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REVIEW

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A BPM-based approach for ensuring an agile and adaptive learning process

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Abstract

Agility is a contemporary approach to IT project management, which we can also use in education. Students learn through the gradual implementation of iterative projects with information exchange between team members. Agility is above all a mindset. Being agile is quite simply being able to adapt to an environment that changes. Furthermore, various research works focused on the assessment of innovative teaching methods to promote the acquisition of new professional skills (e.g. project-based learning, active and collaborative learning, smart learning, etc.). In addition, adaptive learning is a pedagogical method favoring tailor-made e-learning to respond to the acquisition of certain skills, through the adaptation of pedagogical resources according to the learners' needs. Therefore, to establish a model based on these different methods to benefit from their advantages, we based our work on the Business Process Management approach, which constitutes the means of implementing thedesired agility in the learning process. Thanks to such a cyclical and continuous improvement approach, the learning process will evolve and take into account both the needs and the specificities of the involved actors (learners or teachers). We implemented our learning process and applied Process Mining techniques to foster the adoption of "Smart Education". We also attempted to ensure learning process adaptability based on the scrutiny of the log files obtained throughprevious executions of our learning process.

Keywords: Agile learning, Adaptive learning, BPM, Process mining, Smart education

Introduction

It is important to combine different approaches to adapt to the diverse and changing needs of learners. Hence the need to define a global approach to tackle the new situations imposed by the different contexts characterizing the new generations of learners, and also the daily constraints imposed by the evolution of Covid-19. We propose an approach to ensure the continuous and adaptive improvement of learning processes and foster the motivation of learners to effectively develop their knowledge, skills, and culture. Many methods have indeed used agile values, since 2002, including the most famous "EduScrum" and its three pillars: transparency, inspection, and adaptation (Wijnands & Stolze, 2019). The latter is a very useful method for developing a more favorable learning environment than the classic methods whose main

ideas are to build an autonomous learning ecosystem and a new culture where nothing is fixed and final. It was implemented in 2015 by Willy Wijnands in the Netherlands (Kingston, 2015; Magnuson & Cosgrove, 2020).

The global reform of education requires the awareness and mobilization of the involved actors. To resolve the problem of the inadequacy of the school system, the added value of the teaching provided must be reviewed. A teaching based on thedevelopment of initiative, adaptation, creativity, and the ability to solve various problems is recommended. The proposed method aims at strengthening the relationship between the school and its environment so that education will be adapted to the needs of society. The revision of the evaluation system and the professionalism of teachers through internships, retraining as well as the improvement of equipment and working conditions in the infrastructures are necessary. This structural reform is also focused on consolidating decentralization in financial, educational, or administrative decision-making as well as reinforcing the use of new IT technologies in schools (Delhij et al., 2015; Mcgill et al., 2016).To assess more effectively the good transfer of skills and knowledge between students of the same team, it would be possible to add multiple adaptations to the learning process thanks to the principles of the BPM approach. This might include adding a new test type to the individual tests already present in the "Eduscrum" method or the breakdown of tasks set at the beginning of the project into other sub-tasks at any time of the process. This adaptation stemmed from the observation of knowledge-sharing phases by the students, just before the tasks are considered complete (Schmiedel & Recker, 2020). Consequently, we started our research work with a mapping of the 4 fundamental values of agile and their 12 principles from project management to learning. Then we gave a detailed presentation of the process. Moreover, we proposed a BPM life cycle adapted for the learning process to ensure the continuous and adaptive improvement of learning processes and foster the motivation of learners to effectively develop their knowledge, skills, and culture. To validate our approach, we applied the proposed solution to a case study of secondary education, specifically for a "computer science" subject. Based on a questionnaire whose questions were inspired by the four values of agile learning and classified into four respective categories, we targeted a group of 100 students with varying ages (14–18 years) before and after the application of the Agile and Adaptive Learning Process (AALP). Finally, we implemented our learning process and applied Process Mining techniques to foster the adoption of “Smart Education”. We also made an attempt to ensure the adaptability of the learning process based on the scrutiny of the log files obtained through previous executions of our learning process.

The rest of this paper is organized as follows: Sect. 2 covers some related works on agile and BPM for adaptive learning. In Sect. 3, we present our BPM-basedapproach through which we will interpret the four agile values after their mapping. Then we give a statistical study on which we based an identification of the adapted twelve agile principles. We finish this section by modeling the classical and the proposed Agile Adaptive Learning Processes. In Sect. 4 we detail the implementation of our process and focus on how to introduce the intelligence in our process usingprocess mining techniques. Finally, we conclude the paper with hints on possible future work.

Research problem and related work

We present in the following sections the research problem and the most related works we found in the literature.

Research problem

We examined the possibilities of fostering the motivation of learners and set three main objectives to achieve:

- Foster the motivation of learners to effectively develop their knowledge, skills, and culture.
- Ensure the continuous and adaptive improvement of learning processes and associated strategies.
- Ensure the adaptability of the learning process in intelligent education.

Today, a lecture is generally understood to mean a form of teaching in which the teacher orally dispenses knowledge in front of the pupils who are supposed to collect it. It is often said to be "frontal" or "transmissive" as opposed to an educational approach in which the pupils would be put in a situation to “construct” their knowledge. The lecture does not have a good impact at a time when the development of storage techniques and communication of knowledge seems to open the field to new teaching methods, which makes the lecture appear to be archaic and outdated (Bruter, 2013). Based on classical pedagogies: learners cannot become aware of the immediate result of their learning as they are not very active, and this facilitates the lack of concentration or boredom. When the pace of the presentation is sustained, some learners may find it difficult to follow, especially when their note-taking skills are poor. In addition, oral presentations do not encourage students to interact with the teacher. Some teachers are less likely to give presentations. Moreover, the lecture does not promote knowledge transfer if used alone (Papi & Glikman, 2015).

Furthermore, it is necessary to analyze the generation gap, which is the source of the currently encountered problems. Each generation has influenced the generation of its children with its fears, which in reality no longer correspond to the context of the next generation such as Generation Z, now aged 6 to 23, and the alpha generation aged under 6. They are the real carriers of the digital revolution. Children from 1 to 6 years old already spend 3 h and 40 min a week in front of the screens. These generations will therefore expect the companies that hire them to be innovative; they are therefore more marked by the search for the ultra-short-term than generation Y. The alpha generation is called the indoor generation where everyone is alone in front of his or her screen. Sociologists project that this generation will be particularly frustrated with the gap that will exist in bringing their current virtual projects intoreality. However, agile methods are very fashionable today in the business world because they correspond to the needs and the mindset of current generations. Using agile methods makes it possible today to meet the needs and expectations of companies that must recruit and make Generation X and Generation Y work together. It appears undeniable that agile methods are a major response to the issues of listening, trust, and collaborative work on an equal

footing that these young people expect (Vultaggio, 2021). The COVID-19 pandemic has caused the greatest disruption to education systems in history, affecting nearly all students and teachers on the planet (Tessier et al., 2021). So how can we ensure pedagogical continuity and guarantee that students pursue school activities that allow them to progress in their learning? How to maintain the achievements already developed before the pandemic?

We can certainly benefit from the advantages of BPM by adopting it in the learning context to ensure the adaptability of the learning process to different contexts.

In addition, to implement this adaptability and control the educational processto guarantee an intelligent education, we will base ourselves on the Process Mining Techniques.

Related work

To highlight the main concepts of modern learning drawn from the literature such as project-based learning, Agile learning, collaborative learning, adaptive learning, and smart learning, we sought the benefits of each method to learners and checked if they are well motivated in these learning scenarios.

Project-based pedagogy

Project-based pedagogy is a teaching method in which learners acquire knowledge and skills by working over an extended period to investigate and respond to an authentic, engaging, and complex question, problem, or challenge. This type of pedagogy brings authenticity to the classroom in that the problem is easily connected to the outside world and students are challenged to collaborate, communicate, and think critically as they approach the problem (Krajcik & Blumenfeld, 2006).

Following a statistical study comparing traditional and rigid teaching methods commonly used in the history classroom with active learning methods, the authors of Capraro et al. (2013) concluded that many students become passive receivers of historical knowledge and witnesses to historical events. In response to the emerging call to revitalize history courses, they proposed a project-based pedagogy method, which systematically integrates project structuring thinking. Their results indicate that students in the experimental group performed significantly better than students using the old teaching methods in terms of creativity (fluency, flexibility, originality, and elaboration) and learning motivation. The PBL approach has also been used in STEM (Science, Technology, Engineering, and Mathematics) education, which is an integrated and practical method course, to enhance understanding of the course material (Bergener et al., 2012).

For a perceived justice in sustainable Project-Based Learning (PBL) in higher education, the authors of Collins and Chiaramonte (2017) provided a detailed review of a conceptual modelhighlighting the importance of student self-efficacy. They developed an integrated scale that assesses self-efficacy and perceived justice by incorporating educational context into the assignment of PBL following a questionnaire that was administered to two cohorts of undergraduate students in an interdisciplinary PBL course at an international university. In another research work, the authors presented the application of project-based learning in the laboratory of two different engineering degrees (mechanical engineering and chemical engineering), in one of the most time-consuming and challenging subjects in their programs. In addition,

to enhance student enthusiasm and motivation, these sessions included innovative manufacturing technology, 3D printing, and digital image correlation (DIC). Before each practical session, students are encouraged to watch an online video introducing the fundamental aspects. To evaluate the success of this methodology, after completing the lab sessions, students completed a non-formal quantitative survey. The results showed that the proposed project-based learning could contribute to the integration of knowledge and improve the skills included in the core competencies (Pan et al., 2023). In their research work (Beuchat et al., 2022), the authors presented a multiple case study examining the project-based learning model in middle school for teaching the theme of number sequences in mathematics. They provided a conception of a project as a complex system of alternating didactic situations shaped by student and teacher interactions with the global and local environments of each student team. They presented the practical principles of implementing PBL in mathematics education, and they demonstrated a successful strategy that promoted acculturation to the methods of mathematical exploration following a transition ofstudents from open-ended inquiry to structured inquiry by self-constraining the project environment.

Project-based learning has already proven its efficiency, mainly in traditional classroom learning situations. The teacher plays the role of a project manager to monitor and assist learners. As the structuring of the project in time is crucial, it is necessary to recommend a structuring of the synchronous and asynchronous phases, which punctuate the project.

Admittedly, despite all the advantages of this type of pedagogy, we were able to identify some difficulties that will likely arise for the whole team such as:

- Defining the criteria used to choose the first project.
- Time management to meet the deadline.
- Distribution of tasks and selection of techniques, for making an inventory of the necessary resources, find them and adopt the right procedure.
- Organization of the class, the timetable, and the regulations to be applied.
- Finding means of solving interpersonal conflicts and negotiating the differences in points of view.

Zhu et al. (2022) were able to overcome some difficulties, especially in the case of having a complex pedagogical project, and improved the implementation of project-based learning, based on the differential drive robots. They also guaranteed the good management of time to carry out the project by a team of students to achieve a functional prototype. They presented a new subject created to use project-based learning pedagogies for a semester-long project and improved its implementation. Moreover, the authors of Gomez-del Rio and Rodriguez (2022) criticized project-based pedagogy as it requires intensive resources and it is difficult to implement with limited resources. They proposed the use of hybrid project-based learning that seamlessly integrates project-based and course-based pedagogy. Following a statistical analysis and a student satisfactionsurvey, they concluded that the hybrid model is effective in imparting domain knowledge and developing life skills.

However, in Palatnik (2022) based themselves on a project-based pedagogy directed and driven by SCRUM agile design, to overcome the decisional difficulty and guarantee good time management. Also in Raval (2019) were able to solve difficultoperational problems during the educational program for future military officers in the digital age by adopting project-based learning, design thinking, and agility as the mainapproaches. Cruz (2019) proposed the application of the agile manifesto during the whole BPM process. They showed that communication deficiencies are in fact among the most frequent reasons for the failure of a project. Hence, they proved that it is necessary to teach agile communication skills in the application of BPM to overcome the different difficulties encountered such as time management and relational and contextual orders. Thus, the BPM (Business Process Management) approach is a means to implement the desired agility in the learning process. Thanks to such a cyclic and continuous improvement approach, the learning process will evolve and take into account the needs of each involved actor (learner or teacher).

According to the aforementioned list of works, we defined a set of criteria, involving the use of project-based pedagogy such as intellectual challenge, authenticity, reflection, agility, and BPM. They allow classifying in Table 1 the works cited according to these criteria.

We notice that the works, which are based on PBL have a precise idea of the project to work on, with a well-detailed planning that even anticipates all possible risks. As far as Agile methods are concerned, they will rather fit big projects, because they offer better adaptability, visibility, and risk management. The Agile approach aims to make project management more flexible. It favors creativity and adaptability by privileging the interactions between all the actors (learners and teachers). Agile teaching is different from project-based pedagogy in its framework and its values. The learner not only builds knowledge and know-how, but also learns to work in a team.

In the following section, we detail other works in the literature that are based on agile and adaptive learning.

Table 1 Assignment of the basic criteria of project based pedagogy used in some works

Authors	The intellectual challenge	Authenticity	Reflection	Agility	BPM
Capraro et al. (2013)	x		x		
Pan et al. (2023)	x	x	x		
Collins and Chiaramonte (2017)	x	x	x	x	
Beuchat et al. (2022)			x		
Zhu et al. (2022)			x		
Gomez-del Rio and Rodriguez (2022)			x		
Palatnik (2022)	x	x	x		
Bergener et al. (2012)			x	x	x
Raval (2019)		x	x		
Cruz (2019)	x	x	x	x	

Agile and adaptive learning

Hence, to point out the main concepts drawn from the literature, we examined the possibilities of fostering the motivation of learners to effectively develop their knowledge, skills, and culture. Various works in literature related to the agile manifesto application in the learning field. The authors in Noguera et al. (2018) sought to analyze the usefulness of agile strategies for team regulation and project management in online higher education and they approved the benefits of the agile method for teamwork organization (by asking students about their satisfaction with the course and their perception of the usefulness of the method). For the same purpose, Grimheden (2013) carried out a study about the integration of agile methods into teaching mechatronics design with the integration of Scrum into the synthesis projects. He affirmed that thanks to the integration of Scrum in the course, the students were able to solve the complexity of creating mechatronic products, in a much faster time than in the classic method. In the same way the authors in Scott et al. (2014) aimed to discover the relationships between students' performance along a Scrum-based synthesis project.

BPM refers to the ability to perform process documentation and ensure the execution of new or existing processes (IVIIT Capability Maturity Framework and (IT-CMF), 2016). To develop students' skills for workplace challenges, the authors in Longo et al. (2021) conducted an empirical study in the software developmentlaboratory of a higher education institution by applying BPM while managing and developing their processes. The challenge was to reduce the business processes management waste and foster the technological singularity described by Vinge (1993).

In our work, we will keep the same challenge but in the learning process.The benefits generated by BPM are manifold and depend on the nature of the modeled processes, such as visibility, performance, profitability, traceability, and agility that identifies the correction of the encountered dysfunctions, which are major issues of BPM. So applying agile thinking to BPM is not a simple task.

It is crucial to understand the basic concepts, underlying values, and principles of agile working methods. von Rosing et al. (2015) highlighted how agile concepts could be applied to enable BPM in all the various areas and disciplines. Similarly, the authors in Zacarias et al. (2017) showed the strong relationship between BPM and Agile, which resulted in a consolidated intelligent business process management framework.

In our work, we will also ensure this combination of the 12 agile principlesand BPM to ensure an agile and adaptive learning process.

In a face-to-face classroom, the teacher aims to ensure a good lesson and answers all questions simultaneously. He also provides students with adaptive feedback and supports them when they need help. However, in a large classroom where one teacheraddresses multiple groups of students, it will be difficult to provide the right support to the right group at the right time. To solve this problem and promote the effectiveness of collaborative argumentation, teachers need to embrace learninganalytics, which is useful for monitoring large numbers of students simultaneously and providing adaptive support when needed (Magnisalis et al., 2011).

In collaborative learning, students and their groups may face several difficulties that hinder the effectiveness of this group activity. First, group members tendto have difficulty in presenting various opinions on the topic of discussion and their opinions may be

similar from the start of the group decision (Clark et al., 2009). The authors in Han et al. (2021) approved the effectiveness of collaborative learning work based on dashboards whenthey examined a university class of 88 students (56 women, 32 men) for 4 weeks.

Collaborative learning is one of the main pillars in our new agile and adaptive learning process in this paper. Moreover, the collaboration between the different members of the team represents the third value of the agile manifesto, which is the basis of our model. Within the framework of a work carried out in a collaborative intelligent way, there will be no division of the work between its participants. Indeed, the latter will all work together at each stage of the work development. They will be based onthe communication and interaction skills of each participant. Adaptive learning systems are recognized as one of the most interesting research areas in education. According to Fischer (2001), the learning challenge is not only to make resources available to anyone, anywhere, at any time, and in different formats, but also to deliver learning in the place and at the right time in a way that is appropriate and well suited to the needs of the learner. Adaptive learning systems aim to adapt the traditional approach to learning to meet the learners' needs (Essalmi et al., 2010). The work proposed by Ciolacu and Beer (2016) presents an adaptive user interface for eLearning in the higher education sector; the authors based their work on the Aptitude-Treatment-Interaction (ATI) approach to adapt the learning content. For example, in mathematics subject, students take a test that helps them determine their knowledge and their skills. As a result, the system presents the appropriate chapters of the course and hides the parts that should not be learned for each participant. Several authors based their works on the application of artificial intelligence in education to solve certain problems encountered during learning. It helps to remedy the uniformity of the teaching methods and documents provided for all learners without taking into account that each learner is unique in his/her learning style. Moreover, collective intelligence is understood as the ability of a group to make connections with its context, to have logical reasoning, to complete problem-solving skills, and also to have good skills in communication and teamwork. The practices of the agile methodology can be compatible with these characteristics.

Table 2 Assignment of the basic criteria used in some works

Authors	Agility	Collaboration	Adaptability	BPM
Noguera et al. (2018)	x	x		
Cordeiro et al. (2017)	x	x		
Scott et al. (2014)	x	x		
de Moura et al. (2021)				x
Vinge (1993)				x
von Rosing et al. (2015)	x			x
Magnisalis et al. (2011)	x	x		
Clark et al. (2009)		x	x	
Han et al. (2021)		x		
Irmert (2009)			x	
Essalmi et al. (2010)			x	

We defined a set of criteria, to describe works involving the use of agility, collaboration, BPM, and adaptability in education. We classified them in Table 2 according to their applications in the cited works.

Based on the content of Table 2, we observe that only a few works simultaneously relied on BPM and agility. Adaptability is dealt with according to other approaches.

Smart education

The implementation of an intelligent system in engineering education is described in Rao and Singh (2020): the construction, operation, and maintenance of product developmentare carried out to solve the problems encountered in the company, assist and manage the needs of engineers to provide an effective solution following the standards. The authors of the article Chedrawi and Howayeck (2019) defined a model for the implementation of AI through expert systems (ES) in AACSB (Association to Advance Collegiate Schools of Business) accreditation programs with the capacity to reshape the process AACSB accreditation guaranteeing good results such as the reduction of time, costs, and errors, intended for higher education. The authors of the article Peredo et al. (2011) presented an intelligent educational system for all levels based on the web. It can be adapted to the needs of the learners, consisting of an authoring tool, an assessment system, an interactive voice system, and a virtual laboratory for programming in Java. It uses web services andexhibits the characteristics of powerful adaptability for the management, creation, delivery, and monitoring of learning content. In the work Lin et al. (2018) a method of filtering the given course according to the learner's profile is proposed. The authors based this method on the SLIM method (the sparse linear method). The authors of Katalnikova et al. (2017) proposed a collaborative intelligent educational system, which focused on the evaluation and improvement of the performance of the educational process based on the principles of the extended semantic network. In the work Batagan et al. (2011) an intelligent system for an education cluster is proposed to ensure a true knowledge-based link between companies and students. It will allow companies to integrate students into real activities during periods of practice or joint projects and will improve the quality and performance of higher education. An Auto-Encoder is described in the research work (Yang et al., 2019) to decide which project unit should be the most likely selected to achieve the greatest skill enhancement and accomplish agile SDCT teaching goals. Koper (2014) made an analysis of Human Learning Interfaces (HLI) to identify the conditions for the development of Smart Learning Environments (SLEs). These are physical environments enriched with digital, context-sensitive, and adaptive devices to ensure better and faster learning, based on HLIs. All of these together represent the mechanisms of interaction with the outside world related to learning that learners use to control, stimulate, and facilitate their learning processes. Shen et al. (2020) proposed the integration of technology in the traditional classroom providing an atmospheric learning analysis. For example rolling tables, stackable and folding chairs as well as ergonomics based on space present a diversity of furniture elements. The creation of a dynamic educational system based on the IoT and the 5G network is described by Bai and Zhang (2020).

Their proposed system allows: Collecting and analyzing data to be used in the Smart English Teaching Classroom Tests, where each learner's correct answer will becalculated separately through the organization of learning resources, the integration of 5G technology in education, the integration of three-dimensional viewing technology: 3D video, UHD (Ultra High Definition) screens and the use of cloud computing (storage and applications).

We defined a set of criteria, to describe works involving the use of artificial intelligence in education. These criteria are presented in Table 3 and classified in Table 4 according to their applications in the cited works.

Table 3 Assignment of the basic criteria used in some works

Adopted criteria of artificial intelligence in education	According to these criteria, intelligence in education allows
Smart tracking	Finding the causes of learning process failures immediately Anticipating changes and faults Taking into account the actual and predicted durations as well as the occurrences Developing technologies that are likely to replace repetitive and relatively predictable tasks of teachers' responsibilities Using MOOCs (Massive Open Online Courses) as a base Freeing the teacher from certain administrative tasks so that he can focus more on pedagogy
Social emotions	Initiating the construction of a sense of belonging Regulating group dynamics Facilitating the collaboration of learners Breaking the isolation of the learner Suscitating technical assistance between learners Facilitating the awareness of affective states tasks Producing formative feedback
Motivation	Bringing out the learner's personal goals Supporting the process of autonomy Proposing significant activities Fighting against abandonment Encouraging the use of tools Identifying the intrinsic motivations Encouraging and praising

Table 4 Assignment of artificial intelligence criteria in some works

Authors	Smart tracking	Social emotions	Metacognition	Motivation
Rao and Singh (2020)	x			x
Chedrawi and Howayeck (2019)	x	x		x
Peredo et al. (2011)	x		x	
Lin et al. (2018)	x			x
Katalnikova et al. (2017)	x	x	x	
Batagan et al. (2011)	x	x		x
Yang et al. (2019)	x	x		x
Koper (2014)	x	x	x	
Shen et al. (2020)	x			x
Bai and Zhang (2020)	x		x	x

Although many research works frequently focused on smart tracking, none of them adopted the Process Mining techniques. In the next section, we will detail our approach, which consists in applying data mappingto ensure the best match between project management and Learning (processes and actors) on the one hand and resolve thedifferences between the two systems on the other hand. In this way, the accuracy of the data of the 4 values and the 12 principles of agile is well ensured during the transfer from the source to the target.

A BPM-based agile approach to ensure adaptive learning

Section 3 is divided into 2 main parts: first, we interpret the 4 agile values after their mapping. Then, we draw up a statistical study to approve and validate the adoption of the 4 agile values in our model. Afterwards, we move on to the large second part, which defines the twelve fundamental principles of agile adopted for the learning process, the BPM life cycle adopted for learning, and we present the BPMN model of the two classical and agile adaptive learning processes (Bergaoui & Ghannouchi, 2021; Bergaoui & Sonia., 2021).

Mapping of the 4 values of the agile manifesto towards education

The main objective of developers in 2001 was how to revolutionize the processes of software development. They wrote the agile manifesto, which brought together the 4 main values and its 12 principles. The Agile manifesto defines the method to be followed thanks to its four fundamental values (Table 5).

The four new values of agile learning are described bellow.

A. Students and their interactions over learning and exercises

The following learning conditions must be met:

- The workspace in which each individual (teacher or student) spends almost 8 h a day must be a pleasant place (Spacious, having the light of the day, and well equipped).
- Self-organized teams (Students self-organize themselves and the teacher will help them to make it through).

Table 5 Correlation table of the 4 values of agile

Project management →	Learning
1/ "Individuals and interactions over processes and tools."	1/ Students and their interactions over learning and exercises
2/ "Working software over comprehensive documentation."	2/ Concise course over an exhaustive course
3/ "Customer collaboration over contract and negotiation."	3/ Collaboration between students teacher over excessive competition
4/ "Responding to change over following a plan."	4/ Developing skills and keeping them up todate by ensuring continuousadaptation over following a plan

- Having a manager of the servant leader type (a person who leads the team while doing his best to help it) or using a facilitator (student dedicated to help the team: "scrum master").
- Very human practices to always keep positive interactions.

B. Concise course over an exhaustive course

The teacher must:

- Favor the quality of the instructions and the course over the quantity.
- Avoid grades and rankings.
- Provide students with the means to know their strengths and weaknesses.
- Help the student to perceive the demands of a task.
- Encourage autonomy and give real or symbolic examples of excelling in oneself.

C. Collaboration between students over the excessive competition

The teacher performs the following tasks:

- Organizes tasks to promote collaboration between students.
- Removes any ranking and competition in the organization of tasks.
- Facilitates self-assessment through feedback.

D. Developing skills and keeping them up to date by ensuring continuous adaptation over following a plan.

The teacher carries out the following tasks:

- The teacher carries out the following tasks:
- repares learners for an active life.
- Brings the university closer to the world of work.
- Develops skills that are expected by employers.
- Develops the students' entrepreneurial spirit.
- Encourages business start-ups: project management, risk-taking, initiative spirit, etc.

Statistical study

The key to the success of our Agile and Adaptive Learning Process (AALP) model is that it adopts the philosophy of the agile manifesto. It is also a result of the application of the four core values, which have been previously proposed for correlation in the field of educational learning. The emphasis is on the intrinsic contribution of the agile philosophy to the methods of classical education in terms of role (actors) and information transfer (interaction).

Questionnaire elaboration

The questionnaire is developed and presented to a group of 100 students of different ages (14–18 years) before and after the application of the Agile and Adaptive Learning.

Process model, which was distributed in two stages. We used the "Likert" scale, which is a very popular tool for surveys and questionnaires.

It allowed us to ask about their degree of agreement or disagreement with a statement. It is a very reliable tool for measuring opinions, perceptions, and behaviors. Since the questionnaire was developed based on the foundations of the agile method, the questions are therefore divided into 4 categories. Students/participants have toanswer each question on the Likert scale by indicating how much they agree or disagree: (Strongly agree, agree, neutral, disagree, strongly disagree) (Table 6).

We used a detailed statistical study to identify the impact of our Agile and Adaptive-Learning Process model through a comparative analysis of the data collectedand illustrated by different graphs.

As presented in Fig. 1, the chosen mode of representation clearly demonstrates the dissimilarity and contrast of the responses obtained before and after the application of the model. It seems to be inverted; if we compare the affirmative responses colored in blue, we notice that the number of affirmative responses before the application of the

Table 6 Classification table

The four values of agile	The statements
1/ Students and their interactions over learning and exercises	S n°5: The collaboration between the pupils is well ensured S n°6: The interactions help learning and assignments S n°7: Initiative-taking is encouraged S n°8: Face to face dialogue is well ensured S n°15: You have a large amount of lessons toremember and memorize S n°16: You feel that a good quality of the course contentis necessary S n°17: You notice that grades and rankings are preferred
2 / A concise course over an exhaustive course	S n°1: The course objectives are clearly stated S n°2: The pace of the course allows you to follow and understand the new concepts S n°3: Your experiences and background are taken into account S n°4: Learning conditions (schedule, team, room, etc.) are adequate
3/ Collaboration between students and teacher over the excessive competition	S n°11: Ideas are shared between students and teacher S n°12: Curiosity and unpredictability are present when taking the course S n°13: Ludo-pedagogy (gamification, rewards, etc.) is well-ensured S n°14: Self-assessment is encouraged
4/ Developing skills and keeping them up to date by ensuring continuous adaptation over following a plan	S n°9: The entrepreneurial spirit is well developed S n°10: Preparation for an active life is well-ensured (through outings and visits, etc.) S n°18: You notice an increase in business start-ups (project management, risk-taking, etc.) S n°19: Time management is respected and a balance exists between learning and assessment S n°20: You have a continuous improvement and an adaptation to newly encountered contexts such as covid-19

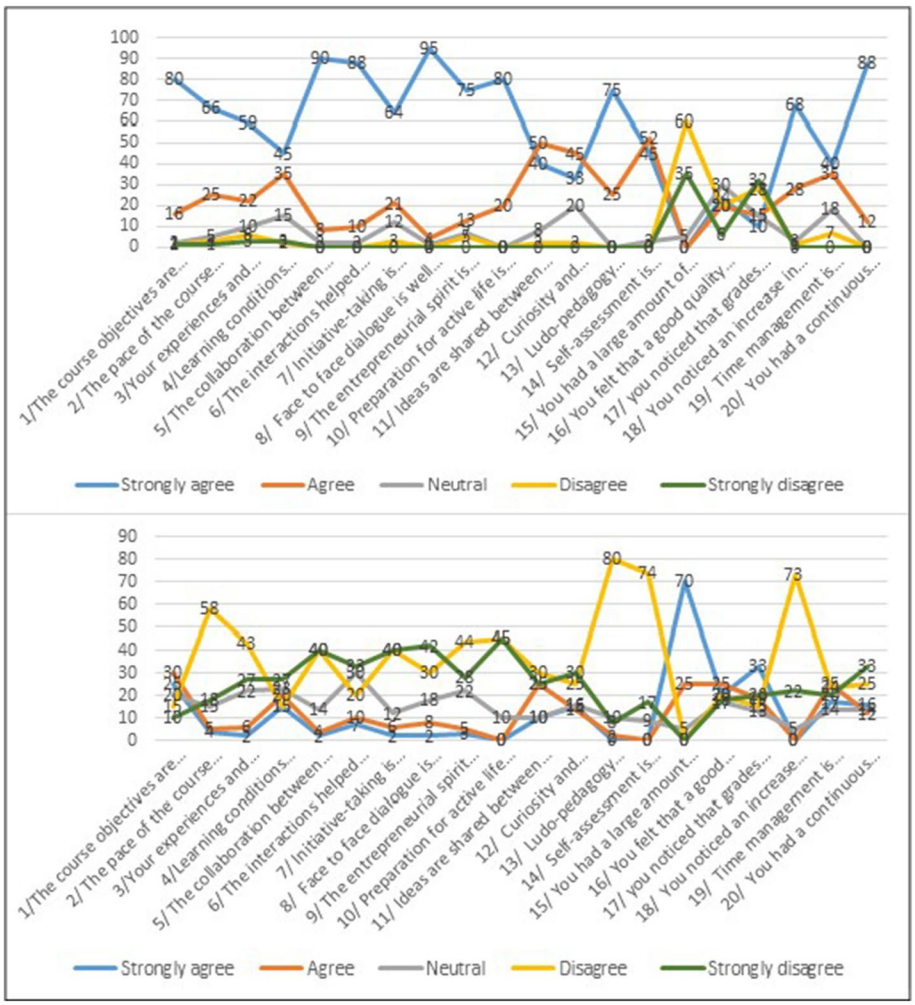

Fig. 1 Statistical curves before and after the application of the Agile and Adaptive Learning Process model. (Out of 100 students)

Table 7 The average of affirmative answers before and after the application of each agile value of the model

The four values of agile	Average of affirmative answers before application of the model	Average of affirmativeanswers after application of the model
1/ Students and their interactions over-learning and exercises	7.42	64.14
2/ A concise course over an exhaustive course	11.5	62.5
3/ Collaboration between students and teacher over the excessive competition	6.25	52.5
4/ Developing skills and keeping them up to date by ensuring continuous adaptation over following a plan	8.6	70.2

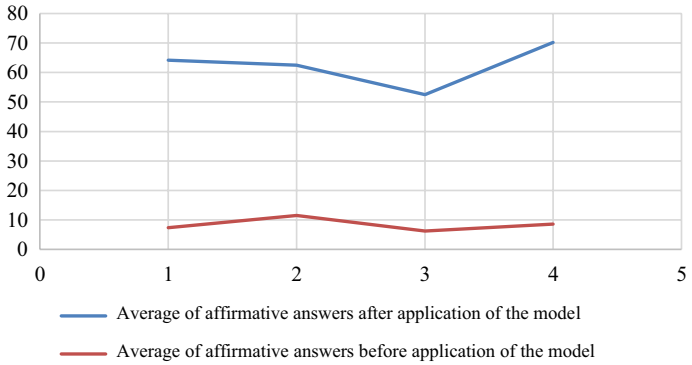

Fig. 2 The average of the four agile values before and after applying the model

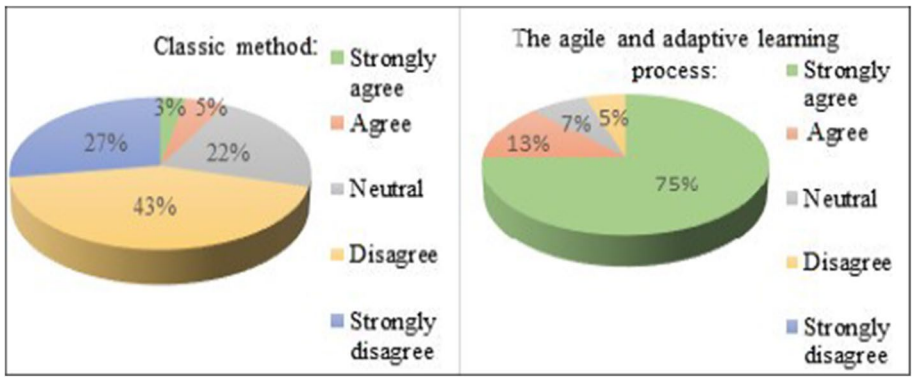

Fig. 3 S9: The entrepreneurial spirit is well-developed

Agile and Adaptive Learning Process are practically less than 20 except for question n°15 which targets the quantity of the taught course where there are 70 affirmative answers. Then, to properly interpret the result we calculated the average of affirmative answers before introducing a new model and after deploying it (Table 7).

Figure 2 clearly shows the difference between the two averages calculated (before and after the application of the model). Thus, the use of the agile 4 values is well verified and approved in the agile and adaptive learning process model with a maximum average found in the fourth agile value "Developing skills and keeping them up to date by ensuring continuous adaptation", which is equal to 70.2.

Some response samples before and after applying the agile and adaptive learning process model targeting this fourth agile value are discussed below.

The fourth agile value adopted in the agile and adaptive learning process promotes the entrepreneurial spirit that allows having a creative student. The latter is able toset a clear goal, guide his choices toward this goal, and find innovative ways to achieve it. This is well reflected in Fig. 3 since this state of mind is not adopted in thetraditional methods.

In fact, only 3 pupils out of 100 affirmed it, while 75 affirmative answers are given after the agile and adaptive learning process application.

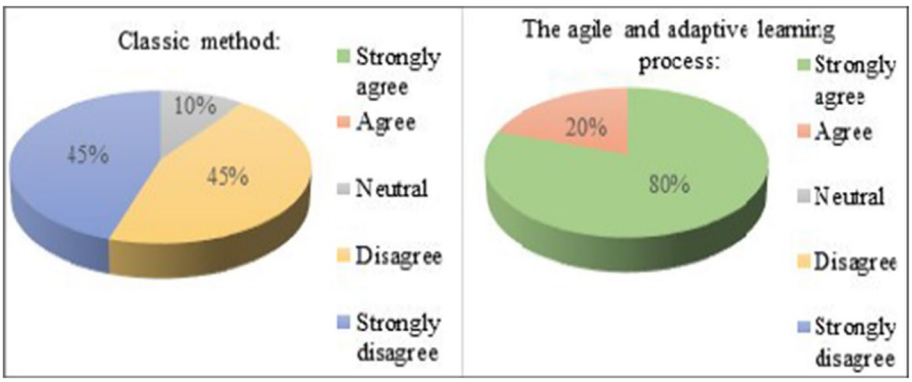

Fig. 4 S 10: Preparation for an active life is well ensured (outings and visits, etc.)

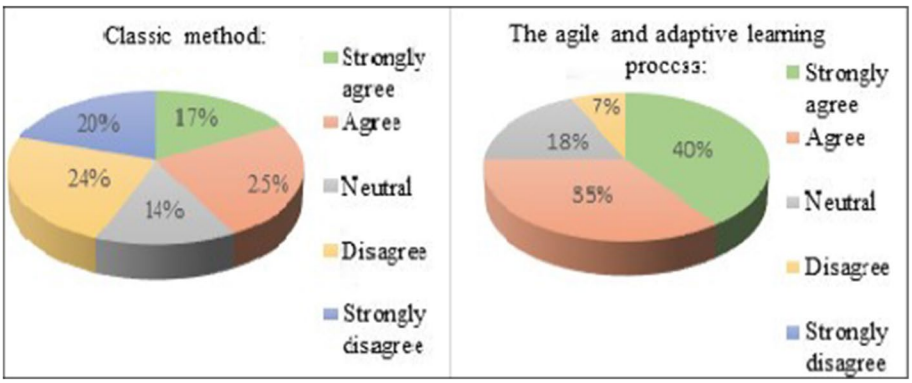

Fig. 5 S19: Time management is respected and a balance exists between learning and assessment

The fourth agile value which is adopted in the agile and adaptive learning process romotes active living, which enables students to make well-informed decisions, effectively communicate, and confidently evolve in their environment.

As shown in Fig. 4, zero affirmative responses are found in the conventional methods, while the rate rises to 80 affirmative responses out of 100 for the agile and adaptive learning process.

In the classic methods, assessments are carried out by the teacher who respects predictability and determines which and when questions will be asked in a test. However, in the agile and adaptive learning process, we distinguish three types ofevaluations which are: summative evaluations, which will take place after each sprint (variable date according to the progress of students' groups in their projects), the formative evaluations which will be organized regularly during the sprint whilst testing each of the tasks carried out and ensuring self-assessment.

In Fig. 5, we notice a remarkable difference between the two results: 40 affirmative answers out of 100 for the agile and adaptive learning process and only 17 affirmative answers out of 100 for the classic process. This proves the promotion of thebalance between learning and evaluation in the agile and adaptive learning process.

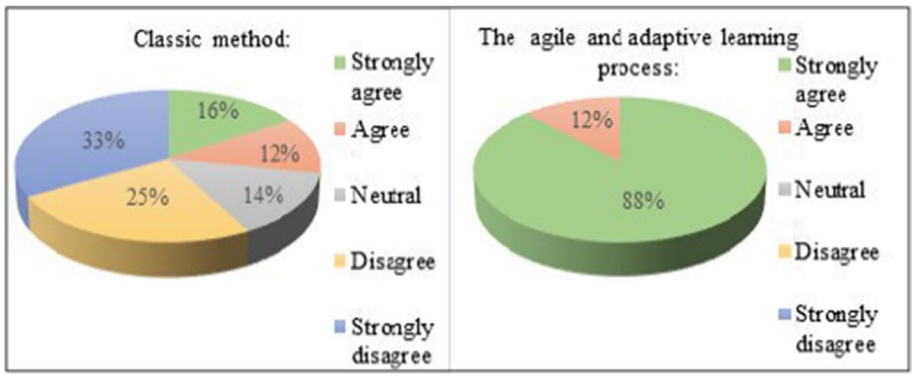

Fig. 6 S 20: You have a continuous improvement and an adaptation to newly 20 encountered contexts such as covid-19

In Fig. 6, we notice that the vast majority of students (88 out of 100) confirmed that continuous improvement and adaptation to new contexts are present in the agile and adaptive learning process, which provides two types of adaptations: didactic adaptation (modification of the curriculum, changes in teaching activities, reduction of the length of learners' tasks according to their needs and improvement of the process performance), and specific adaptation (such as the case of the great disruption caused by the covid-19 pandemic using online platforms).

For all the other agile values, the statistical study confirmed again a clear difference in students' answers about the added value brought by the new model.

The twelve fundamental principles of agile adopted for the learning process

The most important advantage of the BPM methodology is the optimization ofprocesses, which guarantees their agility. The processes are modeled and optimized to avoid wasting time on unnecessary activities and delays thanks to the implementation of the 12 principles of agility during the process execution. We are particularly-interested in applying them in the context of learning processes. Hence, we propose a mapping of the agile principles of Project Management to the specific context of learning (Table 8).

In what follows, we will interpret and explain the twelve principles of agile adopted for the learning process.

A. Our highest priority is to satisfy the student through continuous learning of new valuable concepts

To know if the student is satisfied and has understood the lesson well, it is necessary to know how to involve him/her in the learning process. This is possible through targeted projects to be carried out comprising new concepts to be implicitly learned during the realization of the project.

B. Accommodate changing requirements, even late in completing the requested job. Agile processes harness change for the student's competitive advantage

Table 8 Correlation table of the agile 12 principles

Project Management→	**Learning**
1- "Our highest priority is to satisfy the customer through early and continuousdelivery of valuable software."	1-Our highest priority is to satisfy the student through continuous learning of new valuable concepts
2- "Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage."	2- Accommodate changing requirements, even late in completing the requested job. Agile processes harness change for the student's competitive advantage
3- "Deliver working software frequently, from a couple of weeks to a couple of months,with a preference to the shorter timescale."	3- Carry out frequent and regular evaluations of all types to ensure good learning
4- "Business people and developers must work together daily throughout the project."	4- Ensure collaborative work between students and teachers
5- "Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done."	5- Build projects around motivated students. Give them the environment and support they need, and trust them to get the work done
6- "The most efficient and effective method of conveying information to and within a development team is face-to-faceconversation."	6- The most effective method of conveying information to and within a group of students is face-to-face conversation
7- "Working software is the primary measure of progress."	7- Relying on a concise course and doing a lot of practical exercises with self-assessment promote good learning
8- "Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely."	8- Agile processes promote sustainable development. Teacher and students should be able to maintain a constant pace indefinitely
9- "Continuous attention to technical excellence and good design enhances agility."	9- Continuous attention to infrastructure excellence and a good choice of project plan enhances agility
10- "Simplicity—the art of maximizing the amount of work not done—is essential."	10- Simplicity-the art of maximizing the amount of concepts not to be taught by teachers-is essential
11- "The best architectures, requirements, and designs emerge from self-organizing teams."	11- The best organizations of work, pedagogic objectives and ideas
12- "At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly."	12- At regular intervals, the student's team reflects on how to become more effective, then tunes and adjusts its behavior accordingly

This principle is the formal definition of agility. Lightening up and summarizing become the new concepts to learn, which will evolve anyway during the realization of the projects. This does not mean that we have to turn everything upside down at the slightest request. Each contingency must be treated like any other functionality: we analyze it, quantify it, and prioritize it. As in the case of covid19, we can change the schedule of sessions, minimize the number of groups of students by dividing it into sub-groups, or even ensure collaborative virtual work to keep the same development pace of the learning process.

C. Carry out frequent and regular evaluations of all types to ensure good learning

Splitting the learning process into sprints is not enough. Each sprint must be crowned with one or more evaluations to control the progress of the educational project to be carried out by each group of students on the one hand and to ensure the good level reached by the students on the other hand.

D. Ensure collaborative work between students and teachers

Collaboration is one of the skills that all teachers and learners must develop in their learning practice. Collaborating, that is exchanging, clarifying, and asking also means developing a collective intelligence by pursuing a common goal, which aims at the success of the pupils, and the achievement of their full potential. Collaborative work helps to break the isolation of teachers and school administrators' work while promoting the overall development of students and ensuring better consistency in interventions.

E. Build projects around motivated students. Give them the environment and support they need, and trust them to get the work done

An agile team (teacher and students) must be motivated to be successful. Indeed, an agile team needs time to get around. In EduScrum for example, it takes a few sprints for the team to figure out how many objectives they are capable of achieving because members get to know each other and learn from the mistakes and successes of previous sprints.

F. The most effective method of conveying information to and within a group of students is face-to-face conversation

Communication is the key to success and face-to-face communication is the best means.

G. Relying on a concise course and doing a lot of practical exercises with self-assessment promote good learning

In education to measure the progress of the course, we use assessments and exercises.

With methods such as EduScrum, it is very easy to assess groups of students based on objectives, burn-up / burn-down charts, etc. The goal of each iteration is to ensure the team's self-evaluation. This is the best way to evaluate the performance of a team.

H. Agile processes promote sustainable development. the teacher and his students should be able to indefinitely maintain a constant pace

The eighth principle of agile does not contradict the principle of adaptability. Being agile does not mean interrupting everything following a student's academic orpsychological blockage. We should not forget that the teacher who represents the Product Owner is part of the team, and his role is to ensure a sustainable pace.

I. A Continuous attention to infrastructure excellence and a good choice of the project plan enhance agility

Infrastructures (classrooms, laboratories, and equipment) are essential elements for learning in our schools and universities. There is strong evidence that high-quality infrastructure facilitates better education and strengthens learning outcomes.

Moreover, project-based learning places students in the position of responsible actors for their projects. This leads them to collectively seek solutions to the problems arising from the concrete realization of the project. Thus, they will become able to gradually build their learning and their own personal and professional project.

J. Simplicity-the art of maximizing the amount of concepts not to be taught by teachers-is essential

Simplify as much as possible the work method and the new concepts to be learned. If the project is complicated then you should not aim for the end but start by the first stage. If necessary, divide each step as much as necessary to make each task and each story seem simple. Moreover, students will learn through their involvement in concrete projects and teachers should avoid giving them concepts that might complicate their tasks.

K. The best organizations of work, pedagogic objectives, and ideas

A team learning under pressure will always be less efficient. Thus, you have to let the students self-organize. Those who work towards a common goal because they want to achieve it will always be more efficient and reliable than others working together with various objectives because they have been told to do so.

L. At regular intervals, the student's team reflects on how to become more effective, then tunes and adjusts its behavior accordingly

Continuous improvement is a principle that must be kept in mind when learning in an agile method. Every week each team of students thinks about ways to become more efficient to ensure a good quality of the requested work, then as a consequence, they will adjust and modify their behavior or the software used or the first plan considered initially.

Now, having these principles always in mind in education is of paramount importance.

They allow us to guarantee the agility of the students whatever method is used. To make its principles more dynamic and efficient, we used BPM (Business Process Management) in our study; its implementation minimizes wasting time, reduces operational costs, improves the quality of the course presentation, and ensures greater competitiveness of educational learning by enabling the definition, execution, measurement, analysis, evaluation, optimization, and control of organizational procedures.

In the rest of this section, we will see how BPM provides the tools and methods to improve the learning process while respecting the 4 stages of its life cycle (Bergaoui & Sonia, 2021).

Modeling of the proposed learning process

In this section, we first introduce the concept of business process and BPM, next we focus on the lifecycle of adaptive learning process management. Finally, we present the modeling of the classical method of the teaching process and our new learning process.

The business process

A business process is defined as an orderly and chronological sequence of tasks intended to produce an added-value result. On the one hand, the result may concern the customers who are in our case the students, and on the other hand, the shareholders and the employees who represent in our case the teachers and the directors. Many definitions of business processes were proposed. For example, Hammer and Champy (1993) defined a business process as "a set of activities whose ultimate goal is the production of a specific result that is of value to the customer. It is affected by events in the outside world or other processes". Hence, the need for a modern contemporary approach ensuring the increase in productivity (the success of learning on all levels) and the reduction of costs.

Moreover, innovations and continuous improvements of business processes are required. BPM (Business Process Management) adopted a cyclical approach to the continuous improvement of various business processes (Ayech et al., 2021).

A learning process is defined as an ordered and chronological sequence of tasks intended to produce a result with an added value for the learners. Thus, the idea in this paper consists in applying BPM to learning processes.

In our work, the BPM process represents a starting point to understand and derive the good flow of educational learning. It also determines the different opportunities to improve performance.

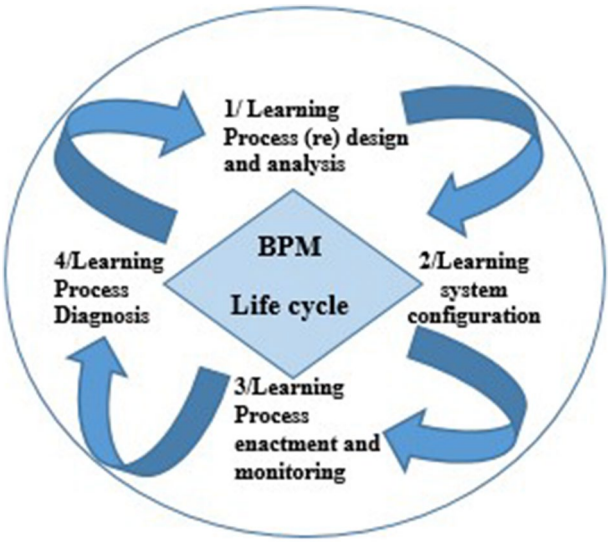

Fig. 7 The BPM life cycle adapted for learning processes

The BPM life cycle adapted for learning processes

BPM brings to our learning method an added value to the process overview. The 12 agile principles are integrated throughout the 4 stages of the life cycle proposed in this section. We present in Fig. 7 the different stages of the management life cycle of the business processes as adapted for learning processes (Bergaoui & Sonia., 2021).

A. Learning Process (re) design and analysis

It consists in determining the appropriate organization of tasks and concepts to be given to students to achieve the objectives set by the teacher. We build the learning process based on the BPMN modeling language. Therefore, the cycle begins with the creation of an initial learning process model either from scratch or by modifying an existing one.

B. Learning system configuration Learning

It aims to integrate organizational and technical changes such as the number of students per group and their different ages, which will influence the content and nature of the given course. The main objective of this step is to make the deployed learning processes operational and accessible to learners regardless of the requirements of the adopted system (Learning management system, website, classic classroom, etc.).

C. Process enactment and monitoring

It consists in executing the learning process, controlling it, and analyzing thedifferences between the objectives set and the measures carried out. It is also known as the control and supervision phase of the learning process during its execution.

D. Learning Process Diagnosis

It is in this stage of the cycle that the decision will be taken on the initiatives to change the learning processes developed in the first stage of the cycle. These changes allow us to cope with the circumstances encountered during the execution, such as the management of student absences, the covid- 19, etc., and then use them as input forpossible learning process improvements.

The modeling of the learning process

Business process modeling (OMG Document Number, 2011) is considered the most important step in BPM.Business process modeling is a way to represent ongoing activities, information flow, and decision logic in business processes. It has increased the ability to understand business processes. Several modeling languages have been proposed for this purpose.

In this work, we will adopt BPMN (Business Process Model and notation) resulting from a project initiated by the Business Process Management Initiative (BPMI), which

was merged in 2005 with the Object Management Group (OMG). BPMN is a notation for the graphical representation of business processes in a workflow (Sadowska, 2015).

We present in Fig. 8 the modeling of the classical learning process and in Fig. 9 the modeling of the proposed Agile Adaptive Learning Process.

Classical pedagogy certainly has qualities, but also limits. Facing this situation, schools are established on classical foundations and their administrative and real structures seem hopelessly static. We can confirm that the classical method is boring, extremely competitive, unequal, authoritarian, etc. Moreover, it is considered outdated.

The BPMN model presented in Fig. 8 shows the succession of tasks to be followed in the educational process. It has no possibility of ensuring self-evaluation or adapting to changes, which may suddenly be encountered, and above all, there is a total neglect of collaborative work, thus generating an absence of a climate of trust and responsiveness. The process is made up of five parts:

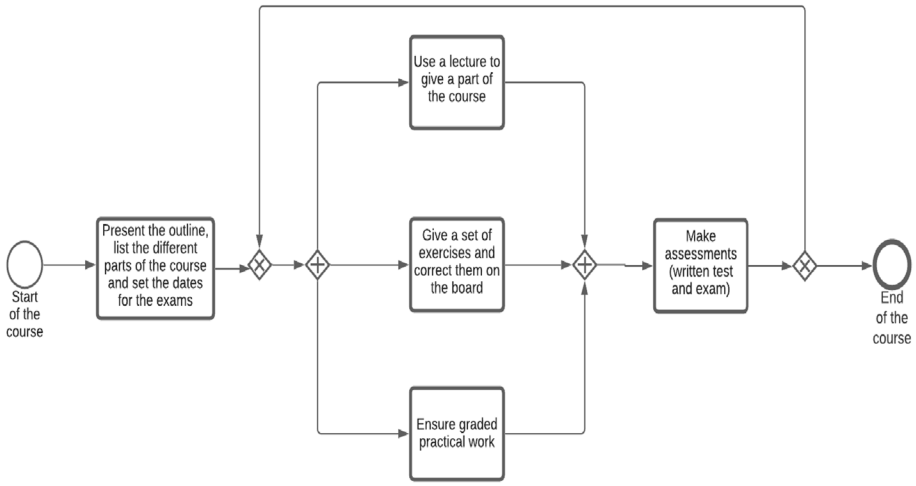

Fig. 8 The BPMN Model of the classical Learning Process

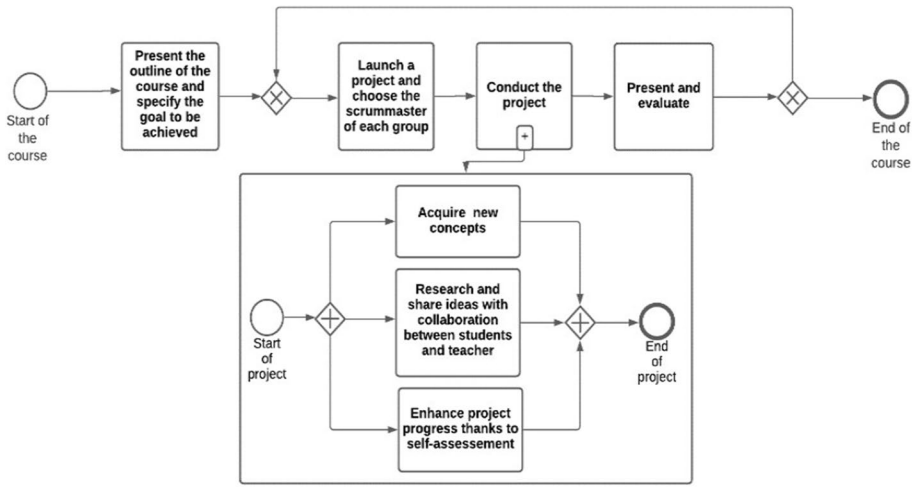

Fig. 9 The BPMN Model of the Agile Adaptive Learning Process (AALP)

In the first contact with the students, the teacher presents the different parts of the program and sets the dates for the evaluations.

Then he/she teaches the first part of the course based on a lecture, which is a form of teaching in which the teacher orally conveys knowledge in front of students who are supposed to collect it. It is often considered a transmissive way.

Afterward, in the third and fourth parts of the process, the teacher moves on to tutorials and practical work, which are a form of teaching allowing the application of knowledge learned during the lectures.

Finally, learners get an evaluation, which is an integral part of the learning process. It is established in a way that is tightly linked to the study programs and teaching.

The model of our process consists of four main steps.

The first step is triggered by the teacher during his/her general presentation of the different parts of the course by specifying the main objectives to be achieved. The second step starts when the teacher launches the first detailed project to be carried out by teams of 4 to 5 students by specifying two mandatory rules:

- The scrum-master of each group is elected following a vote carried out on the same day of the start of the project with the possibility of replacing him/her during the progress of the project.
- A free choice of software and method to follow when carrying out the project (to guarantee adaptability to different contexts), while respecting the deadline.

The third step is the sub-process carried out by the different teams of students and corresponds to conducting the project itself. It requires collaborative work between learners and their teacher and a self-assessment after each part of the project to promote good progress in the work and guarantee good learning of new concepts.

Finally, the fourth step of the process consists in the evaluation of the various projects carried out following a presentation of each team with an interaction of the other teams and the possibility of inviting other teachers during the presentation.

When we come back to step 2 of the process, we repeat the same steps until the end of the course. This means that the learning process will pass through many projects (one by one).

In our proposed new agile and adaptive learning model, adaptivity is guaranteed since it represents the fourth value of the agile manifesto. It corresponds well with the spirit of Agile methods as a whole and emphasizes the rapid detection of problems as in the case of covid-19.

Smart education and adaptability in our agile and adaptive learning process (AALP)

It is necessary to acquire good reflexes from the beginning and adopt good tools to guarantee the adhesion of all stakeholders to the agile and adaptive learning process. Any efficient process requires evolutionary and agile tools that allow its implementation and ensure the transmission of clear information to stakeholders. There are also dedicated solutions that facilitate mapping and process control. For our work, the chosen tool must ensure that our process approach remains valid and credible in the long term, guarantee

that the areas of improvement reassembled in the field are applied, and make sure that appropriate responses are put in place.

Our Agile and Adaptive Learning Process is indeed based on the 4 values and 12 agile principles mapped and interpreted in the previous sections. The intelligence of our AALP emanates from the log files left by the learning, as well as the use of process mining techniques. It appears in particular through anticipation, innovation, and adaptability.

Implementation of AALP

The first step is to draw a diagram of our process by respecting the BPMN notation.

Then, we specify for each task of the process the user who is going to accomplish it (teacher or learner). Next, we create and assign the forms that users will complete when they connect to the web portal. Finally, we move to the compilation and execution of the process and correct the errors if they exist. With each connection to the web portal, there will be an automatic recording of the process chain with the possibility of uploading files or triggering message conversations between the currently connected actors of the process. With the Bonita tool (Failed, 2011), we need to create a form as long as an actor provides the task, while with other tools like Heflo and Signavio the form is crated automatically. At the start of Bonita BPM, we find various quick access links arranged in the eclipse studio to start the creation of a diagram. In the diagram area, we add the succession of tasks, pools, lanes, etc. we use drag-and-drop, which makes getting started very easy. When creating forms for human tasks, the BPM elements area is replaced by the widgets shown in Fig. 11. The diagram area is also replaced by the form design area, shown in Fig. 10. The menus in the diagram configuration area are then adapted to correctly configure the forms.

In Figs. 10 and 11 we present an example of form creation made for the actor who is the teacher in our process. After having created the respective forms for the tasks of our process, during execution, if there are no errors indicated, we move directly to the web portal where the first form will be displayed. Thus, we follow the recording of the various tasks of our agile and adaptive learning process (AALP). The Web Portal has two distinct views: the testing of the processes thanks to the forms created as shown in Fig. 12, and

Fig. 10 Creation of the first form

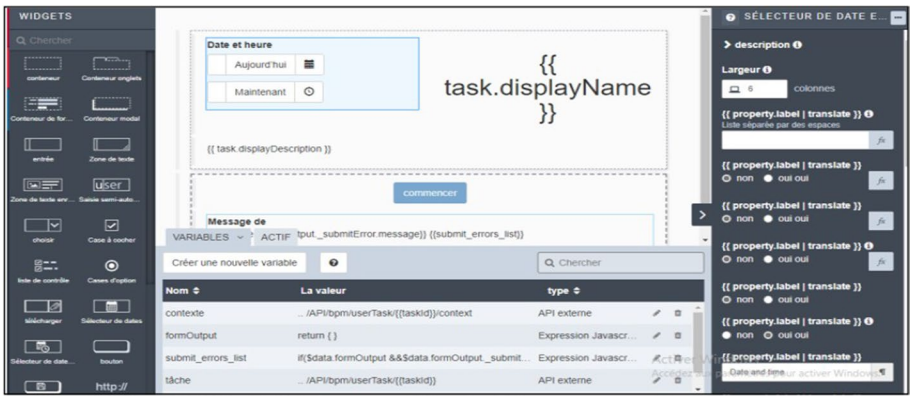

Fig. 11 Inserting buttons and widgets in the form

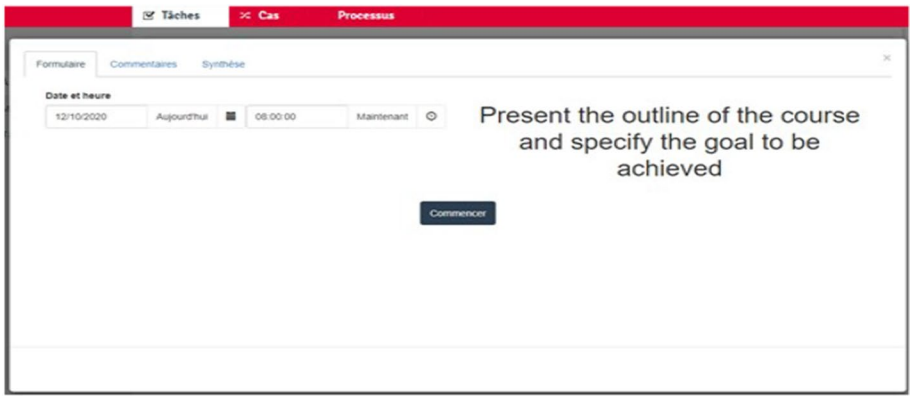

Fig. 12 Form executed on the web portal

the administrative portal that opens when the project is launched and can be directly tested.

When the first actor in our process, who is the teacher, clicks the "start" button, the process Begins. We then have several possible actions: view the tasks in progress, available tasks and completed tasks, process the task to move on to the next step in the process, or add a comment, as shown in Fig. 13.

Fig. 13 Indication of the teacher's first task

Thanks to the Bonita tool, we were able to visualize each step of our process and thus analyze it.

Setting up process mining

In our work, we propose an agile and adaptive learning model where its intelligence finds its source in the log files left by the learning and the use of process mining techniques. It appears in particular through anticipation, innovation, and adaptability.

To ensure this intelligence base support or foundation during the development of a list of sessions, based on the data and traces already recorded after the end of the process, process mining techniques make it possible to exploit the traces of our educational model. Process mining can be used iteratively, which helps us to build more and more detailed data records (names of actors, notes, dates, etc.), and design the program to be taught (work required, new concepts to remember, the main objective of the teacher, etc.). Therefore, process mining makes it possible to quickly identify the problemsencountered and remedy them in the future (Aalst & Wil., 2012).

- Process mining techniques aim to translate the data entered during the execution of the process into actionable information/knowledge.
- Three main types of Process Mining analysis are identified: process discovery, conformance checking and process enhancement.
- Process Discovery: The goal is to identify and establish a process model, i.e. a formal behavioral description, which describes the process as captured by the event data.
- Conformance Checking: we seek to assess the extent to which the data relating to events correspond to a given reference model.
- Process Enhancement: The main objective is to improve the process sequences of the process, that is, by improving the process models based on facts derived from event data (Bannert et al., 2014; dos Santos Garcia, Cleiton et al., 2019).

To run Process Mining algorithms, it is necessary to have data detailing the various tasks carried out within the framework of the agile and adaptive learning process. In the following section, we present an example of a log file of previous executions of our AALP and its analysis based on the conformance-checking technique done with the Prom tool. Since we need to assess the conformity of our AALP model against the data generated during its execution over a given period, we applied the control checking (Brüß, 2019).

Practical application for smart education

In this part, we analyze the drawn log files following the execution of our AALP, based on the Celonis tool (Badakhshan et al., 2020) and the confirmation of the first criterion of smart education "Smart tracking" which is mentioned in Table 4 of "Smart education" section.

We have recovered all the tasks carried out by the various actors of our AALP, as well as the indication of the problems encountered during this period. We have also recovered the scores assigned during the peer assessment after each session and

the final score assigned to the fifth session during the presentation of the work. We start by importing the recorded log files, which are either xls, or xml, or CSV, or xes extension.

This step of analysis consists of counting the number of tasks made for each actor as shown in Fig. 14 The main objective is to better understand the agile and adaptive learning process (AALP) to make it more efficient. The process mining technique used is indeed Conformity Checking, which assesses the conformity of the existing process model with the current data.

Therefore, thanks to this technique, which is based on the analysis of log files, we were able to review our process and identify the optimization potentials. Hence, the elimination of operational inefficiencies is well established. Thus, by relying on process mining and the conformance-checking technique, we were able to bring transparency to our agile and adaptive learning process to guarantee harmony and the needed improvements. It also allowed us to quickly uncover any valuable information that can reveal the opportunities nested within the process. This PM technique has a considerable advantage over more traditional analyses since it was possible to access event data in real-time. (Exploring the process also involves looking at historical data).

Thanks to the detailed examination of these series of event logs seen in this section, we were able to gain an in-depth understanding of the fulfillment of the 4 successive sessions by applying the agile and adaptive learning process such as:

- The discovery of the real behavior of the process actors (teacher and students) then compare it with existing models.
- The correlation of different events shows how reality differs from perceptions, opinions, and beliefs.
- The foundation of continuous improvement.

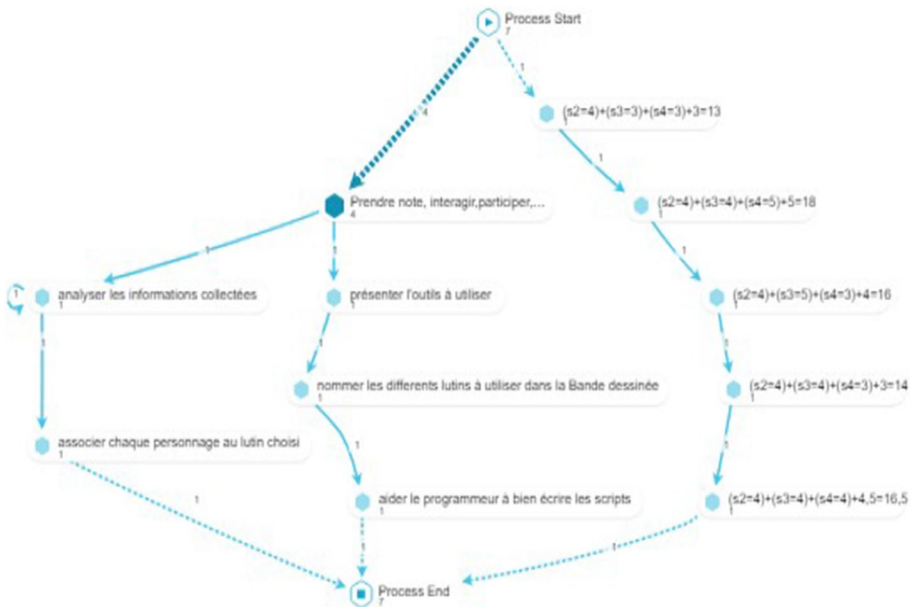

Fig. 14 Indication of the teacher's first task

Above all, process mining has allowed us to understand the current state of the agile and adaptive learning process, while providing a faster and more accurate way to identify deviations and outliers to take the necessary actions /decisions.

In the next section, we will show how we deploy the adaptability of our process for all instances, by adopting specific versions adapted to each case.

Deploying adaptability

After iterating our process three times in a row, (approximately for 3 months), we propose an improvement in its functioning. Hence, we generate two other versions of the process to maintain the agility and consolidate the adaptation of the process for each change of the context examples (absence of students, covid 19, rework, degradation of the scores affected during the evaluation, etc.).

Therefore, to remedy or avoid all these risks of degrading our level of learning, we are offering two versions of the agile and adaptive learning model taken after a detailed analysis carried out by the Celonis tool that will maintain the stability of the sequence of tasks in our process.

We offer two main evaluation factors: time factor and evaluation factor.

The time factor During the second step of our process carried out by the teacher, there will be a setting of the start date of a part of learning new concepts and the end date of this part to learn and acquire to relaunch the next part to do.

The time factor is very important because generally each part of the course taught is dependent on the previous part as well as the next one. Therefore, the elapsed time for each part to learn depends on the time of the previous and next parts.

Example:

During the realization of the project: "Creation of a comic strip" which contains an apprenticeship of four delicate and dependent concepts, which are:

- Internet usage charter.
- Data collection and analysis (images, sound, scenarios).
- Word processing (how to write scripts correctly).
- Image processing (characters and episode backgrounds).
- Sound processing (recorded or downloaded).
- Programming (iterative and repetitive loops).

However, according to the principle of our agile and adaptive process, all the concepts cited will be carried out in the form of tasks in parallel and collaboration with each team of 5 students. Therefore, here the importance of the time factor lies in the strong interdependence of these different tasks/steps to be carried out since the task of sound processing cannot be carried out without going through text and image processing. The same applies to other tasks. We then propose a general solution adaptable to all possible scenarios. Its main objective is not to waste time redoing a task 2 or 3 times, for accidental causes such as sudden breakdowns of the computers of the members of the group, or a long absence due to the covid-19 pandemic or internet connection problems or others.

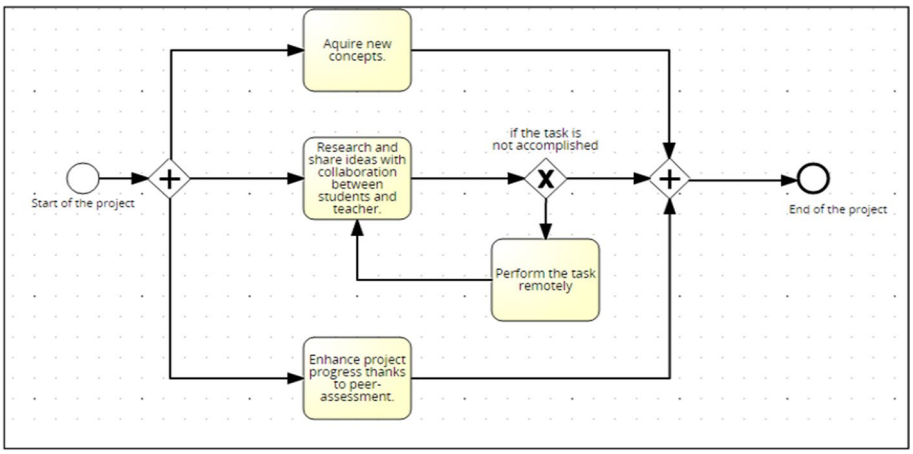

Fig. 15 The BPMN model of the "conduct Project" sub-process of the AALP **v1**

Figure 15 shows the BPMN model of our first version of the agile and adaptive learning process. The added value in the sequence of our process is: "distance education" which will take place only to remedy the loss of time during the various tasks of the-sub-process, which will be carried out by the two actors of our process (the teacher and learner), using the Padlet tool. It is a "virtual wall" on which the teacher and the learner can display any kind of document to distribute and share texts, images, audio recordings, videos, and internet pages. It is a versatile collaboration tool, which has multiple applications in education.

We can also use other essential tools to remotely collaborate and maintain the linkbetween the members of the group and the teacher (such as MOOC platforms,Microsoft Team, or Google meet) to accomplish the failed task during the sub-process and not waste time to redo it in the next session. We can even have the option to perform a remote assessment and meet deadlines.

The evaluation factor In classical methods, the evaluation step is completely different from the principles of our agile and adaptive process. As already detailed in Sect. 3, the assessment is done after a succession of lectures and tutorials. Sometimes, the received mark does not reflect the true level of the learner.

However, in our agile and adaptive learning process, the evaluation must be done at each session: there will be an addition of four marks out of 5 respectively: 3 marks based on the self-evaluation according to the progress of the work. The fourth mark will be on the presentation of the work carried out while taking into account the linguistic level and the correct answers to the questions asked by the teacher and the members of other groups of learners. A worth asking question here will be can we guarantee an improvement in a student level by applying the agile and adaptive learning process? If so, how can we maintain it?

Thanks to process mining (using the Celonis and Prom tools), we were able to analyze the log files of a 3-month job, then we drew the marks < 10, then we specified the possible causes of having this mark.

Finally, we generated a process, which is progressively adaptable to the circumstances.

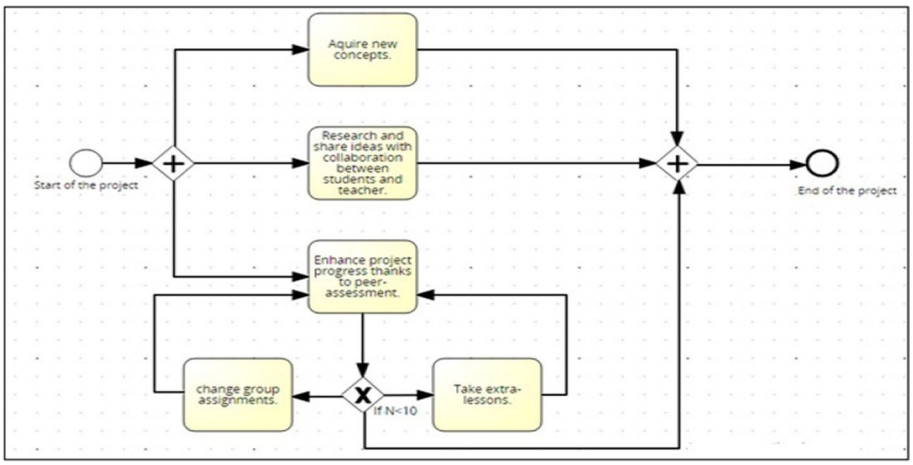

Fig. 16 The BPMN model of the "conduct Project" sub-process of the AALP **v2**

Figure 16 shows the BPMN model of our second version of the agile and adaptive learning process. The added value in the sequence of our process is: "take tutoring support" or change the workgroup which is a solution to prevent learners' academic failures. A significant drop in their marks is often due to organizational problems and a lack of working methods. This could be taken as an alarm that shows that the learner is starting to be demotivated. Therefore, by applying version V2 of the AALP, the learner will be able to upgrade and consolidate one's knowledge, reach the average, acquire a methodology, provide regular work, and above all strive for excellence.

In this section, we discussed the strong relationship between educational intelligence and adaptation. Thanks to the process mining techniques, we were able to ensure an analysis of the agile and adaptive learning process, which is established automatically, based on real and objective factual data.

Process Mining can be exhaustive even on a very large number of data. Mapping is an ultra-fast analysis compared to traditional means and approaches for describing and analyzing processes. This is a way to enhance the available data traceability.

Conclusion

Our main objective is to improve secondary education with an agile mindset through its four values and move away from the deeply authoritarian and Cartesian aspects of the current educational structure. Although the application of the agile and adaptive learning process requires a lot of investment and time for the first implementation, it will be extremely rewarding to see its valuable results, and especially to see the great majority of students flourish throughout the learning process.

Certainly, our new method will foster an improvement of their social network and will tend to make them more altruistic by encouraging the reciprocity of the received help. It is a perfect setting for experiencing equality and fraternity, a method that helpsdevelop critical thinking in groups as well as arguing and respecting fellow students. Besides, it corresponds well to the spirit of agile methods as a whole and emphasizes the rapid detection of problems as in the case of covid-19 sanitary crisis. This agile and adaptive learning process also promotes the freedom to create other personalized roles in teams

to have functional interdependence. Consequently, members of teams could be separated and integrated into other teams. The agile and adaptive learning process could be easier to set up with more mature students in higher education. In addition, older students who are closer to active life may be more motivated by learning a method derived from Agility. It is possible to further improve our agile and adaptive learning process method and generalize it for all levels of secondary and higher educational learning. Agility still has a lot to contribute to education, especially in enhancing performance, innovation, and intelligence. After applying our method, we are convinced that it is possible to exploit the heterogeneity of learners to make them strength if we rely on the principles of group pedagogies. We also confirmed that learning was facilitated when motivation was present. However, contrary to what one might think, it is not the learners' role to come already motivated to class; it is rather up to the teacher to propose a motivating teaching method. Fortunately, group learning pedagogies are in themselves, motivating because of their operation in project mode, which gives meaning to learning. The work carried out has validated the adequacy of the innovative functioning of the agile and adaptive learning method with the principles of group pedagogies on the one hand and the expectations of young people today on the other. In addition, following the application of process mining in our method, we were able to implement the adaptability necessary to the different contexts.

To conclude, we remain in a process of continuous improvement. We wish to continue the work by focusing this time on a broader issue, which is how to motivate the new Z and alpha generations by using the agile and adaptive learning method and its adaptable versions such as group pedagogy to promote their learning.

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Author contributions
NB mapped the 4 values and 12 agile principles from project management to education, and SAG corrected and improved them. NB designed a new BPM lifecycle adapted to learning and SAG commented every stage of the life cycle, moving on to the educational process modeling stage, and this is the third contribution: NB modeled the traditional educational process based on BPMN, and SAG proposed the AALP (Agile Adaptive Learning Process) model after a lengthy discussion. And the last contribution is the intelligent aspect of to the AALP process, for which SAG proposed the use of PM (Process Mining), and following the analysis of the data (learner log files) carried out by NB, they came up with the final result, which is an adaptive and agile educational process that adapts to the different situations encountered. NB wrote the manuscript in consultation with SAG.

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Competing interests
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