absence of a standard trace model. We applied the model proposed in IDLS [4] to our context of assistance.

The trace is defined as an observed temporal sequence, providing the information about the learner's actions collected in real time from his interaction with the learning environment and with external resources, such as files or programs running on his machine or on the Internet. Formally, **T <U, (O1, O2, O3 ... On)>**

- U: observed user,
- Oi: observed trace. Each **Oi** is a couple of (Pi, Ai) , when:

Ai is a learner's actions, for each action Ai we have recorded all learners' interactions with the content of the page, when each action is identified by:

- An order of appearance
- A date, hour and execution time
- A type of action: (mouse actions: left, right or middle button click, the keyboard keys: F1, F2, CTL + C and CTL + X, etc.)
- An object on which the action was performed (scroll, link, text, picture, menu, etc.)
- And the type of interaction performed (open a file, search, copy, paste, print, etc.).

Pi is a page consulted by learner, for each page Pi we have stored:

- URI (Uniform Resource Identifier)
- title T, if it is available
- the program that have executed it PG
- content, we distinguish three types:
  - Pedagogical resource "R" if the content is a set of concepts (courses).
  - Learning activity "AL" if their content is an exercise, a test or homework.
  - Browsing activity "AB", if their content is a file or a program executing on the learner's machine or on the Internet.
- Order of appearance.

5 The environment

The MISNA Environment (Modeling and identifying the situations of Needs for assistance) implements our theoretical propositions through two main tools: an assistance editor and an assistance situations detector.

5.1 The assistance editor

The assistance Editor is a tool intended to the assistance designers. It implements the IMAC model and allows us to specify an assistance system described by a set of assistance situations. The assistance editor provides two interfaces, one for the learning environment description and another for the creation of each assistance situation.

- **Description of Learning Environment**

The aim of this phase is to describe the components that the designer wishes associated to the assistance interventions. This description is based on the Reflet representation, presented in [9]. This representation allows describing the environment according to a tree structure of three levels: MAT (Module-Activity-Task). In this representation, a module can contain another modules (sub-modules) and/ or activities but an activity contains only tasks. Thus, a task may be homework, exercise to do or course to study. These different types of tasks will be represented in the form of web pages or screens composed of several objects (link, text, image, menu ...). The various components of the environment are grouped according to their type (Module, activity, task) in a database; this base can be advanced throughout the life cycle of the system through the analysis of learners' interaction traces.

An interface has been developed for the creation of each basic component without any programming skills. A snapshot of our interface is given in Figure 4; the interface is divided into two parts: The left side (see Ⓐ Figure 4) presents the components that have already been created. The right side (see Ⓑ Figure 4) allows creating, modifying or deleting a component (Module, Activity and Task).

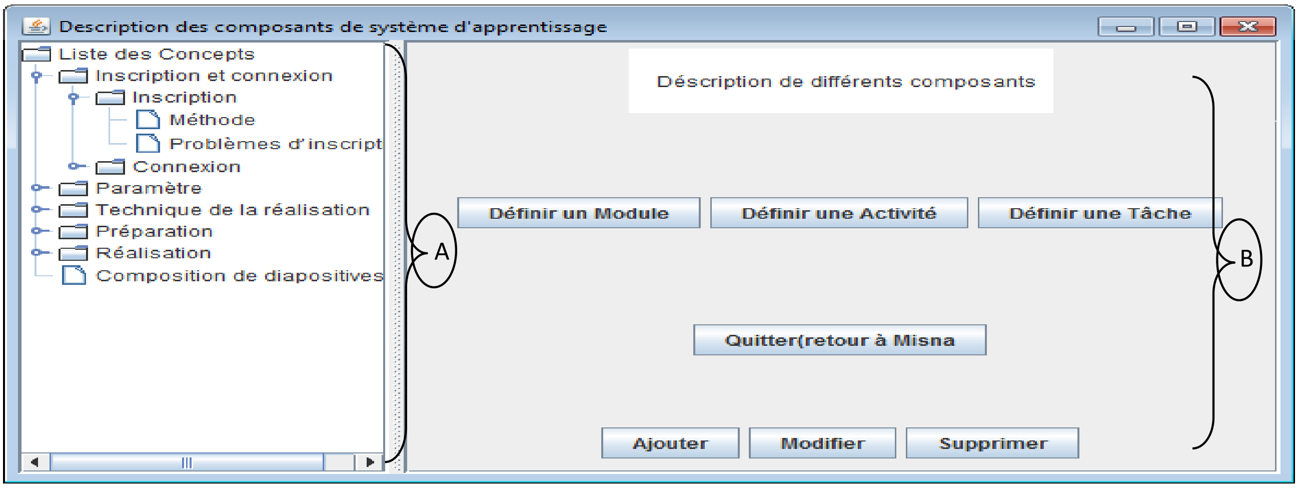

Figure 4: Screen-shot of system description.

- **The Assistance Specification**

After the description of the environment, the designer proceeds to the specification phase. This phase aims to characterize the assistance in learning environment based on a formalism that models the assistance in the form of a couple formulated in a difficult situation and an assistance proposal. Our IMAC model is used for modeling the difficult situations and three forms of assistance are adopted for defining the assistance proposals: messages (in the form of an adjacent page to provide additional information to the learner), examples (like demonstration videos) and the change in the environmental interface (either by adapting or modifying links: addition, deletion, annotation, sorting ... etc.).

In order to implement this step, we developed an interface that allows designers to enrich their learning environment through an assistance system without any programming skills. The designer must create the revealing indicators of difficult situations as well as the assistance proposals.

Figure 5 shows the interface that presents the specification phase. This interface is divided into four parts: the part Ⓐ allows creating a new situation of assistance needs. The partⒷ and Ⓒ present respectively indicators and created assistance proposals. And finally, the part Ⓓ presents the defined assistance situations.

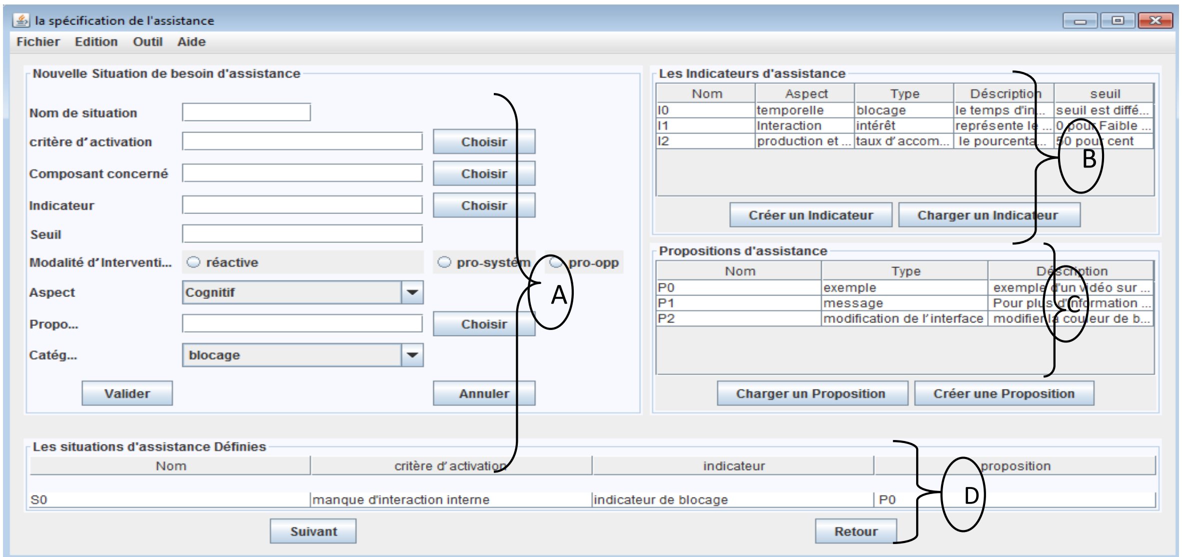

Figure 5: Screen-shot of assistance specification.

Each situation is characterized by a set of predefined parameters. The assistance designer must specify the types and the thresholds, as well as certain additional information. Consider an example related to the designer when proposes a difficult situation of blocking type, first, he must specify the detection sign (activation criteria), and he must choose, from the list of indicators (predetermined by the assistance system) a favorable indicator to this situation, that is the inactivity time indicator. This indicator is varied according to the type of the task. The inactivity time of a reading task is not the same as of a realizing a duty or of an exercise. For this, the designer must identify a threshold for each indicator. In addition, he must specify the aspect and the category of the situation and the concerned component, in order to facilitate, on one side, the indexing of situations in the creation step and on the other side, the search for a similar situation at the problematic situation in the step of executing assistance.

5.2 The assistance situations detector

In order to provide to ILE's learners, a personalized assistance in a proactive manner, we have developed a detector of assistance needs. This detector exploits the database of the assistance situations created in specification phase and the database of modeled interaction traces, in order to identify the learner in difficulty.

Over the course of learning, when a sign of an assistance situation is detected, the detector starts the information process, in order to determine some parameters about this problematic situation (concerned component, aspect and category of situation). This information will be the source of knowledge for the selection process used to exploit them in order to select the suitable situation to our problematic situation. At the end of this selection, the detector initiates the indicators' calculation process. According to the confrontation between the indicator's value and the threshold's value, the detector decides either to start the execution process to realize the proposals associated to this situation or to ignore them.

6 Experimentation

To validate our suppositions about deducting assistance situation based interaction traces and the ability for providing a proactive assistance thanks a detection of an assistance needs situations and learner's difficulties, we designed a website including forms and assistance means with the theoretical models proposed(Figure 6). This application was designed for undergraduate students at the Faculty of Human Sciences, Department of Communication at Badji-Mokhtar University of Annaba in Algeria. It aims to help these students in the course of professional presentations preparation.

Before, obtaining the license degree, it is expected that students are able to make a professional presentations using the computer software. Therefore, the Practice Works (PW) sessions have been proposed, which are assisted by teachers on computer science. However, each year, these teachers observe the problems about the methodology of presentation preparation, on top of that, the problems about the use of a computer software (like PowerPoint for example). The design of our site can be a solution to these problems; It provides to students the explanations and examples (such as Know-how) in addition to the basic concepts (knowledge) given in masterly course.

In order to test our suppositions, three series of experiments were conducted: two with teachers and the third with learners.

The first experiment involved six (6) assistance designers, three(3) teachers of methodology have a PHD Degrees in Communication with seven (7) years of experiments in the communication department and three (3) teachers of computer science are PHD students, with four years of experiments associated at the communication department. We asked these designers, in four (4) sessions of (3) hours, to work in collaboration,

Figure 6: Welcome screen-shot of MISNA website.

for describing the training content. The aim of this collaboration is the description of training environment pedagogically, technically and administratively. After this experiment, we obtained, a structured representation composed of six modules: registration and connection, parameters, realization techniques, preparation of presentation, realization and finally composition and animation of the slides. Each module is divided into one or more activities and each activity consists of one or more tasks. For example: the parameter module is divided into two activities: site parameter and learning parameter. The first one contains two tasks: parameter of site usage and parameter of the contact.

In the second experiment, we asked our assistance designers team (teachers of two modules: Computer science and methodology) for passing to the second phase of experiment, the specification phase of assistance system. Thanks to specification interface of our MISNA system, the designers defined 112 assistance situations (associated to the six (6) predefined modules), 51 indicators, 67 thresholds and 138 proposals of assistance. The assistance needs situations appear in different types (pedagogical, technical, cognitive, and methodological) and the proposals appear in three types: text messages, modification of the interface and examples. The message content is either prerequisite proposals or explanations of the following steps (Figure7).

We note that the majority of the proposals are example or message type. Probably, because the designers think that these two types are more adapted to their students' learning style.

Finally, in spring semester 2015, we asked our students to use our training site during a PW session for 90 minutes, after 5 minutes of explanation about the

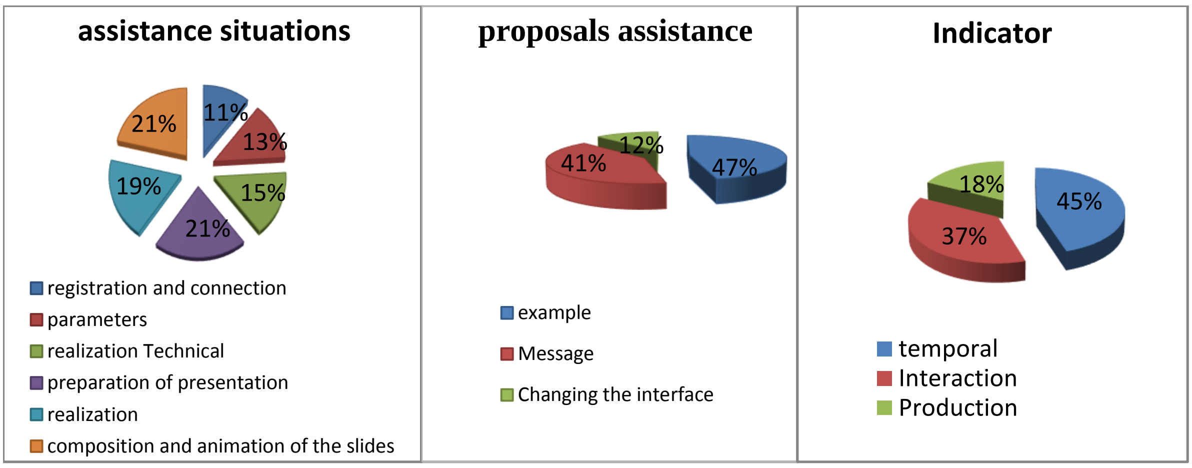

Figure 7: Results of the specification phase.

experiment objectives. Thanks to this explanation, the students are motivated to participate in our study.

This experimentation was applied with 40 undergraduate students, 14 male and 26 female, aged between 20 and 24. Their participation was voluntary and they were divided into two (2) groups of 20 students due to the number of available machines. In order to avoid the confounding variable, we have fixed the values of age and previous knowledge and we have divided the participants in equal way, where the both groups are equal in gender, age and previous knowledge according to their exam results of the first semester.

The students performed a professional presentation of a proposed text in the communication field. The proposed texts are reports made by the same students on themes related to their thematic. At the end of the presentation creation step, participants were invited to fill in a satisfaction survey about their experience using MISNA in order to measure the contribution of the interventions and assistance propositions. The learner declares his views on the relevance of each intervention by the satisfaction or non-satisfaction. This satisfaction was measured by a global manner, in two contexts; one is on time and mode of intervention and the other on assistance content.

In order to validate the proposed indicators with a data from the experiment and to verify with the students the trigger conditions, our system saves the learners' interactions after each assistance intervention, in order to evaluate the effect and the contributions of proposed assistances, the interactions are stored in log file (in XML format).

7 Results and discussion

The satisfaction survey shows that learners are relatively satisfied by the assistance interventions in particularly by those that have been triggered through an alarm from indicators such as interaction and temporality. These indicators have enabled us to easily identify learners that are lost in the learning environment or which take more time to complete their tasks. The blocking indicator and interactivity rate allowed us to get a global view of the type and nature of learners' interactions. This view allows to identify the real-time learning, and to distinguish between abandonment situations and blocking ones. These indicators show that the semantic similarity between the offered courses and the content of the visited pages, during the inactivity time, is very high which proves that (87%) of inactivity situations are situations of assistance needs. This result seems in agreement with those in the studies of [6], who found that the learners prefer to resort to the training in order to acquire the necessary knowledge to use the software and that the occasional users appeal their colleagues to overcome blocking situation (Table 2).

The three indicators "degree of cognitive engagement, correspondence rate and interest indicator" allow revealing the learners that lose their motivation in front of the difficulties they encounter during learning sessions. However, the learners reject 40% of assistance interventions identified by the interest indicator which indicates that, if the learner has a low interest does not mean that he is in a difficult situation, but he may be in a task change situation or passing to another stage. With regard to the cognitive engagement degree indicator, the experimental results show that the majority of learners (if not all of them) use the same learning strategy in average depth, which puts us in contradiction with the basic rule that indicate: each person has own learning strategy. These results forced us to examine other indicators such as the indicator of achievement and progression for these critical situations. Following this analysis, we found that 25% of learners use a surface learning strategy after the completion of their tasks. Therefore, we decided to link the cognitive engagement indicator to the task completion indicator in order to distinguish between the learner in difficulty and the one who borrows all the components of the environment in search of a global vision. Thus, regarding the perseverance indicator, 89% of assistance interventions related to this indicator are accepted by learners, which shows that the connection between the correspondence rate and accomplishment rate is very fruitful as well as the motivation rate.

At the end of the second step of experimentation (system specification), we identified the preliminary

	Nb Intervention for every learner	Profile	Nb Intervention For all the group	Nb and rate Reactive intervention	Nb and rate Proactive intervention	Nb and rate Satisfied intervention	Nb and rate Unsatisfied intervention
Group1(10 learners)	1 – 5	Fort	37	12 33%	25 67%	29 78.37%	8 21,63%
Group2 (20 learners)	5 - 8	average	122	24 20%	98 80%	93 76.22%	29 23.78%
Group3 (10 learners)	8 – 12	weak	105	13 23%	92 87%	87 82.85%	18 17,15%
Total (40 learners)	- - -	- - -	264	49 18.65%	215 81.43%	209 79.16%	55 20.83%

Table 2: Some Results related to the experimentation.

thresholds for our indicators, and during the third step of experimentation some thresholds were changed according to the learning styles adopted by our students, like the variable identifying the disorientation indicator. Indeed, a little higher number of additional solutions is not always a sign of disorientation. But, it can rather confirm a learning style. The results confirm that the competent students repeat the same task until three times in order to know the different methods of possible solutions and/or to memorize well the instructions to be followed. Thus, for redundancy and additional reading, the analysis of the results shows that a significant number of learners (65%) prefer to read the concepts acquired more than twice before they start to learn the new concepts.

According to the results of our experiment and the previous knowledge following to their exam results of the first semester, the 40 students that compose the study sample have been divided into three experimental groups:

• ***Group 1:*** when learners' profiles are strong: each learner has benefited from one to five interventions, 67% proactive and 33% reactive, with 78.37% of satisfaction rate.

• ***Group 2*****:** when learners' profiles are average: Each learner has benefited from five to eight interventions, 80% proactive and 20% reactive with 76.22% of satisfaction rate.

• ***Group*** *3*: when learners' profiles are weak: each learner has benefited from eight to twelve interventions, 87% proactive and 23% reactive, with 82.85 % of satisfaction rate.

8 Case study

In order to assess the feasibility and correctness of our approach, we will present in the following, an example of the identification assistance situation in framework comprehension the theoretical concepts (technique of realization) by analyze of interactions.

The student (1) worked on machines equipped with a key-logger, with a personal account on the web site. The interaction collection started with their connection to the web site, after activation of the key-logger. At the time of the learning activity, the key-logger provides initial trace, which describes the interactions in XML. Interaction data are temporal sequence of observation (pages and actions). These traces were then processed, by the MISNA system, in order to detect the situations of needs for assistance.

During the learning, a sign of assistance situation is detected, which is the inactivity time. The detector activates the information process to determine the parameters of this situation. The information process identifies the situation by: technical realization as a concerned component, consultation of theoretical concepts that indicates the cognitive aspect and blocking or comprehension difficulties as a category. Following these results, the system activates the selection process for selecting a suitable situation to the detected situation. This selection process selects three assistance situations. In this case, the detector activates the calculate process for calculating the indicator associated to assistance situation, which is in our case, the blocking indicator.

The calculation of this indicator uses the interactivity indicator for distinguishing between the blocking and the

Figure 8: Screen-shot of assistance message.

abandonment situation or the changing of task. We use the indicators related to the number of action performed by the learner on the page and number of page concepts. The result is 1.2, according this value; the system will start the calculation of another indicator, the indicator of semantic similarity between the content of the task and the content of the pages visited by the learner. The student are consulted three pages by his navigator (passive and active voice, example of transparent and PowerPoint software). In this case, the semantic similarity is relatively high it means that, the learner has consulted other content having the same subject of task, in order to learn more or to explore new perspectives. We estimate that, this student is active and is not blocked, but he is in difficult situation and he needs more information for these three concepts. Finally the detector decides to start the implementation process for achieving the proposals associated to this situation, as indicated in the following figure (Figure 8).

9 Conclusion and future works

This paper discussed the possibility to identify automatically the difficult situations based on learner's interaction with his ILE. To bolster up this assumption, we first proposed an active assistance approach able of providing a spontaneous assistance to ILE's learners. This approach is based on a formalism which models the assistance situations in couple form problematic situation and assistance proposal. The problematic situation appears with IMAC model that specifies the learning moments when the learner needs assistance by a set of characteristics: a Trace indicator, a modality of intervention, an Aspect and a Category. The assistance proposal is defined by the assistance means associated to component of learning environment (messages, examples and modification of interface). Secondly, we identified five revealing indicators with their thresholds and formulas. Then, we proposed our assistance system, called MISNA. We implemented this system in an operational prototype with a learning environment, an assistance editor, trace collector and our detector of assistance needs situations. The assistance editor provides two interfaces, one for the learning environment description based on structured representation MAT (Module-Activity-Task) and another for the creation of each assistance situation according to IMAC model. The detector of assistance needs situations exploits the database of assistance situations, created in specification phase and the database of modeled interaction trace, in order to identify learners in difficulty. We conducted a first experiment in order to validate the utility of our assistance approach with 40 students.

In a future work, we intend to test our MISNA system with other learning environments. We also plan to add other indicators for providing more fertility to the detection mechanism proposed by our assistance approach. Accordingly, we want to improve the proposed mechanism by involving learners' profiles management mechanism with regard to a defined formalism. In addition, we hope to add other interfaces such as supervision interfaces, side assistant and assisted.

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