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Integration of Adaptive Collaborative Learning Process in a Hybrid Learning Environment

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***Abstract*—Technology integration has been crucial in the practice of the learning process. The use of technology aims to find effective solutions to traditional learning problems. Despite the enormous efforts adopted, using e-learning systems was optional in many education systems. However, the COVID-19 health crisis has shown the importance of the transition to e-learning to ensure pedagogical continuity. According to several studies that have measured the impact of COVID-19 on education systems and the adopted solutions, blended learning represents an effective solution for combining the advantages of face-to-face and distance learning. But the implementation strategies regarding this mode of learning are still limited. For this purpose, we propose a hybrid learning model based on collaborative work through an intelligent assignment of learner roles. This approach aims to support adaptive learning via a hybrid learning environment. The proposed solution is based mainly on collaborative work as an active learning method, using the Naïve Bayes algorithm and Belbin theory. The usefulness of collaborative work is to keep the learning rhythm between face-to-face and distance learning and to encourage learners' engagement and motivation through this mode of learning. According to Belbin's theory, the results of this work propose an adequate role for each learner. This intelligent assignment leads the learner to live the learning situation and not undergo it.**

***Keywords*— Hybrid learning; e-learning, collaborative learning; naïve bayes; Belbin theory.**

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I. INTRODUCTION

Technological development has led to other learning models, especially e-learning and blended learning. The choice of one model or other mainly depends on the type of training, the learner's context, and preferences. Each mode has a specific position in the learning process due to its advantages. E-learning is a teaching modality that frees the learner from time and mobility constraints. Its objective is to make knowledge more available due to its flexibility and accessibility. It provides a variety of training devices based on multimedia tools to create an interactive learning environment. In addition, e-learning systems support collaboration, autonomy, motivation, and learning content adaptation to each learner's profile and cognitive needs. It represents a wide field of application of various learning methods and strategies [1],[2],[3].

Face-to-face learning retains its strength through its traditional advantages such as direct interaction and communication between learners and teachers and the socialization of learning, which can present some limitations for e-learning. However, the mobility of learners, the timing of training, and the availability of tools and classrooms constitute some constraints for this learning mode.

Hybrid learning or "Blended learning" aims to combine face-to-face benefits with distance learning to overcome the approved challenges and ensure an effective learning process. It involves implementing a learning strategy based mainly on the use of technology and the best practices of face-to-face learning. The blended learning process can use both synchronous and asynchronous learning activities. The structure of a blended course should be based mainly on pedagogical guidelines and not only on the potential of technologies. The health crisis imposed by the spread of the COVID-19 epidemic has shown the need for a transition to distance learning. To this end, many studies have been conducted to share the experience of several countries and to measure the impact of COVID-19 on education systems during the lockdown period. For example, from India, Agarwal and Chitranshi [4] presented the efforts adopted by this country in the transition to digital learning, as well as the difficulties encountered, and the lessons learned. The study of Suyadi and Selvi [5] presented the impact of COVID-19 on

work and school from home in Indonesia. The work of Sabates, Carter, and Stern [6] conducted a study to estimate the rate of learning loss during a three-month transition during the COVID-19 pandemic within government schools in Ghana. Another study from Georgia by Tabatadze and Chachkhiani [7] investigated the need to adopt emergency remote teaching practices. Other countries had similar experiences, such as China [8], Germany [9], and Morocco [10], [11]. Other work has highlighted the benefits gained in the process of education during this period [12], [13], [14].

The works developed focused on the need for an innovative learning strategy. This strategy is based on the pedagogical use of technology. For this reason, hybrid learning has been a convenient solution to benefit from the advantages of e-learning systems during the lockdown period [15], [16]. Moreover, it offers a wide range of applications of the pedagogical practices of the face mode, especially social interaction.

Several studies have discussed the hybrid learning model. Raes et al. [17] presented an overview of synchronous hybrid learning and some recommendations for implementing techno-pedagogical supports for synchronous hybrid learning. Lestari et al. presented a work that promotes adopting hybrid learning as an alternative way to guide learners in solving learning problems in physics [18]. Another work conducted by Gao, Jiang, and Tang [19] examined the impact of the blended learning platform and engagement on student satisfaction. Rasheed, Kamsin, and Abdullah [20] presented an overview of the challenges in the online component of blended learning.

The concept of hybrid learning represents a promising solution to ensure a balance between study, work, and family for students. Face-to-face and distance learning sessions are complementary to satisfy the learners' individual needs and achieve the learning objectives. Nevertheless, several studies have asserted the difficulties of implementing this model.

The health crisis imposed by the spread of COVID-19 highlighted the need to transition to the hybrid learning model. To this end, we propose an intelligent hybrid learning approach based on collaborative work and artificial intelligence technology. This work aims to ensure adaptive learning via an intelligent assignment of learners' roles using the naive Bayes algorithm and Belbin's theory. The use of collaborative work ensures that the learning rhythm is maintained between the present and the remote mode.

The researchers continue this paper by introducing an overview of hybrid learning by highlighting its benefits and challenges in section II. Section III focuses on the proposed hybrid learning strategy. Section IV presents the adaptive collaborative learning process. Section V shows the numerical results with an illustration of the functioning of the proposed approach. Then we will end with a conclusion and the perspective of the presented work.

II. Materials and Method

A. Hybrid Learning

The hybrid learning model provides an environment for integrating multiple technologies and pedagogical practices to benefit from the advantages of both modes. (Fig. 1). This model is a solution to achieve learning flexibility. At the pedagogical level, blended learning facilitates the implementation of active methods that encourage learners' engagement and develop their autonomy. It also allows the development of adaptive learning approaches to satisfy the needs and preferences of learners. The objective of this mode is to overcome the difficulties of traditional learning through a strategy that combines the advantages of face-to-face and distance learning.

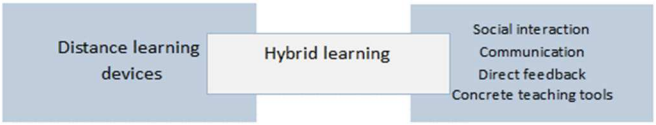

Fig. 1 Concept of hybrid learning

1) Benefit and challenges of hybrid learning: Blended learning focuses primarily on the learners by providing them with adaptive content to their needs and characteristics. It is a mode that offers flexibility to ensure a higher level of engagement. It also encourages sharing experiences and ideas through collaboration within and outside the institution. For teachers, it aims to reduce the workload through synchronous blended learning, which avoids teaching the same course twice. Also, at the management level, it represents a solution to regulate the number of learners registered in the classroom. However, despite its advantages, it still involves some challenges for students and teachers. Firstly, learners need to have a certain mastery of using technological tools and of being able to learn in different ways. With the hybrid mode, learners are invited to invest more time in learning outside the classroom and ensure better time management. Teachers are required to ensure a balance between face-to-face and distance learning sessions. This will be achieved through better time management and diversification of the methods adopted, as well as through the proposal of different techno-pedagogical devices to support the commitment and motivation of the learners.

2) *State of the art:* Blended learning represents a very broad field of research due to its advantages and its implementation in several training sectors. Several studies have been carried out to measure and compare its effectiveness with traditional learning. For example, we cite the study of Alsalhi et al. [21] which aims to investigate the impact of blended learning in science teaching. The study is dedicated to learners of the intermediate stage in the United Arab Emirates to improve their achievement. The study sample consists of 116 students divided into two groups: the first comprises 61 students as the experimental group, and the second is the control group composed of 51 students. The idea is to compare the two groups through a pre-test and post-test presented to the learners to measure the attitudes acquired after six weeks of conventional and blended learning. The results show a significant difference in favor of the experimental group through a high post-test score reflecting the positive impact of this learning mode.

Another work by Syam et al. [22] studied teachers' perceptions, strategies, and challenges via hybrid e-learning in the teaching process in higher education. This study recommends that teachers be familiarized with the updated technology and the importance of adopting hybrid e-learning

as an official policy by universities to be used in many university activities and contexts.

On the other hand, learner engagement is a key factor in ensuring learning effectiveness. To this end, Lima et al. conducted a study comparing earners' engagement in hybrid and non-hybrid learning processes [23]. An experiment was conducted with 92 students in a public secondary school in northern Brazil. The trial procedure included a survey on familiarization with information and communication technologies first. Then learners are invited to follow two blocks of lessons separated by two months. The first block is composed of blended learning scenarios using technological tools. In comparison, the second block is based on course lectures. A screen recording application recorded the results and the level of engagement measured from student observation criteria. Comparative tests show higher levels of engagement in favor of blended learning scenarios.

For the same purpose, another study was conducted by Khodeir [24] to measure the impact of hybrid learning on learner engagement and learning effectiveness; this study aimed to investigate the application of the blended learning mode in the curricula of architecture students. The strategy adopted for this work focuses on a qualitative analysis of the methods applied in the Management Project courses in two different programs. The first course was taught for eight years at Ain Shams University using traditional methods. The teaching method of this course has been improved during this period. The second course was taught to the 3rd cycle architecture students at the British University of Egypt for four years in a row. The method adopted was based on the hybrid learning mode from the beginning of the learning process. The results of this analysis showed the benefits in terms of the presentation of the PM courses as well as an improvement in the students' levels of engagement and knowledge acquisition over the years.

Due to the flexibility, blended learning has been integrated into several types of training and for different specialties. For example, the study of Biddle and Hoover [25] used blended learning to teach motivational interviewing (MI) to 3rd year pharmacy students. This study aimed to demonstrate the effectiveness of blended learning in the acquisition of motivational interviewing skills through the combination of communication and information technology (CommIT) e-learning systems and face-to-face classroom activities. The results of this study show that after 60 days of training, the learners improved the formative abilities of the motivational interview responses.

Another field of application of blended learning is that of obstetrical emergency and newborn care training [26]. This study aims to evaluate the effectiveness of blended learning towards obstetrical emergency and newborn care training services in reducing the cost of learning. The learning process involves 12 days of training, four days in the classroom, and eight days of practical work, followed by learning activities via SMS or phone calls. The results of this study show that hybrid learning is cost-effective compared to the conventional method.

Another study has focused on the learner satisfaction rate provided by hybrid learning; within this context, we find the work of Alabdulkarim [27], which aims to measure the satisfaction of health science students in Saudi Arabia with blended learning. The study was conducted through a quantitative-qualitative design during the 2017-2019 academic years. The results of this study showed that virtual classrooms are the most preferred elements for students.

B. Proposed model

Blended learning focuses on face-to-face practices, especially social interaction, communication, sharing, and collaboration. It also focuses on the technological solutions offered by e-learning. This combination aims to put the learner at the focus of the learning operation through the development of his/her autonomy and motivation. For this, the role of the teacher is not limited to the transmission of knowledge, and it is a whole process of planning and management to stimulate and guide the learner to achieve the learning objectives.

The present work aims to implement a hybrid learning strategy based on collaborative work (Fig. 2). We have defined this strategy through pedagogical regulations and the potential of technology, especially artificial intelligence.

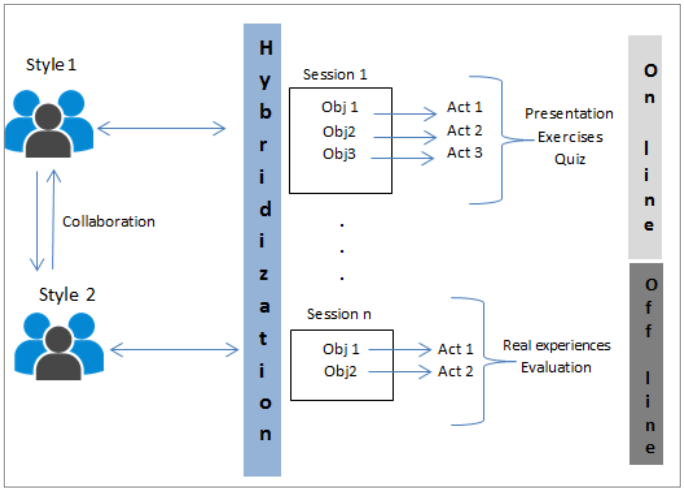

Fig. 2 The proposed hybrid learning model

When implementing this model, we focused on the learning content and the learner. Each course is organized in sessions with several activities (demonstration, exercise, presentation, audio/video document, simulation...), that can be attended or distance mode depending on the learner's needs. Learners work on the activities collaboratively and in a planned order. The proposed blended learning model consists firstly of identifying learning styles to highlight learners' characteristics and needs. In this way, the rate of learner engagement can be increased. In a blended learning environment, it is recommended to identify and analyze the learning practices of learners in face-to-face and distance learning, such as their participation, communication, and level of technological mastery. This identification is crucial for the formation of the groups in order to carry out collaborative work. At the level of course organization, each course will be divided into face-to-face or remote learning sessions. The learning objectives of each session are achieved through a learning activity scenario. This plan aims to keep the learning rhythm between the two modes. Each learning activity corresponds to a mode that enables them to achieve the learning objective. That is why we present in the table below

(table1) a classification of the learning activities according to the most appropriate mode.

TABLE I
ASSIGNMENT OF LEARNING ACTIVITIES

	Online learning	Face-to-face learning
Presentation	✓	
Exercises	✓	
Quiz	✓	
Real experiences		✓
Debate		✓
Role playing activities		✓
Simulation	✓	
Discussion	✓	
Search	✓	
Evaluation		✓

Regarding the learners, this approach is based mainly on collaborative work as an active method. The use of collaborative work aims to develop the ability of learners to share ideas and experiences. Well-structured and organized collaborative work ensures that the learning objectives are met with the highest quality. The idea is to analyze the behavior of learners in class and their interaction with the e-learning system. This analysis aims to identify the needs and characteristics of the learners in order to assign them the most suitable role within the group. This procedure aims to personalize the learner's learning process.

Hybrid learning uses the coactive aspect. For this purpose, collaborative work is a method that aims to ensure the sequencing and rhythm of learning between face-to-face and distance learning. It represents a wide area of integration of collaborative work to achieve a common goal between the two modes.

C. Collaborative Learning

Collaborative learning is an active method for sharing and exchanging knowledge and experience. Learners and teachers work towards a common goal. Each learner is engaged in a task to develop their skills and achieve the learning objective, while teachers are engaged in guidance, monitoring, and mediation. The interaction and motivation of the group members characterize the collaborative learning environment. To do this, learners commit to developing their dynamism and creativity and mobilizing their prerequisites. Thus, improving their critical thinking skills in the acquisition of knowledge. Integrating the collaborative approach into the learning process requires a strategy for designing, planning, and managing learning activities. It also requires considering the individual needs of each group member to develop the skills targeted by the program.

Several works have been developed to explore collaborative work in the learning process [28]. Moreno, Sánchez, and Pineda [29] proposed a hybrid approach to group formation in a collaborative learning context. The study of Haataja et al. [30] discussed the impact and instructions for conducting collaborative work to increase learner engagement. Also, the study of Meza, Castro, and Vivas [31] showed the role of using diagrams as an effective tool for learning through collaborative work.

Through this study, we aim to implement a hybrid learning strategy based on collaborative work. The proposed approach is presented in two stages, the first via the proposition of a collaborative learning scenario, and the second involves presenting an efficient solution for collaborative learning that aims to ensure an intelligent assignment of learners' roles.

1) Collaborative learning scenario:

The learning scenario represents a model to follow when planning the learning process. It is a reflective task that requires consideration of learning styles, requirements, and objectives. The scenario defines all the phases to be followed in order to achieve the learning objective.

The planning for distance activities differs from that of face-to-face activities. The scenarios for distance learning focus mainly on integrating technologies like a tool to ensure effective learning. On the other hand, the major challenge of blended learning scenarios is keeping the connection and the learning rhythm between the two modes. Collaborative work aims at creating an interactive bridge between face-to-face and distance learning through the interaction and the dynamism created during the learning process. For this purpose, we propose a hybrid learning scenario based mainly on the collaborative work below.

The proposed scenario covers three phases (Fig. 3). The first level is devoted to the constitution of the groups via an intelligent approach based on the combination of the Naive Bayes algorithm and the Belbin theory. We have defined the learners' characteristics and needs to conduct an adaptive learning process. This phase aims to create homogeneous groups and get each learner to work within his or her comfort zone to achieve the learning objective. The following section deals with this phase in more detail.

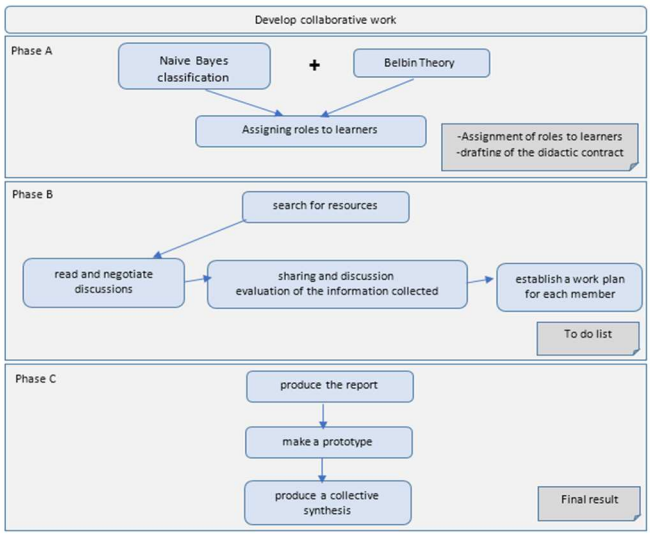

Fig. 3 Proposed Collaborative learning scenario

The second phase is dedicated to finding resources, sharing, evaluating, and planning. The learners engage in defining the work plan under the roles defined in the first phase. In comparison, teachers provide guidance and mediation. The result of this phase is a list of tasks to be carried out for each member. The last phase focuses on presenting the final results through the realization of a prototype and the collective production of the synthesis.

2) Assignment of roles

In order to support adaptive learning, we have developed an intelligent approach for collaborative work within a blended learning environment. Based on the different profiles that characterize each learner, we aimed to create homogeneous groups to ensure diversity in the composition of the groups. learners are strongly committed to adaptive learning, especially tasks that are closer to their personal or professional life experiences. For this, each learner's role in the group will be assigned according to their skills, profile, and prerequisites.

Collaborative learning has several challenges, mainly related to the engagement and motivation of learners and their intellectual level. On the other hand, the organizational approach adopted and the distribution of tasks. In order to conduct collaborative work, we propose a solution that responds to the characteristics of each learner in an organized method. The solution is based on the combination of artificial intelligence technologies, especially the Naive Bayes classification algorithm and the Belbin theory.

Belbin's theory proposes a distribution of the group members' roles into 9 roles. It is widely adopted in the business community [32], as well as in the field of education [33], [34], [35]. The purpose of this combination is to ensure an intelligent and automatic assignment of roles in order to organize tasks more easily and to increase learner engagement. Each learner will work in their comfort zone in a highly productive way.

3) Belbin theory

The Belbin role method was developed by Dr.Meredith Belbin in 1981. The theory describes and analyses the behavior of group members in their relationship with others, as well as their knowledge and working habits. Among the advantages of Belbin's theory, we mention:

- Improve the functioning and performance of the team through better role management in order to build balanced groups.
- Help team members to better know each other and to assess their skills in team behavior.
- Highlight specified tasks for each member.
- Provide a reference for the management and distribution of the different roles according to the profile of each member in the group.
- Help to achieve the desired objectives through complementary and effective groups.

Belbin's theory defines three areas of behavior that contribute to successful group work: Reflection, action, and relationship. (Fig. 4).

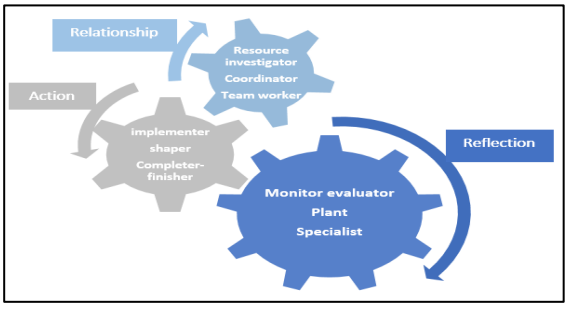

Fig. 4 Belbin theory

Reflection: The group members are oriented toward reflection work; they have critical thinking that leads them to develop analytical and decision-making skills. They can present creative ideas or new points of view. The reflection axis includes the following roles:

- Monitor evaluator: They are responsible for analyzing problems and evaluating and suggesting ideas. Generally, their decisions are objective and based on facts and critical thinking.
- Plant: They have a crucial role in forming groups because they are members who promote the team's progress through their creative and original ideas. They prefer to work on their own, using their imagination.
- Specialist: Members who have expertise in a specific field. They have in-depth knowledge that enables them to make relevant decisions.

Action: Action team members are responsible for the progress of the tasks. The work for them is challenging while meeting the deadline and the requirements. The action axis includes the following roles:

- Implementer: Implementers are organizers who structure and organize the working environment. They aim to develop concrete plans from abstract ideas. Their goal is to implement effective strategies to carry out the work quickly and efficiently.
- Shaper: They are self-motivated and able to work under pressure despite challenges. They can inspire and motivate team members to carry the work forward.
- Completer-finisher: they are finishers who verify the quality of the work. They notice the details of the tasks if they are perfect and error-free, which allows a high-quality level to be achieved.

Relationship: Team members in this role use communication skills to complete tasks successfully. They are active listeners; they provide the necessary support to other members to reinforce the solidarity bonds between group members. The people axis includes the following roles:

- Resource investigator: Resource Investigators are extroverts who are able to make new professional contacts. They are also receptive to new ideas and opportunities that can be exploited within the group. They are open to new sources of information.
- Coordinator: tend to focus on helping group members to achieve their goals. They are careful to lead members with different personalities and skills to help them work in the most appropriate conditions.
- Team workers are also extroverted people who lead the team to function as a unit. They are able to solve interpersonal problems and aim to establish harmony within the group. They offer support to all members to make them not feel neglected.

Belbin's theory [36] provides insight into the roles of group members. A team's success depends on their equilibrium and not their intellectual level. Assigning a role compatible with the learner's profile within the group makes the work more efficient and dynamic and avoids any role conflict. We can summarize the characteristics of the Belbin theory in the table below (Table 2).

TABLE II
ACTIVITY CLASSIFICATION ACCORDING TO BELBIN'S THEORY

Reflection	Monitor evaluator	moderate, strategic
	Plant	creative, imaginative, nonconformist.
	Specialist	determined, autonomous, focused on a single objective
Action	Implementer	disciplined, reliable, orderly, methodical and efficient
	Shaper	dynamic, go-ahead
	Completer-finisher	conscientious
Relationship	Resource investigator	outgoing, enthusiastic, communicative.
	Coordinator	mature, attentive, confident
	Team worker	sociable, sensitive, conciliatory, tactful

We have implemented Belbin's theory in the field of education to take benefit of its advantages. Learners differ in their acquisition methods and attitudes. Also, each of them has a unique level of motivation and commitment. This difference can lead to ensuring effective collaborative work with productive results. To do this, we identified the characteristics of each learner that constitute the input data for the Naive Bayes classification algorithm. The data identified corresponds to the learning practices most frequently used by learners, either in face-to-face or distance learning mode (Appendix 1), for example: the use of various methods, participation in the forum, listening skills, task planning, etc. Each data item corresponds to one or more roles of Belbin's theory.

4) Machine learning algorithm

Machine learning is a form of artificial intelligence technology that allows the analysis and exploitation of data. Its aim is to stimulate the behavior, attitudes and reactions of living beings, especially humans, in their ability to learn, memorize and evaluate in order to find effective solutions to problems encountered in all areas. Its applications are spreading more and more widely through the use of performing tools. The aim is to reduce the overall effort required to carry out many varied tasks [37]. It is structured in supervised, unsupervised, and reinforcement learning.

Unsupervised learning: is generally used in clustering; it aims to assemble a set of various elements to form groups with common properties. The machine makes the reconciliations according to those properties that it can identify without external intervention. The learning is done autonomously; the data is communicated to the machine without delivering the expected results at the output. Among the clustering algorithms we find: K-means algorithm.

K-means algorithm is one of the partitioning-based, nonhierarchical clustering methods [38] it deals with the repartition of data according to different clusters based on distance measurement [39]. Its main idea is to group elements with the same characteristics within the common cluster. The number of K clusters is initially defined depending on the specificity of each problem.

The steps in which k-means clustering algorithm works are as follow:

- Step 1: choose a number of elements K corresponding to the initial centers of the clusters (centroid) randomly.
- Step 2: assign each element to the nearest center according to the calculated distance between the elements and each centroid.
- Step 3: Recalculate the centroids using the new cluster memberships.
- Step 4: Check if the union is met; otherwise, go back to step 2.

Supervised learning: uses classification algorithms and regression techniques to generate predictive models. It provides both input data and expected output data. This data is labeled for classification to establish a learning base for further data processing. The error margin is reduced through the training to generalize learning in new cases. We can mention: Decision trees, Neural networks, and Naive Bayes.

We adopted the Naive Bayes algorithm as a solution to assign the most appropriate role to the learner (Fig. 5).

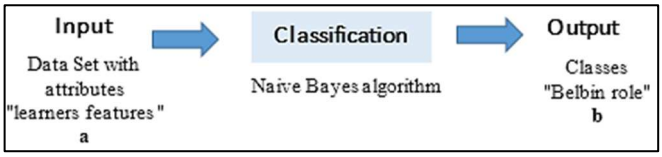

Fig. 5 Classification from 'a' to 'b'

Naive Bayes: is a simple and efficient algorithm for predictive modeling. It includes two types of probabilities that can be calculated directly from the training data: the probability of each category and the conditional effect probability for each class taking into account each value x. Once calculated, the probability of a model can be used to make predictions for new data using Bayes' theorem [40]. The advantages of the Bayes classifier are: simplicity of the implementation, learning process is quite fast, it also gives quite good of accuracy rate [41].

There are several applications of the algorithm in different fields, for example, Wu and Hicks [42] opted the naive Bayes as a solution for the prediction of Breast cancer type. Also, other study conducted by Fatima and Pasha [43] have proven that naive Bayes is widely used in the detection of diseases such as: heart, Diabetes, Hepatitis, with a better accuracy comparing to other algorithms.

According to the Naive Bays algorithm the probability calculation is based on the Bayes theorem using the following formula (equation 1).

$$P\,(y \mid X) = \frac{P(X \mid y)\,P(y)}{P(X)} \qquad (1)$$

For our case the variable y indicates the role of group members identified by Belbin theory and the variable X represents the parameters or features (learner characteristics). Therefore, X is given by X= (Feature1, Feature 2, ……, Feature n). So the probability formula will be calculated as follows (equation 2). The algorithm process is shown in below (Fig. 6)

$$\frac{P(Fe\ 1|role)\ P(Fe\ 2|role)\ P(Fe\ n|role)\ \ P(role)}{P(Fe\ 1)\ P(Fe\ 2)\ P(Fe\ n)} \qquad (2)$$

```
Input:          features of learners
Output:         Probability of each role
Begin
    Read training data
For each role
For each feature
    Calculate
        P(role)
        P(Fi)
        P(Fi|role)
End
End
For each role
        Calculate the probability
            P(Fi|role) * P(role)/P(Fi)
End
Return
    Role
End
```

Fig. 6 The Naïve Bayes algorithm

III. Results and Discussion

The assignment of roles to learners within a collaborative learning process aims to ensure an organized and structured work. For this purpose, we have carried out an automatic and intelligent affectation according to Belbin's theory. The idea is to identify all the behaviors and habits of the learners and their interactions with the e-learning system. Through the identified data (Appendix 1), we will proceed to set up a collaborative and adaptive learning process according to the learners' profile. The identified behaviors and interactions form the input data to calculate the probability of each role.
The most adaptive role to the learner is that which has a high probability rate and will be assigned to the learner automatically.

This assignment aims to get the learners to work according to their preferences and skills to achieve successful collaborative work and avoid any role conflict within the group. To further illustrate how the approach works, we provide the following example. We have selected the most noticeable and frequent learner features in the hybrid learning environment. The example chosen is a learner who frequently accesses the spaces dedicated to wikis. This collaborative tool gives free access to the information produced by the learners. In addition, he shared a great number of resources in order to enrich the learning environment. Regarding collaborative tools, the learner is active on the forum through discussions, messages and posted content. Another feature that will help us to identify the appropriate role for the learner is self-assessment. This feature has been identified through the practices and habits noted in face-to-face and distance learning. We take the following characteristics:

"Open page in wiki, File exchange, discussion forums, Self-assessment"

TABLE III
Assignment of the first role

Features	Belbin Team Roles	Probability
Open page in wiki, File exchange, discussion forums, Self-assessment	Monitor evaluator	0.009009009
	Plant	0.009009009
	Specialist	0.018018018
	Implementer	0.018018018
	Shaper	0.018018018
	Completer-finisher	0.009009009
	Resource investigator	**0.900900901**
	Coordinator	0.009009009
	Team worker	0.009009009

We calculated the probability of each role depending on the identified characteristics. According to the table below, the results of the Naive Bayes algorithm show that the most appropriate role for this learner is "Resource investigator" from the Relationship area. This role takes advantage of ideas and information from the outside. These results reflect the frequent access of these learners to collaborative tools via the blended learning environment. To better illustrate the effectiveness of the approach, we have identified a learner with the following characteristics:

"Works fast, use of various techniques, achieves learning objectives, makes notes"

TABLE IV
Assignment of the second role

Features	Belbin Team Roles	Probability
works fast, use of various techniques, achieves learning objectives, makes notes	Monitor evaluator	0.008849558
	Plant	0.008849558
	Specialist	0.017699115
	Implementer	0.017699115
	Shaper	**0.884955752**
	Completer-finisher	0.008849558
	Resource investigator	0.035398230
	Coordinator	0.008849558
	Team worker	0.008849558

The table results show that the shaper's role is the most appropriate for this learner. This type of learner is dynamic and extroverted; he is able to find the best approaches for solving problems. Through this approach, we aimed to facilitate the assignment of roles to successfully conduct collaborative work. We have identified specific characteristics of learners through their classroom practices as well as their interactions via distance learning platforms. This hybridization makes the learning process more organized and efficient.

A. Example of the Implementation

In order to illustrate the functioning of the proposed approach, we have presented an example of the realization of a project presented to students in the higher cycle. The project aims to lead the learners to set up a distance learning platform dedicated to parents of children with autism. This training aims to enable parents to use effective methods of caring for their children with autism. The first phase of this project deals with the design, including the context analysis, the pedagogical strategy and the existing content. The second phase is focused on the scenarisation of the learning activities. At the same time, the third phase is reserved for the mediatization of the training content and its integration.
Tasks to be carried out in order to complete the project:

Pedagogical design:

1. Contextual analysis: An in-depth study to determine the course use, target audience, and requirements.

2. Structuring the content: this task defines the information materials used, the architecture of the course, and its organization.
3. Definition of teaching methods: this task aims to associate a teaching method for each course in order to highlight the role of the learner in the learning process.
4. Scripting of learning activities: development of pedagogical scenarios for each activity defined in the content structuring.

Implementation of the platform

1. Definition of the platform's functionalities: in order to organize the interaction between the different actors of the platform (Administrator, session administrator, supervisor, trainer, and learner).
2. Mediatization of learning activities: This task aims at digitizing the learning content by using technological tools and respecting the rules of ergonomics and
3. navigation. The result of this task is a digitization of the planned learning scenarios.
4. Structuring of learning and assessment activities: the aim of this task is to ensure a better integration of the different learning modules and functionalities of the platform.
5. Testing and putting it into operation: the task of testing is crucial for controlling the proper functioning of the platform.

Then, we have related the planned tasks to the Belbin roles to facilitate the task assignment to learners according to their profiles. The table below shows the results obtained (table 5).

TABLE V
THE ROLES' TASKS

Reflexion	Monitor evaluator	Definition of the platform's functionalities
	plant	Definition of teaching methods
	specialist	Analysis of the context
Action	implementer	Scenario-building for learning activities.
	shaper	Mediatisation of learning activities
	Completer-finisher	Testing and commissioning
People	Resource investigator	Structuring the content
	Coordinator	Structuring of learning and assessment activities
	Team worker	Ensuring the Ensure communication between group members and offer the support to all of them.

According to the analysis of the learner's practices during face-to-face and distance learning process, we have identified the most relevant characteristics. These characteristics constitute the input data for Belbin's classification. We take a learner with the following characteristics:

{Solve complex problem, use variety of methods, planning strategies, planning of tasks}

After applying the Naive Bayes algorithm, the most appropriate role is the Implementer (table 6). This role aims to transform ideas into concrete actions.

TABLE VI
ASSIGNMENT OF THE THIRD ROLE

Features	Belbin Team Roles	Probability
Solve complex problem, use variety of methods, planning strategies, planning of tasks	Monitor evaluator	0.008849558
	Plant	0.008849558
	Specialist	0.017699115
	Implementer	**0.884955752**
	Shaper	0.017699115
	Completer-finisher	0.008849558
	Resource investigator	0.035398230
	Coordinator	0.008849558
	Team worker	0.008849558

To further clarify the approach, we propose a prototype of its functioning. The objective is to illustrate the classification of roles to the learners (Fig. 7) and show the tasks planned for each profile (Fig. 8).

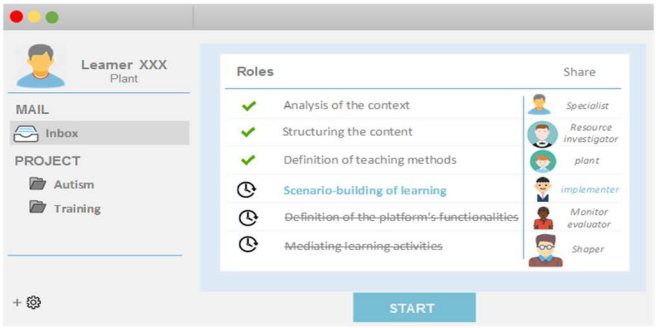

Fig. 7 Prototype of the role classification for learners

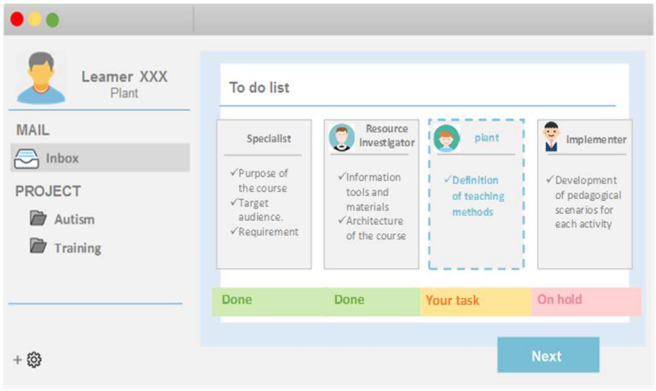

Fig. 8 Tasks planned for each profile

IV. CONCLUSION

During the lockdown situation imposed by the spread of COVID-19, The most education systems in the world have made a full transition to e-learning systems to ensure educational continuity. However, the high impact of social interaction and direct feedback has been a limitation for e-learning. For this reason, in this work we have proposed a hybrid learning model based on adaptive collaborative work through an intelligent assignment of the roles of the group members. The integration of collaborative work has enabled the learning rhythm to be balanced between face-to-face and distance learning, thus ensuring adaptive and effective learning. The results of this work lead us to further enrich the hybrid learning process through the integration of other active learning methods, such as problem-based learning or project-

based learning via artificial intelligence technologies within e-learning systems.

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APPENDIX 1

		Reflection		
		specialist	plant	Monitor evaluator
1	Participation in chat	No	No	No
2	Making a calendar	No	No	No
3	Respect deadline	No	No	No
4	High level of correct answers	Yes	No	No
5	FAQ participation	No	No	No
6	Open page in wiki	No	No	No
7	Send msg in conversation	No	No	No
8	mastery of technological tools	Yes	No	No
9	Use variety of methods	Yes	Yes	Yes
10	links the prerequisites	Yes	No	No
11	achieves learning objectives	Yes	No	Yes
12	Study hours	No	No	No
13	practice and homework	No	No	No
14	discussion forums	No	No	No
15	File exchange	No	No	No
16	Videoconferencing / whiteboard	No	No	No
17	Orientation/ Help	No	No	No
18	Searching Within Course	No	No	No
19	Self-assessment	No	No	Yes
20	Student community building	No	No	No
21	Student portfolios	No	No	No
22	Generating report	Yes	No	No
23	Messaging and notification	No	No	No
24	Work organization	No	No	No
25	use of various techniques	Yes	No	No
26	works fast	No	No	No
27	respect the instructions	No	No	Yes
28	creator of new ideas	No	Yes	No
29	consult the news	No	No	No
30	research of external resources	No	No	No
31	planning of tasks	No	No	No
32	asks questions	No	No	No
33	makes notes	No	Yes	No
34	Listening well	No	No	No
35	use of the dictionary	No	No	No
36	Solve complex problem	No	Yes	No
37	Planning strategies	No	No	No

		Action		
		implementer	shaper	Completer-finisher
1	Participation in chat	No	No	No
2	Making a calendar	No	No	Yes
3	Respect deadline	Yes	No	Yes
4	High level of correct answers	No	Yes	No
5	FAQ participation	No	No	No
6	Open page in wiki	No	No	No

7	Send msg in conversation	No	No	No
8	mastery of technological tools	No	No	No
9	Use variety of methods	No	No	No
10	links the prerequisites	No	No	No
11	achieves learning objectives	Yes	Yes	No
12	Study hours	No	Yes	No
13	practice and homework	No	Yes	No
14	discussion forums	No	No	No
15	File exchange	No	No	No
16	Videoconferencing / whiteboard	No	No	No
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18	Searching Within Course	No	No	No
19	Self-assessment	No	No	No
20	Student community building	No	No	No
21	Student portfolios	No	No	No
22	Generating report	Yes	No	No
23	Messaging and notification	No	No	Yes
24	Work organization	No	No	No
25	use of various techniques	No	No	No
26	works fast	No	Yes	No
27	respect the instructions	Yes	Yes	Yes
28	creator of new ideas	No	No	No
29	consult the news	No	No	No
30	research of external resources	No	No	No
31	planning of tasks	No	No	Yes
32	asks questions	No	No	No
33	makes notes	No	No	Yes
34	Listening well	No	No	No
35	use of the dictionary	No	No	No
36	Solve complex problem	No	No	No
37	Planning strategies	No	No	Yes

		People		
		Resource investigator	Coordinator	Team worker
1	Participation in chat	Yes	No	No
2	Making a calendar	No	No	No
3	Respect deadline	No	No	No
4	High level of correct answers	No	No	No
5	FAQ participation	Yes	No	No
6	Open page in wiki	Yes	No	No
7	Send msg in conversation	Yes	No	No
8	mastery of technological tools	No	No	No
9	Use variety of methods	No	No	No
10	links the prerequisites	No	No	No
11	achieves learning objectives	No	Yes	No
12	Study hours	No	No	No
13	practice and homework	No	No	No
14	discussion forums	Yes	No	No
15	File exchange	Yes	No	No
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27	respect the instructions	No	No	No
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35	use of the dictionary	Yes	No	No
36	Solve complex problem	No	No	No
37	Planning strategies	No	No	No