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INTELLIGENT AGENTS FOR DYNAMIC OPTIMIZATION OF LEARNER PERFORMANCES IN AN ONLINE SYSTEM

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ABSTRACT

Aim/Purpose	To identify and rectify the learning difficulties of online learners.
Background	The major cause of learners' failure and non-acquisition of knowledge relates to their weaknesses in certain areas necessary for optimal learning. We focus on e-learning because, within this environment, the learner is mostly affected by these vulnerabilities due to the lack of direct contact with the teacher, who would be able to point out the learner's difficulties and help to rectify them.
Methodology	The research sample was 49 learners enrolled in an online course. We focused on three cognitive factors: language, memory, and reasoning. We propose an approach to optimize learners' performances based on two intelligent agents that model the role of a teacher: the "detector agent" and the "rectifier agent".
Contribution	The intelligent agents beneficially contribute to e-learning enrichment and the development of cognitive skills and solidification of knowledge acquisition. This is achieved by strengthening the memory, the assimilation of lessons by improving language skills, and the reinforcement of problem solving by developing reasoning and analysis capacity.
Findings	The results show that the proposed approach efficiently detects the weaknesses of learners and resolves them intelligently.
Future Research	The approach toward e-learning performance can be improved by focusing on other factors and intelligent agents that can improve the yield for learners and more effectively optimize system operation for their perceived needs.
Keywords	e-Learning, learner performances, optimization, detector agent, rectifier agent

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INTRODUCTION

At the beginning of learning within an e-learning environment, the learner is the main actor who must be interested in his/her own success. Several studies have been carried out in the field of e-learning education to improve the quality of services offered to learners and ensure the development of their skills and thus, their success. This work emphasizes individualized training paths (Idris, Yusof, & Saad, 2009; Vazquez, Ramirez, Gonzalez-Abril, & Morente, 2011), pedagogical content adaptation (Ruiz, Diaz, Soler, & Pérez, 2008; Wong & Looi, 2009), and learner guidance (Dahbi, El Kamoun, Aqqal, & El Hannani, 2009; Kamsa, Elouahbi, El Khoukhi, Karite, & Zouiten, 2016). Yet despite all of these valuable aspects, we may note the high failure and abandonment rates in e-learning, regardless of the quality of the services provided (Linard, 2000). The question that we must therefore ask is: What is the primary cause of this failure? In a traditional teaching setting, the teacher who has various skills and several roles (teacher, coach, psychologist, and so forth), helps learners in their training. The teacher may detect learners' difficulties during the learning process and try to help resolve them by proposing training programs or extracurricular activities. This does not exist in e-learning and, as a result, learners are alone with their difficulties. Thus, given the scarcity of research in e-learning that focuses on the cognitive difficulties of learners, we became particularly interested in trying to detect the difficulties that lead to the failure and drop-out of online learners and to improve learner results by using training techniques in parallel with face-to-face training.

This paper addresses three principal weaknesses of learners outlined as follows:

> **Language:** Given the vital role of language in the understanding and assimilation of content, learners with language problems have difficulties in the learning process. They cannot express their ideas and understand the context. This problem is particularly widespread among learners who did not receive a solid language base in primary school and especially in countries using foreign languages in higher education training.
>
> **Memory:** Given its major role in the acquisition and validation of training, learners who have not trained their memorization capacity quickly forget the learned concepts and cannot remember them on the day of the test.
>
> **Reasoning:** Good reasoning helps locate a problem in the problem space and solve it through logical thinking and a suitable choice of concepts or methods. Learners who do not have this skill are quickly blocked in learning more complex topics.

These three factors are essential for efficient and optimal learning. To help online learners to understand and generate maximum gain from their training, we implemented an approach based on intelligent agents that simulate the behavior and role of teachers. These agents work dynamically and automatically for efficient processing. We developed two agents. The detector agent (DA) identifies whether learners have any difficulties with the aforementioned factors based on a thorough analysis of their profiles and their responses in formative evaluations (Adebayo & Abdulhamid, 2014; Adebayo, Abdulhamid, & Fluck, 2013). If a deficiency exists, an alert is sent by the DA to the rectifier agent (RA) to resolve the problems through appropriate, useful, and motivational training.

In the next section, we present several studies that confirm the contribution of language, memory, and reasoning factors to learning success. This is followed by an explanation of these factors and the purpose of this paper. Next, we describe the operation of the agents developed in our approach before presenting some of the results of our experiment. Finally, we draw conclusions and prospects for future research directions.

RELATED WORKS

Learning difficulties have received increasing attention in the field of neuropsychology. The studies conducted in this field have confirmed the strong influence of memory, language, and reasoning on knowledge acquisition and learning. The work of Clemence (2005) affirmed that memory is a guaran-

tee for success, while the act of memorizing is a critical step in knowledge acquisition. Moreover, memory can be trained and educated, although it is necessary to understand how learners memorize and help them to optimize their memory using methods and techniques such as mental management techniques (Cèbe, Goigoux, & Thomazet, 2004). Memory performances greatly contribute to academic success and may be gradually improved if the memory type is identified. This is especially confirmed by the work of Lieury (2012). In terms of language, the same conclusions apply. Girouad and Drzystek (2013) argue that language learning is an asset that allows people to express ideas, perceive the world, and live and work successfully. Bautier (2001) likewise confirmed that language preeminence has an influence on school success. Bessonnat (1988) reaffirmed that language is situated at the heart of learning and that its success can only be ensured through the involvement of all disciplines. The same that applies to language also affects reasoning. Escorcia (2010) unveiled the importance of metacognitive knowledge and the ability of students to use it to plan and guide their writing. Proulx (1999) stressed the importance of problem-solving abilities in learners' development as well as the learning process. For this reason, several approaches have been identified to help learners with problem solving in a professional context; for instance, there is learning through projects (Leclet & Quénu-Joiron, 2006) and learning through skills (Crahay, 2006).

To the best of our knowledge, the majority of studies deal with the learning difficulties faced by learners in a face-to-face environment; that is, learners in the traditional teaching setting. In this mode of learning, the teacher is an active actor who participates extensively in the development of learners' skills. By contrast, in e-learning, learners are alone to face their difficulties, which is the case in our study. The questions that therefore interest us here is how to identify and rectify the learning difficulties of online learners.

BACKGROUND

PROBLEM

In an online self-learning system characterized by a weak interaction between tutors and learners, the tutor's awareness of learners' difficulties and subsequent intervention to improve them seems imperfect or even non-existent compared to the traditional system with face-to-face interaction (Nissen, 2005). In addition, it is more difficult to ensure the success of learners with cognitive difficulties in this type of online system. Given this issue, there is an obvious need to develop a method to detect and resolve the weaknesses of online learners. Figure 1 indicates the key factors contributing to learners' success (Morel, 2003).

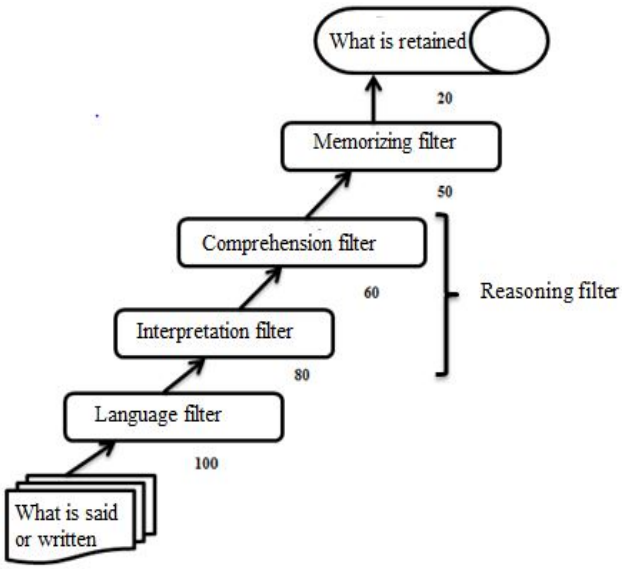

Figure 1. Communication filters

If learners fail to grasp a given factor, their performance and learning may be limited. In this regard, we focused on identifying learners' skills related to the three following filters:

- Language filter, which supports understanding and communication between learners.
- Reasoning filter, which includes both the comprehension filter that serves learning and the interpretation filter that facilitates the assimilation of knowledge.
- Memorizing filter, which simplifies the acquisition and storage of data.

We also concentrated on the impact of these filters on the concordance between what is said or written and what is understood and retained.

The following subsections aim to clarify the concepts relating to these filters.

Language proficiency

Language proficiency includes all of the necessary linguistic skills using the mother tongue or a foreign language; they are grouped according to the major functions (reading, writing, speaking, and listening) ("Compétences linguistiques", n.d.).

Language proficiency and command are essential elements to optimize the semantic understanding of learners. Without them, they are unable to grasp the meaning of the learning unit.

Memorization

"Memorization is a memory function by which acquired knowledge and information are saved and stored and then recovered and restored when needed, either automatically or using mnemonics or methodical procedures such as effort, tests, exercises, etc." ("Mémorisation", n.d.). This filter is therefore essential to any learning, since it ensures the recall of information learned.

Without memorization or with memory operation problems, the acquired knowledge fades with time, and learners eventually fail in their training.

Reasoning

Reasoning is a cognitive skill that can be determined by understanding skills, persuasion, judgment, and knowledge extraction. This competence is necessary for the interpretation, analysis, and determination of the adequate solution to any problem ("Raisonnement", n.d.). Learners who lack these skills or do not know how to exercise them do not take advantage of training, since they cannot put the acquired knowledge into practice when solving problems.

A lack of any one of these factors makes learners unable to recall the obtained knowledge, understand the meaning of learning units, or analyze the context of problems, which, of course, indicates failure in training.

GOALS

Within the framework of optimizing the acquisition of an online learner, we implemented a detection-remedial approach that detects any weaknesses related to the aforementioned factors and remediates them by conducting parallel training. This approach is innovative in the field of e-learning and aims to become efficient and competitive on a large scale. Two autonomous and dynamic agents act as a neuropsychologist to assist learners in optimal learning. The first agent, DA, aims to detect any problems that point to potential learning difficulties and then informs the second agent, RA, by sending it a message to clarify the vulnerabilities of the learner. The RA is responsible for solving these problems by offering learners supplementary training in parallel with the main training sessions.

PERFORMANCE OPTIMIZATION APPROACH FOR ONLINE LEARNING BASED ON INTELLIGENT AGENTS

The agent paradigm has been applied in many studies addressing online learning problems, such as the learning-time planning of an online learner (Kamsa, Elghibari, Elouahbi, Chehbi, & El Khoukhi, 2015) and the learner's privacy protection (Bekrar, 2014). In addition, intelligent agents in e-learning are suggested to provide learning content adapted to the needs and styles of learners (Chellatamilan & Suresh, 2011), and to customize learning (Alexandru, Tirziu, Tudora, & Bica, 2015; Baylari & Montazer, 2009; Gregg, 2007). Since these agents have already solved many problems in online learning, we focus on an evolving concept by adopting them to improve the performance of learners. This improvement is implemented by the diagnosis of learners' weaknesses and their improvement using parallel training. Figure 2 briefly outlines our approach and the features included therein.

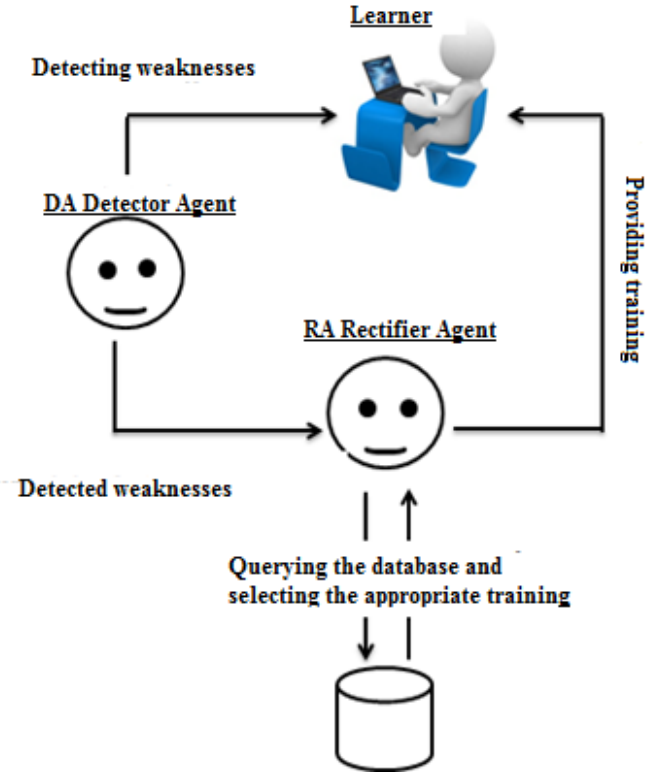

Figure 2. Approach for the detection and remediation of the weaknesses of online learners

Figure 2 defines the general idea of our approach, notably the development of learners' skills by detecting and improving their weaknesses. Thus, we implemented two agents: the DA identifies the degree of learners' facility with the factors necessary for learning, while the RA solves any problems and optimizes the level of assimilation. The functioning of our agents are discussed next.

DETECTOR AGENT CONCEPT

The DA is a cognitive and intelligent entity that acts as an assistant and performs two functions pre-programmed in the system as defined below and described in Figure 3.

First comes the detection of learners' difficulties: this is the mission of the DA. To achieve this, two tasks must be done carefully. The first begins as soon as the learners complete their registration, when the DA conducts a direct query of learners' profiles based on whether they have indicated their cognitive difficulties when completing the registration. This query must also be dynamic to take into account any changes in the profile. The second task occurs during the analysis and interpretation of

learners' responses during evaluations. After observation, these responses allow the DA to determine whether learners have difficulties concerning memory, language, and reasoning. If the DA analysis reveals that learners have real difficulties in any factor or if their profile indicates them, a second mission begins automatically.

The second stage concerns the declaration of cognitive difficulties. The DA has an interactive capability that connects directly to the RA. This capability allows it to communicate and send the detected difficulties to the RA in order to resolve them.

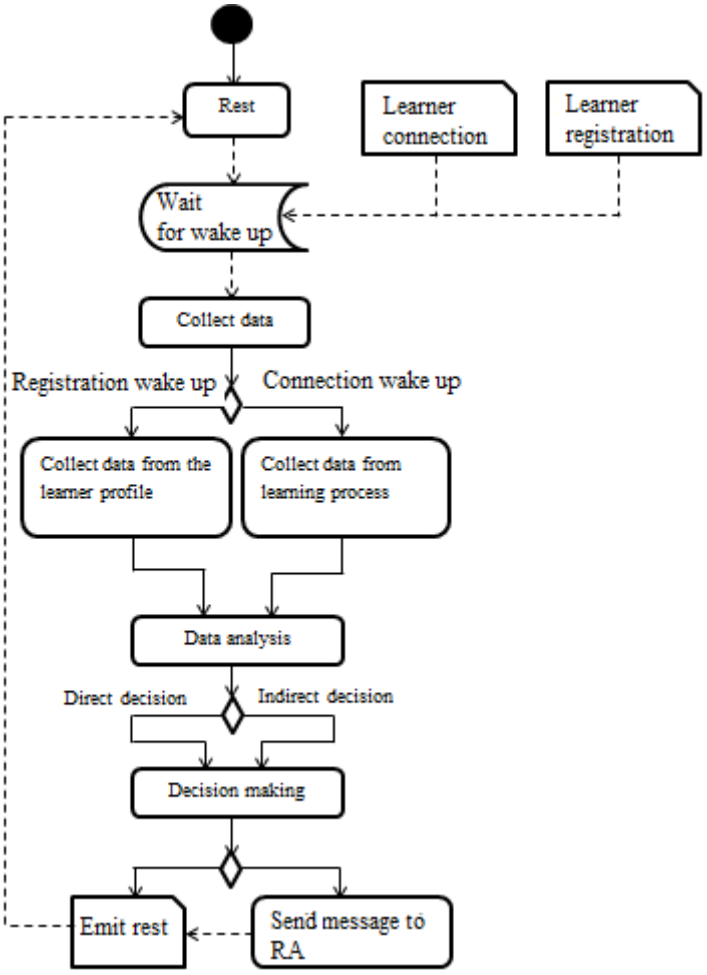

Figure 3. Activity diagram of the detector agent

As shown in Figure 3, the DA's task is to collect all data that may help determine whether learners face a particular difficulty or not. If learners have a difficulty, a message will be automatically sent to the RA. If not, the DA will be in standby.

Detection of learners' weaknesses

A set of direct questions in the form of a questionnaire is added to the personal part of learners' profile. After registration, learners are invited to respond to this questionnaire, which allows the DA to save time and be aware of learners' weaknesses at the beginning of the learning process. Examples of questions on the questionnaire are as follows:

- During learning, do you easily remember dates, names, events, or theories?
- Is your grammar and spelling level good?
- Are you able to apply acquired knowledge to solving specific problems?

Nevertheless, in some cases, learners are unaware of their difficulties and respond positively; whereas, in reality, they have cognitive problems. To remove any doubt, whenever learners finish a learning unit, the DA proposes a formative or summative evaluation test to collect information not only about their knowledge acquisition level but also about their cognitive skills. This test includes a set of questions to vary the type of information collected. We introduce closed and direct lesson questions that include dates, proper names, and events. These types of questions allow the DA to know the ability of learners to remember the acquired concepts. After an observation, if the DA notes that learners are able to respond efficiently to such questions, they can be considered to have a good memory. Otherwise, if learners cannot retrieve the explained data in each test, they can be considered as having a weak memory and so require support. Similarly, questions that test learners' level of understanding and restitution of the encoded information are provided. These questions help the DA to identify the language level of learners by diversifying the content and form of the proposed answers. For example, we can vary the syntactic form of answers, diversify the vocabulary used, and introduce inferences: anaphors, elaborative, logical, and pragmatic inferences, and so on. This diversity allows the DA to know whether learners have a good language level and ability to understand meaning. Similarly, two other types of questions are included in our assessment tests: open questions, which learners answer by self-explanations and interpretations, and synthesis questions, in which they must gather their personal knowledge into a coherent structure. Such questions help to identify the extent to which learners are able to analyze the problem, organize and use the statement data, and think logically in solving the problem. Furthermore, each answer includes a justification text in order to identify the understanding and analysis level of learners. It is possible to provide the same answer with different justifications.

Rectifier Agent Concept

The RA is an autonomous and active entity that follows a specific process in order to optimize learners' cognitive abilities. This process is modeled by identifying relevant and adequate training to resolve the difficulties of the learner. Figure 4 describes in detail the features of the RA.

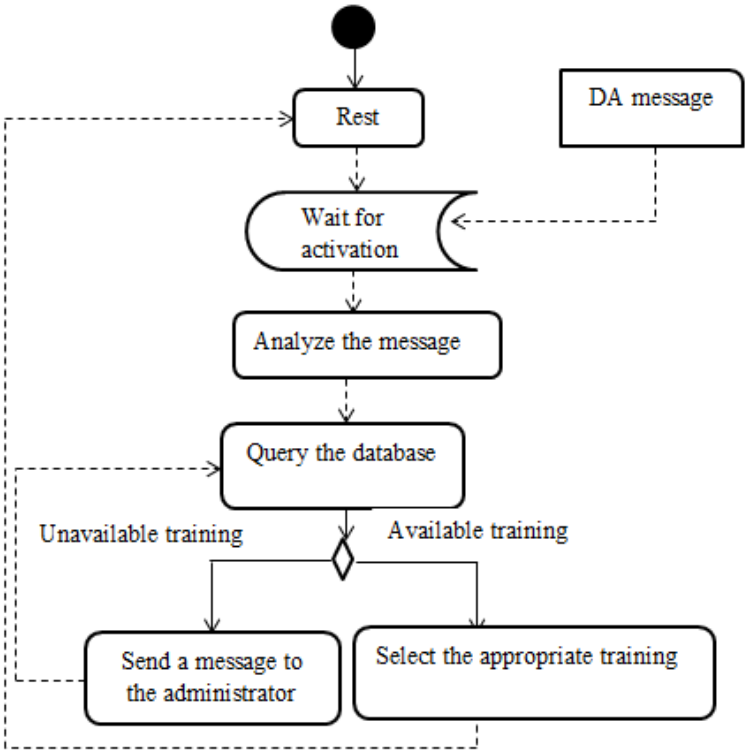

Figure 4. Activity diagram of the rectifier agent

As can be seen in Figure 4, as soon as the RA is activated, it remains in standby mode while waiting for an event to initiate its process. This event comes from the DA (message indicating the learner's identified problem). Once the RA is active, it is responsible for this learner and proposes one or several training courses in parallel to the initial training so as to resolve the identified problems. The training courses chosen by the RA are very relevant, attractive, and customized to meet the needs of learners and ensure their motivation and positive participation. In most cases, the RA suggests flexible training in the form of education games so as not to overload and burden learners. To select this training, the RA queries the database of the remote training platform, analyzes the annotations describing each kind of learning, and finally selects the proper training that may improve the learner's skills and ensure success.

TEST AND SIMULATION

OBJECTIVES

Our aim is to assess our approach to determine its contribution in terms of learner performance, and then to validate and concretize it. This assessment should also serve to refine the specifications of our agents and provide an opportunity to allow the emergence of new ideas and research perspectives.

DESCRIPTION

Our first experiment was applied to learners of the Master's degree in French Literature and Islamic Education in the Faculty of Literature and Humanities, Moulay Ismail University, Meknes, Morocco. Students take online computer courses on the Moodle platform.

We set up our DA to offer a questionnaire to learners at the beginning of the learning process. This questionnaire would allow the DA to identify any language, memorizing, and reasoning difficulties.

Once learners had responded to the questionnaire, we proposed for them to take the "Asynchronous Communication: Email" course, which was integrated into the Moodle platform in SCORM Format.

At the end of the course, the DA proposed a formative assessment test to learners, measure their levels of achievement, and refine the detection of the aforementioned factors.

To achieve this goal, we set a performance threshold to enable the DA to identify any learners with memorization, language, and reasoning difficulties based on the completed evaluation tests. The performance threshold value is set to 2/3; that is, learners who failed to correctly answer two-thirds of memorization questions were considered by the DA to have memorizing difficulties, and likewise for the language and reasoning difficulties.

Information about the learners for whom the DA had detected difficulties was sent to the RA. The latter then offered parallel training courses to resolve their difficulties in the second part of the course entitled "Asynchronous Communication: Mailing List, Forum."

In our case, we chose to develop this method in the form of educational games integrated into Moodle. We have developed our games as web pages that were automatically and dynamically proposed to learners during the main training session. After a certain number of lecture slides, the RA proposed an educational game to learners.

Similarly, we identified a success threshold. This threshold measures the effectiveness of the RA and the extent to which it succeeded in rectifying learners' weaknesses. The value of this threshold is fixed to 1/2; that is, learners who managed to answer half of the memorization, language, or reasoning questions correctly are considered to have sustained an improvement in their learning ability.

Analysis and Results

Detection of memorization, language, and reasoning difficulties (DA)

We tested our simulation on a sample of 49 learners enrolled in an online course. Based on the collected responses to the DA questionnaire, the results showed that 30 out of 49 learners faced memorizing difficulties, 22 had language difficulties, and 20 experienced reasoning difficulties. Furthermore, the evaluation test indicated that 55.10% (27 learners) did not reach the performance threshold in terms of memorization. In other words, they did not correctly respond to direct memorization questions (dates, names, numbers, etc.), which prove that they were not able to recall the knowledge acquired. The language performance threshold was not met by 51.02% (25 learners); that is, they did not choose the correct answers in terms of grammar and lexicon, which proves that they had language difficulties. Finally, 46.93% (23 learners) were below threshold performance in reasoning, as they were unable to analyze and apply the learned knowledge, which implies that they had reasoning gaps.

Overall, considering there is an overlap among learner problems, only 21 respondents (42.85%) passed the evaluation test successfully, while 28 (57.15%) were sent to the RA.

To confirm the strong dependency between learners' memorization, language, and reasoning levels and their success, we have analyzed the results of the first assessment using SPSS statistical software. This analysis allows us to determine if there is a statistically significant relationship between two variables. We sought to assess the relationship of memorization, reasoning, and language levels to the respective success of learners. This evaluation was conducted using the descriptive statistical methodology and chi-square test as well as Phi and Cramer's V measures. The values of these indicators confirmed the strong dependence between the above factors and learners' results, as discussed in the following paragraphs that describe the involvement of each factor.

Table 1 measures the involvement of memory in learner success.

Table 1. Memorization level and level of success (cross-tabulation)

		Level of success			Total
		Good grade	Average grade	Bad grade	
Memorization level	Good	18.37%	2.04%	0%	20.41%
	Average	0%	8.16%	16.33%	24.49%
	Low	0%	2.04%	53.06%	55.1%
Total		18.37%	12.24%	69.39%	100%

Good memorization means that learners easily memorize the learned data. In our case, learners with a good memory answered at least two-thirds of memorization questions. Average memorization means that learners can remember data with little effort. The learners who answered between half and two-thirds of memorization questions are considered in our experiment to have average memorization levels. Low memorization means that learners find it difficult to acquire new data. In this study, learners who fail to answer half of the memorizing questions are characterized as having low memorization levels. Good, average, and poor grades indicate the quality of the score obtained by learners in the assessment test.

In Table 1, we noticed that nine learners (18.37%) had a good memory and obtained good grades, while only one learner (2.04%) with a good memory obtained an average score. We can therefore say that nine learners successfully reached the performance threshold in terms of memorization. Similarly, we found that no learners had a poor memory and obtained a good score, while only one learner (2.04%) with a poor memory obtained an average score. However, just over half of learners

(53.06%) had both a poor memory and poor grades. This proportion corresponds to the learners who are below the performance threshold in terms of memorization.

The above results show that there is a significant relationship between memory and learner success.

The chi-square test and Phi and Cramer's V measures confirm a highly significant statistical relationship, as success greatly depends on memory (chi-square= 50.877a; p-value= 0.000<α= 0.05; Phi=1.019; Cramer's V = 0.0721). We may conclude that the analyzed sample suffers from deficiencies in memory (55.1%); these learners are supported by the RA.

Table 2 measures the involvement of language level in learner success.

Table 2. Language level and level of success (cross-tabulation)

		Level of success			Total
		Good grade	Average grade	Bad grade	
Language level	Good	18.3%	6.12%	4.08%	28.5%
	Average	0%	6.12%	14.29%	20.41%
	Low	0%	0.07%	51.02%	51.09%
Total		18.3%	12.31%	69.39%	100%

Good language level means that learners understand language well. In our case, the learners with a good language level at least answer two-thirds of language questions correctly. Average language level means that learners' spelling and grammar level is average and that they have some difficulties in assimilating the course. The learners who answer between half and two-thirds of language questions are considered in our experiment to have an average language level. Low language level means that learners do not master the language of learning. In this study, learners who fail to answer half of the language questions are characterized as having a low language level.

As shown in Table 2, nine learners (18.3%) had good language skills and good grades, which corresponded to those who successfully exceeded the performance threshold in language. By contrast, two learners (4.08%) with good language skills had poor grades. Around half of learners (51.02%) had both a low language level and poor grades. All learners with a low language level thus received poor grades. This group corresponded to the learners who did not meet the language performance threshold. The conclusion that can be drawn from these results is that the language level directly influenced learners' grades, with this influence being highly significant (chi-square= 38.03a; p-value= 0.000<α =0.05; Phi= 0.885; Cramer's V= 0.628). We also note that half of learners (51.09%) showed difficulties in terms of language (French). In this case, an involvement of the RA was demanded for these learners.

Table 3 measures the involvement of reasoning level in learner success

Table 3. Reasoning level and level of success (cross-tabulation)

		Level of success			Total
		Good grade	Average grade	Bad grade	
Reasoning level	Good	12.5%	4.17%	0%	16.67%
	Average	4.17%	6.25%	25%	35.42%
	Low	0%	2.08%	45.83%	47.91%
Total		16.67%	12.5%	70.83%	100%

Good reasoning means that learners analyze and interpret the acquired data well. In our case, the learners with good reasoning answer at least two-thirds of reasoning questions correctly. Average reasoning means that learners find difficulties in applying the acquired data to solve problems. Learn-

ers who answer between half and two-thirds of reasoning questions are considered in our experiment to have an average reasoning level. Low reasoning means that learners are unable to find the adequate solution to a given problem. In our study, learners who fail to answer half of the reasoning questions are characterized as having a low reasoning level.

Table 3 aims to detect the influence of learners' reasoning level on their success and grades. We observed that 12.50% of learners had both a good reasoning level and good grades. This proportion represents learners who surpassed the reasoning performance threshold. Inversely, no learners with a good reasoning level had low grades. Similarly, no learners with a low reasoning level obtained good grades, while almost half of learners (45.83%) had a low reasoning level and poor grades. This proportion corresponds to the learners who did not meet the performance threshold in terms of reasoning. These results demonstrate the relationship between learners' reasoning level and their success. The chi-square test also confirmed the significant relationship between these two variables (reasoning level and success) (chi-square=19.451a; p-value= 0.001<α =0.05; Phi= 0.637; Cramer's V=0 .450). These results also allowed us to deduce that almost half of our learners (47.91%) had difficulties in reasoning. In this case, the RA support is necessary for them.

The conclusions drawn from this statistical analysis affirm that memorization, language, and reasoning are necessary factors to ensure the success of learners, and as a consequence, remedying these problems is necessary so that learners have a better chance to be successful in their training.

Remediation of memorizing, language, and reasoning difficulties (RA)

After the RA intervention, we observed a noticeable improvement with learners who experienced memorization, language, and reasoning difficulties, with a substantial increase in their grades in the second evaluation test: almost 79.59 % of all learners exceeded the success threshold for memorization, as they correctly solved the memory questions; 75.51 % were above the language success threshold, as they chose lexically and syntactically correct answers; finally, 60.45% surpassed the reasoning success threshold, as they correctly responded to reasoning questions. The overall success rate for the second test was 75.51% (37 learners) compared to 42.85% (21 learners) for the first test. In other words, the RA successfully rectified the weaknesses of 16 out of 28 learners who received its training.

The following paragraphs present the refinement of memorization, language, and reasoning levels for three exemplary learners who received RA training. Figure 5 shows the improvement of the learner's memorization level and his test grades after the RA intervention.

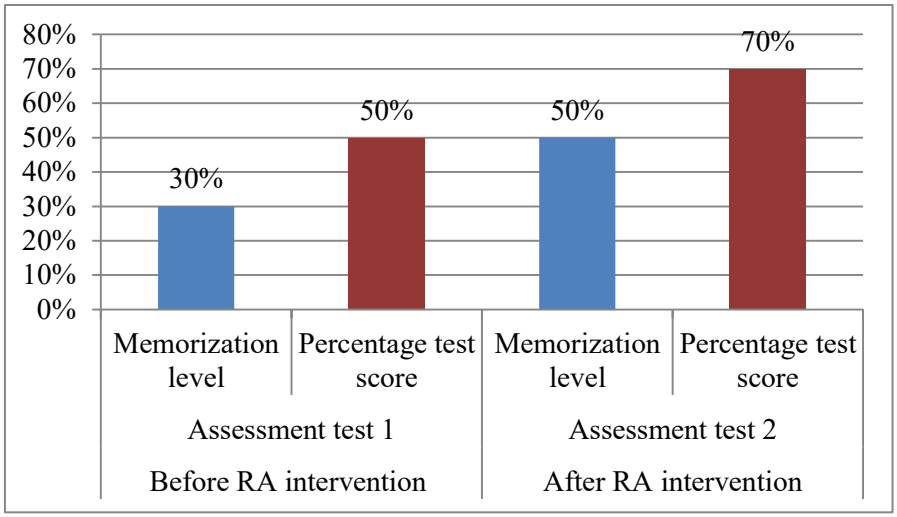

Figure 5. Difference between the learner's memorization level and the percentage of his success before and after the RA intervention

As shown in Figure 5, at the beginning, the learner was only able to respond to 30% of the memory questions, and his grades expressed as a percentage were 50%. After the RA intervention, we noted in the second test that the memorization of this learner reached 50% and his grades 70%. The increase in the learner's memorization level thus positively influenced his grades.

Similarly to memory, Figure 6 describes the evolution of the learner's language level after the RA intervention.

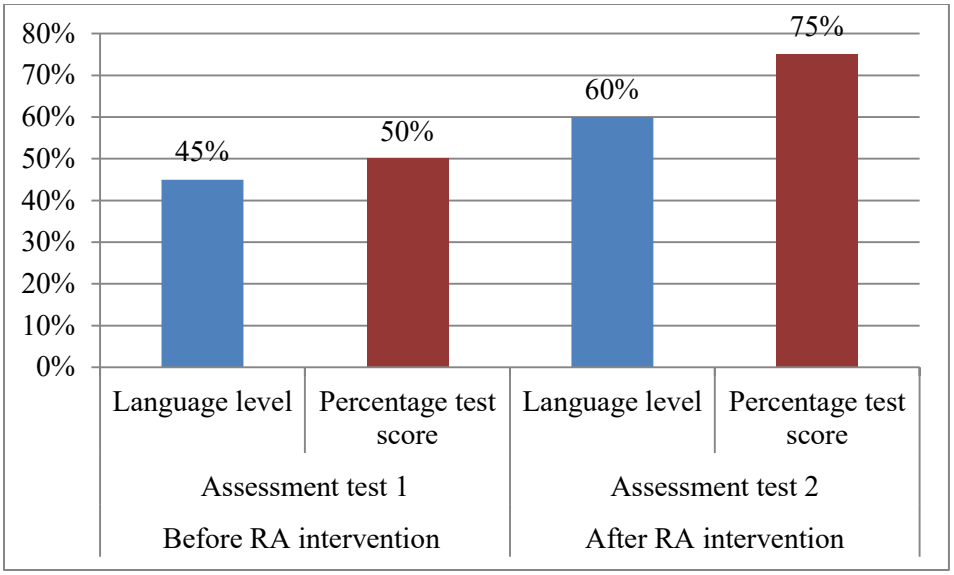

Figure 6. Difference between the learner's language level and the percentage of his success before and after the RA intervention

In Figure 6, before the RA intervention, we noted that the learner's language level was almost 45% and his grades expressed as a percentage were 50%. After the RA intervention, a substantial improvement was noticed, with the language level increasing to 60% and grades to 75%.

Finally, Figure 7 represents the evolution of the learner's reasoning level after the RA intervention.

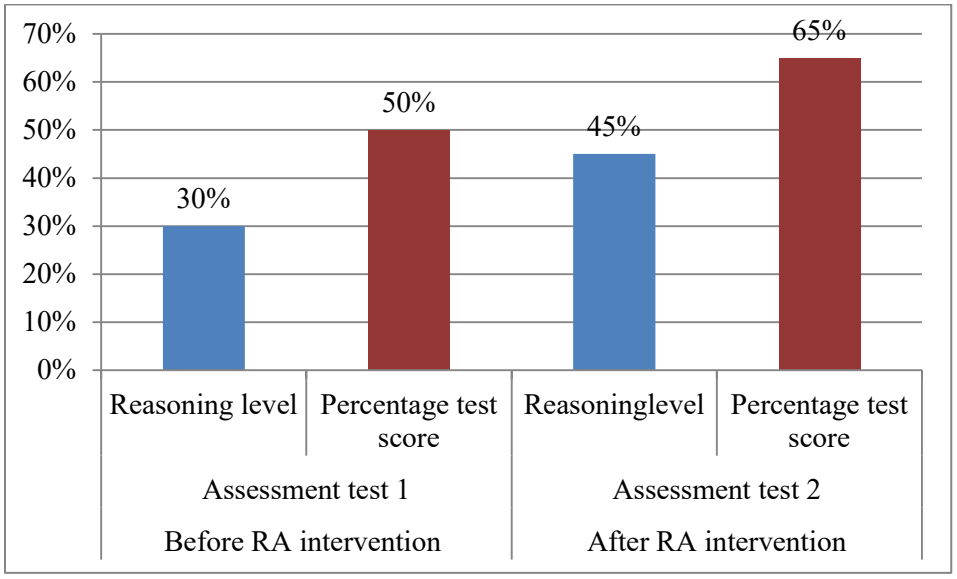

Figure 7. Difference between the learner's reasoning level and the percentage of his success before and after the RA intervention

In Figure 7, we remark that the learner's reasoning level is initially 30% and his grades 50%. Following the training proposed by the RA, the reasoning level increases to 45% and his grades to 65%.

As a conclusion, we can state that our approach is operational with very convincing results.

CONCLUSION

The use of an e-learning environment offers many benefits to learners, and institutions have increasingly tended to adopt this new technology. However, this mode of learning does not ensure the adequate tracking of learners, especially with regard to the cognitive factors that are primary to optimal learning. In this context, our detection-remediation approach was developed. This approach proposes a key solution for ensuring the success of learners through the identification of their weaknesses and subsequent remediation with adequate and effective training. The main contribution of the approach proposed in this paper resides in the solidification of knowledge acquisition by strengthening the memory, the assimilation of lessons by improving language skills, and the reinforcement of problem solving by developing reasoning and analysis capacity. These contribute effectively to the optimization of learners' performances, the assurance of their success, and the improvement of the image and quality of e-learning systems. This objective is achieved by using intelligent agents that work automatically and dynamically for effective treatment. The three factors chosen are necessary, but not sufficient for a unanimous optimization. From this perspective, we want to improve our approach toward e-learning performance by focusing on other factors and intelligent agents that can improve the yield for learners and more effectively optimize system operation for their perceived needs.

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