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Article

A Survey on Educational Processes Based on Agile, BPM, and PM

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Abstract: It is crucial to combine different approaches to adapt to the diverse and changing needs of learners. Hence, the need to define a global approach that facilitates dealing with different contexts characterizing the new generations of learners. Our main objectives are to encourage and motivate learners to effectively develop their knowledge, skills, and culture while ensuring a continuous and adaptive improvement of learning processes and associated strategies, thanks to the adaptability of the learning process in intelligent education. We conducted a survey paper according to the PRISMA method, which facilitated the search and selection of related works by making them more objective and concise. More precisely, our survey focused on published works related to the three domains Agility, BPM, and PM whose common point is that they can be applied to any domain based on processes. But in our research study, we are only interested in the educational processes, and how these three domains can contribute to improve them. Based on the results found, we propose a global framework fostering the agile adaptive learning processes.

Keywords: agility; BPM; PM; PRISMA; adaptive learning process

1. Introduction

Education is a priority for any society since it is the foundation of all kinds of development. It is often associated with a “frontal” or “transmissive” approach as opposed to a pedagogical approach in which students are put in a position to “construct” their knowledge [1]. Based on classical pedagogies, learners cannot be aware of the immediate results of their learning. They are not very active, which can lead to distraction or boredom, especially for generations Z and alpha, who are the real carriers of the digital revolution. Thus, current approaches fail with the new generations [2]. Using agile methods today allows us to respond to the needs and expectations of companies, which must recruit and make generations X and Y work together. It seems undeniable that agile methods are a major response to the problems of listening, trust, and collaborative work on an equal footing that these young people expect [3,4]. Furthermore, the authors of [5] were able to examine how agile education could be radically different from blueprint-based education, and how information technology could reduce the barriers faced. They were also able to finely match student-learning outcomes to the skills required by employers. In particular, the EduScrum method encourages communication, knowledge sharing, critical thinking, and creativity. It also enhances student engagement and develops a mindset of continuous improvement. Better management of learning time is still needed [6]. Unpredictable factors such as the case of the COVID-19 pandemic, which caused the greatest disruption of educational systems in history [7], should also be taken into consideration. Hence the need for a continuously improving educational process, which is optimized and adaptable to different contexts.

Now, BPM (Business Process Management) and PM (Process Mining) provide the means to improve,

optimize and adapt processes based on observations made and any discrepancies recorded in their previous executions. Thus, we will focus on the application of different agile methods, respecting the 4 values and 12 principles of the agile manifesto applied in the context of educational learning. We will also follow the BPM life cycle, presented in [8,9], adapted to the educational process to guarantee the efficiency of the educational learning process in all aspects and ensure the innovation and continuous improvement of its performance. To find the causes of failures, we will ensure the intelligent monitoring of the process through the use of process-mining techniques, based on the log files of the learning process [10].

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 that facilitates handling the new situations compelled by the different contexts characterizing the new generations of learners. We propose an approach that guarantees continuous and adaptive improvement of learning processes and fosters the motivation of learners to effectively develop their knowledge, skills, and culture. Many methods have indeed adopted agile values since 2002, including the most famous "EduScrum" and its three pillars: transparency, inspection, and adaptation [1]. The latter is a very useful method for building a new culture where nothing is fixed and definitive and developing a more supportive learning environment than traditional methods whose main ideas are to build an autonomous learning ecosystem. It has been implemented since 2015 by Willy Wijnands in the Netherlands [2,3]. Comprehensive educational reform requires awareness and mobilization of the involved actors. To solve the problem of the school system inadequacy, the added value of the provided education must be reviewed. An education based on the development of initiative, adaptation, and creativity as well as on the ability to solve different 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 teachers' professionalism through internships, training, and pilot lessons, as well as the improvement of equipment and working conditions are really necessary. This structural reform also aims to consolidate decentralization in financial, pedagogical, and administrative decision-making and to strengthen the use of new information technologies in schools [4,5]. To assess more effectively the successful transfer of skills and knowledge between learners in the same team, multiple adaptations to the learning process could be added using the principles of the BPM approach. This includes the addition of a new type of test to the individual tests already present in the "Edusrum" method or the division of the tasks set at the beginning of the project into other subtasks at any time in the process. This adaptation stems from the observation of the sharing of knowledge phases by students, just before the tasks are considered completed [6].

The rest of the article is organized as follows: in Section 2, we report the background and our methodology. In Section 3, we present a literature review. In Section 4, weinterpret our obtained results for educational processes. Finally, Section 5 concludes the paper.

2. Background and Methodology

2.1. Background

2.1.1. Agility

Agility is an approach to IT project management that aims to revolutionize the traditional predictive V-cycle or waterfall-type approaches, which are too sequential and inherited from the industry. It emerged in 2001 when seventeen prominent figures in software development met to unify their respective methods. In that meeting, Ward Cunningham, the inventor of the Wiki was present as well as the promoters of the scrum method. The great meeting of 2001 built the "Agile Manifesto", which was composed of 4 values with 12 underlying principles.

The 4 values are formulated as follows:

1. People and interactions over processes and tools: We value the interactions between all the actors of the process, including the customer, rather than just following the process, which does not replace the content.

2. Working software over exhaustive documentation: It is true that documentation is essential, but the development team should focus on producing functionalities and not on writing documents because the customer wants to have a functional product rather than a detailed manual. The Agile method allows for document templates, which are always the same, to be quickly completed with the essential information.

3. Customers collaboration over contractual negotiation: The Agile culture requires placing customers at the center of the product creation process, and integrating them in each iteration, as well as in all phases of development. This allows to collect the customers' feedbacks, which are an essential aspect of building valuable products.

4. Responding to change over following a plan: The last value of the agile manifesto is the acceptance

of change requests in the product development even late. The flexibility of agile approaches increases the stability of the project. Change in agile products is predictable.

Although the manifesto states “We recognize the value of the latter, but give priority to the former”, the interpretation of these 4 values is sometimes subject to drift, advocating for example the complete absence of documentation or organization, which is not the objective of software quality.

To fully understand the essence of agile methods, it is important to refer to the 12 underlying principles, which must be considered as a whole to guarantee software quality. They are listed below [11].

1. Customer satisfaction is a priority
2. Welcome change requests.
3. Deliver operational versions of the application as often as possible.
4. Ensure permanent cooperation between the client and the project team.
5. Build projects around motivated individuals.
6. Give priority to face-to-face conversations.
7. Measure project progress in terms of application functionality.
8. Advance the project at a sustainable and constant pace.
9. Pay continuous attention to technical excellence and design.
10. Keep it simple.
11. Empower the teams.
12. Adjust behavior and processes at regular intervals to be more efficient.

In 2021, the first goal of the authors in [8] was to ensure an adaptation of the 4 values and 12 agile management principles for educational learning, and to test them on a case study of secondary education.

2.1.2. BPM (Business Process Management)

BPM or business process management, or business process engineering:

It is a contemporary approach to increase productivity and reduce costs through its potential to innovate and continuously improve an organization’s business processes. BPM is a cyclical approach to the continuous improvement of business processes.

A business process can be defined as an ordered and chronological sequence of tasks intended to produce an added-value result for the organization’s customers, partners and employees. In business process management, the concept of business process is fundamental and represents a starting point for understanding how the business operates in an organization and identifying opportunities to improve its performance. This leads to a shift from organizations initially based on an information processing culture to organizations oriented by their processes [12].

In order to ensure the dynamism of the process, BPM is based on a life cycle is used, following the four following steps:

1. (Re) design and analysis of the business process: the life cycle starts with the creation of business process models either “from scratch” or by modifying an existing model.
2. Information system configuration: the business process is implemented by configuring the organization’s information system.
3. Execution and supervision of the business process: in this phase, the process is executed while controlling and supervising its execution.
4. Diagnosis: this phase consists of learning knowledge from the business processes in execution and using it as input for possible business process improvements.

Each step of the BPM life cycle is crucial [13].

Indeed, various current research works are interested in performance improvement by focusing on one part of this life cycle.

The second objective of the authors in [9] was to define a BPM lifecycle specific to the educational process.

2.1.3. BPMN (Business Process Model and Notation)

The BPMN notation is one of the most widely used today for modeling business processes. It is an Object Management Group standard. The BPMN notation is used to model a business process or a workflow based on a set of graphical concepts [14].

The third target of the authors in [8,9] was the BPMN modeling of the agile and adaptive learning process.

2.1.4. Process Mining (PM)

Process mining uses the logs recorded (log files) during the execution of a business process to study the behavior of business processes by analyzing the data extracted from these logs. The information extracted from these tracks allows detecting anomalies and deviations observed between the execution and the process model.

This information cannot be identified by simple inspections of the static model. There are 3 types of process mining techniques depending on the existence of not of an initial business process:

- The “discovery” technique: It is applicable by when an initial business process model is absent. It is based on the event logs generated directly from the business process instances. This type of analysis makes it possible to reconstruct the original business process.
- The “conformity” technique: It considers an initial model. It consists of comparing it with logs event produced during the execution of the business process instances. This technique highlights the deviations (gaps), their location and their causes.
- The “Extension” technique: It considers an initial model. It consists of using the information extracted from the event logs in the form of extensions to enrich the original model.

Extension techniques can be used to further enrich business process models by integrating new information (perspectives) extracted from event logs.

Mainly, the following perspectives can be distinguished [15]:

- Information about the entities that performed the tasks in the process (organizational perspective).
- Time information (temporal perspective) and information about the data provided or modified by the process instances (informational perspective). This information can be very useful for decision makers.
- Organizational information can be used to gain insight into typical work practices, organizational structures and collaborations within the organization.

Temporal information as well as frequencies and durations of activities can be used to identify bottlenecks and diagnose other performance problems.

2.2. Methodology

Our literature review is conducted using the PRISMA method, which facilitated the search and selection of related works by making them more objective and concise. The first step named screening presents the selection of research works existing in the literature, based on the basic concepts of our research work (presented in Section 2.1), available in Google Scholar and Science Direct. We chose the two platforms Science Direct and google Scholar since they give access to scientific works in all disciplines: articles approved or not approved by reading committees, doctoral theses, scientific books, or citations. These two platforms provide access to the full text of articles in hard and applied sciences and the results are displayed by relevance, without a date limit. The second step, which is the eligibility, represents the first filtering based on the titles and abstracts of each research work. In our case, we kept those that have a direct or indirect relationship with the educational process, while making a comparative study according to the techniques and methods used with each considered area. The third step is the inclusion of an exact and finite number of research works for which we have ensured a detailed comparative study showing how the techniques and algorithms of PM can be used to monitor and improve educational processes applied in different learning environments, by drawing up comparative tables. We quote at the end some proposed solutions, using the algorithms of the “Process Discovery” technique. Thanks to this comparative study, we found a way for proposing an adaptive algorithm for educational processes, and we schematized our solution to foster agility and adaptive educational process [16]. Table 1 presents a synthesis of the initial list of studied research works:

After reviewing this set of works, we can conclude that the common point between the three areas studied in our research work is that they can be applied to any process-based domain. The objective of the agile manifesto has been to revolutionize soft ware development processes since 2001. It will be better adapted when speed is the main criterion of success, when the scope of the project can be modified during the project, when the stakeholders are adaptable and autonomous, or finally when the project applies to a domain in rapid evolution. BPM or business process management is a vector of efficiency and quality within an organization. Companies are increasingly aware of this, given the dynamism brought to processes and their continuous improvement. Process mining can include process discovery, compliance checking, and process improvement. It can also facilitate automation, diagnosis, digital transformation, and Key Performance Indicator (KPI) reporting.

Table 1. Table of the works identified.

	1st Domain: Agile	
Source	Google Scholar	Science Direct
Keyword	Agile	Agile
Number	160	100
	2nd Domain: BPM	
Source	Google Scholar	Science Direct
Keyword	BPM	BPM
Number	80	120
	3rd Domain: PM	
Source	Google Scholar	Science Direct
Keyword	PM	PM
Number	95	130

However, in our research study, we will only focus on the educational process, and how our three considered areas can contribute to its improvement.

In Table 2, we present our second selection of papers adding the term educational process as a keyword.

Table 2. Summary table of the final list.

1st Domain: Agile & Educational Process		
Source	Google Scholar	Science Direct
Keyword	Agile, educational process	Agile, educational process
Number	100	90
2nd Domain: BPM & Educational Process		
Source	Google Scholar	Science Direct
Keyword	BPM, educational process	BPM, educational process
Number	30	25
3rd Domain: PM & Educational Process		
Source	Google Scholar	Science Direct
Keyword	PM, educational process	PM, educational process
Number	95	80

The Figure 1 below represents the flow chart of the PRISMA method, which is the basis of our comparative study:

In the following section, we present a detailed comparative study of some works in the literature that are based on our core concepts (Agile, BPM, PM) and have an implicit or explicit relation to the educational process and its evolution.

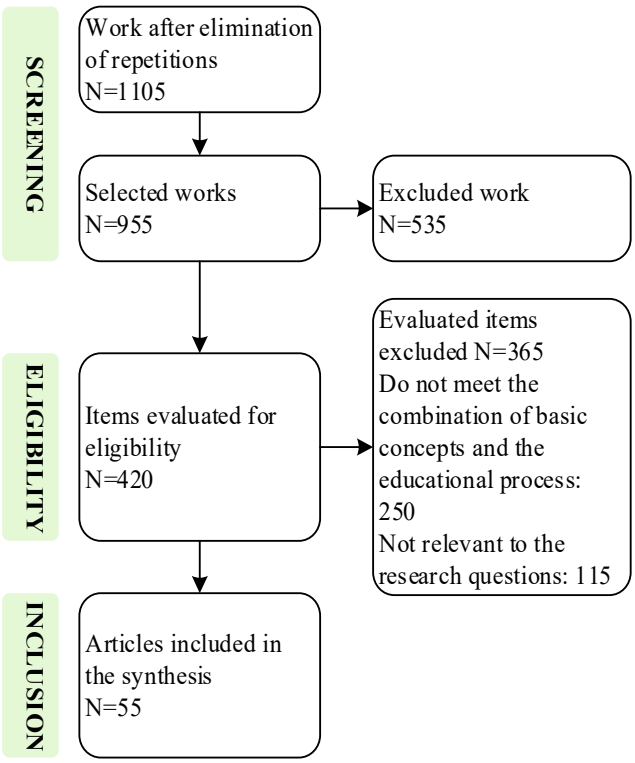

Figure 1. *P*RISMA flow chart.

3. Literature Review

3.1. Agility

The key Most universities provide traditional plan-based education with rigid curricula that force students to make big decisions from the start. Lean and agile education would instead work in small increments and allow students to make many iterative decisions along the way. The authors of the research work [17] were able to examine how agile and Lean education could be radically different from blueprint-based education and how information technology could reduce the faced barriers. They also finely matched student learning outcomes to the skills required by employers and confirmed that the application of agile and Lean methods in education will allow students to keep up with the rapid pace of technological advances and anticipate future needs in detail. There is a growing interest in applying agile and lean concepts in the classroom to enhance educational experiences. The authors of [18] brought together disparate ideas from these two fields from industry practice and existing work to develop and frame key concepts of agile and lean thinking for teaching and learning. They summarized key ideas related to how the values, processes, and techniques of agile software development overlaid with related concepts of lean thinking, can be translated to the broader needs of education across disciplines for students of all ages. Other research works were based solely on a single agile method, which is the Scrum method, as in the research work [19] which aimed to analyze the implementation of Agile learning and described EduScrum practices in teaching English for Specific Purposes (ESP) at the Faculties of Information Technology and Cybernetics of Taras Shevchenko National University in Kiev, Ukraine. They proved the effectiveness of applying agile methods in a project-based learning environment to teach information technology (IT) students. The EduScrum method encourages communication, knowledge sharing, critical thinking, and creativity. It also enhances student engagement and develops a mindset of continuous improvement. The practices of planning, processing, presenting, analyzing, and evaluating were described in the ESP EduScrum teaching. The authors of this work confirmed that this agile method enabled students to gain and retain practical experience and become confident lifelong learners in a modern VUCA (Volatility, Uncertainty, Complexity, Ambiguity) world. They also specified the type of assessment based on criteria that brought students' attention to the problematic aspects of learning and more reasonably assessed their knowledge and skills. The research work [20] emerged from the absence and current limitations of effective teaching models for the development of professional skills. It proposed cutting-edge methods for optimization and process improvement tools while developing general and disciplinary skills in industrial engineering. The notion of learning was presented in the

context of real-world experiences to develop relevant skills in real manufacturing and service companies. Based on competencies, experiential learning, and challenge learning, the authors of this work proposed a learning model and a learning space called Lean-Thinking-Learning Space. A detailed study [21] confirmed and endorsed that manifestos are often a way to trigger change by catalyzing discussion around a core group of ideas and values. Therefore, there is no doubt that the publication of the "Agile Manifesto" in 2001increased the visibility of an emerging breed of lean software practices. The panel discussed the impact of the Agile Manifesto on software professionals, both academic and industrial, in the areas of culture, education, and software practices. The authors of [22] affirmed the appropriateness of using the "Trello" tool to support an educational process based on the application of the 2 agile methods Scrum and Kanban. They also endorsed the experience report on how they used "Trello" to support a Scrum process and a Kanban board for the professional development of in-service teachers, explaining how some of its features can be used to support collaborative agile teams.

Problem-based learning (PBL) has proven to be very effective in training students in an active, self-motivated manner in a variety of disciplines. Student projects conducted using problem-based learning principles are highly dynamic and involve a high level of uncertainty. The research work [23] described an empirical case study conducted at the University of Aalborg University in Copenhagen, involving students from two different semesters of a Bachelor of Science program. In the course of the study, convincing examples of how PBL and the Kanban agile project management method combined were identified. The authors of this work proved through a survey that the application of Kanban produced significant improvements in the creation, assignment, and coordination of project tasks. They found improvements in group communication and awareness of work progress, both individually and collectively. Moreover, students continuously improved their teamwork. A case study was conducted in the research paper [24] on the Agile Kanban project methodology comparing it with the Scrum method, which, although increasingly popular, has received far less analysis on its usefulness in the classroom than other frameworks. This study provided insight into why the Kanban methodology was useful by matching student feedback on the methodology to the twelve principles outlined in the Agile Manifesto. The authors of this work analyzed two key agile principles that helped explain the value of Kanban. They found that students focused on team self-organization and reflection at regular intervals and that these two principles improved the team's communication and coordination. The rapid growth of information technology has led to the development of a multitude of smartphone systems around the world. As a result, the number of educational institutions offering courses in areas such as programming and software engineering has increased. However, traditional software development processes have not kept up with the changing technologies. In recent years, software development has become more dynamic and iterative, requiring stakeholders to work in teams and deliver higher quality projects in less time, using methods such as agile development (for example, Scrum and Extreme Programming). Although some institutions address this content in graduation courses, many students and professors are indifferent to it, resulting in low enthusiasm and practice [24]. The authors of [24] presented a real case of classroom activity to teach Scrum concepts using Lego blocks. The results showed that dynamic games and palpable activities are more effective than theoretical or video lectures. In the same context, the authors of the research work [25] confirmed the effectiveness of the Scrum method for teaching a full semester-long IT project management course with traditional PMI-based content (without software development) while using Scrum as the organizing logic to accomplish the coursework. This framework adapts Scrum practices that are widely used in industry to be utilized in the classroom. A brief overview of the agile philosophy and examples of Scrum teaching in the classroom situate this work in the teaching and learning literature. Classroom-tested Scrum rituals and sample artifacts are provided to help IS educators implement Scrum practices in their courses and meet the growing industry demand for IT professionals with Scrum experience. The authors of [9] proposed a new learning process essentially based on the four core values of the agile manifesto to meet the challenge of achieving maximum organizational and strategic benefits by applying both Scrum and XP methods (in the case of pair work) in the secondary education IT subject. The application of the Lean method improves the performance of existing processes and methods, mainly by providing solutions to recurring problems. The identification and consideration of mudas Lean will be applied to the elimination of waste within the project [26]. In Table 3, we present a selection of papers using the different agile methods.

Table 3. Related works on agile methods used in education.

Author and Date of the Article	Lean	XP	Scrum	Kanban
Parsons et al. (2019) [5]	x			
Ballé et al. (2019) [6]	x			
Lazorenko et al. (2020) [18]			x	

Garay, et al. (2019) [19]	x			
Mancl, et al. (2019) [20]		x		
Parsons, et al. (2018) [21]	x		x	x
Saltz, et al. (2020) [23]				x
Balve et al. (2017) [22]				x
Bica et al. (2020) [24]		x		
Rush et al. (2020) [25]		x		
Bergaoui et al. (2021) [9]		x	x	

3.2. BPM (Business Process Management)

BPM (Business Process Management) approach is the way to implement the desired agility in the learning process. Thanks to this cyclical and continuous improvement approach, the learning process will evolve and take into account not only new needs but also the specificities of each involved actor (learner or teacher). To evaluate the transfer of skills and knowledge between students in the same team more effectively, it would be possible to add multiple adaptations to the learning process using BPM principles. This could include adding a new type of test to the individual tests already present in the "Eduscrum" method or breaking down tasks set at the beginning of the project into further subtasks at any point in the agile educational process. BPM refers to the ability to document processes and ensure the execution of new or existing processes [27,28].

In an effort to develop students' skills for the work challenge, the authors of [29] conducted an empirical study in the software development labs of a higher education institution by applying BPM while managing and developing educational processes. The challenge is to reduce waste in business process management and foster the technological singularity described by Vinge [30].

The authors in the research work [8], ensured the same challenge but applied it to the learning process: they based their work on data mapping to ensure the best correspondence between project management and learning (process and actors) on the one hand and to resolve the differences between the two systems on the other hand.

In this way, the data accuracy of the 12 Agile principles is well ensured, when transferring from the source to the target.

As shown in Figure 2, in this work, the authors also proposed a new BPM lifecycle adapted for learning and presented the BPMN model of the new learning process.

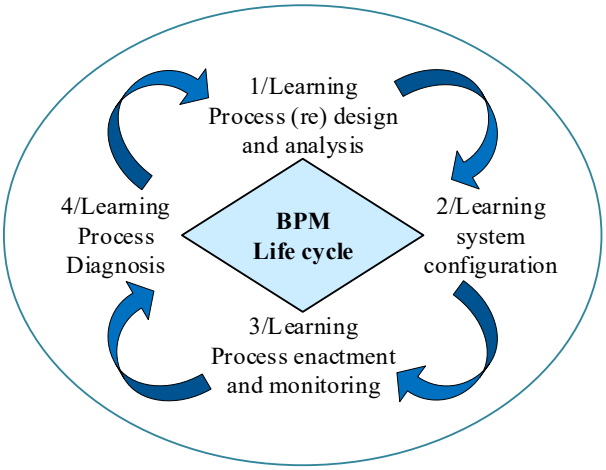

Figure 2. The BPM life cycle adapted for the learning processes [8].

The benefits generated by BPM are multiple and depend on the nature of the modeled processes such as visibility, performance, cost-effectiveness, traceability, and agility. The latter identifies the correction of encountered malfunctions that are major issues of BPM [27]. 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. Mark von Rosing, et al. [31] highlighted how agile concepts could be applied to rely on BPM in all different domains and disciplines. Similarly, the authors of [32] showed the strong relationship between BPM and Agile, which resulted in a consolidated framework for intelligent business

process management.

3.3. Process Mining (PM)

Several authors based their work on the application of artificial intelligence in education to solve certain problems encountered during learning. This helped remedy the uniformity of teaching methods and documents for all learners since each learner is unique in the learning process [33]. Indeed, such situations inflict constraints on this content and the already-used procedure. Moreover, collective intelligence is understood as the ability of a group of people to make connections with their contexts, to have logical reasoning and complete problem-solving abilities, and to have good communication and teamwork skills [34]. Agile methodology practices can be compatible with these characteristics.

In our work, we propose an agile and adaptive learning model where its intelligence comes from the log files left by the actors of the process (teacher and learners) as well as the use of Process mining techniques.

Process mining can be used in an iterative way, which helps us to build more detailed data records (actors' names, notes, dates, etc.) and the program to be taught (work required, new notions to be retained, main objective of the teacher, etc.) will allow us to quickly identify the problems encountered and remedy them in the future [35]. Process mining techniques aim to translate data captured during the process execution in tousable information/knowledge. Three main types of process mining analysis are identified: process discovery, Compliance monitoring, and process improvement.

1. Process discovery: the goal is to identify and establish a process model, i.e. a formal behavioral description, that describes the process as captured by the event data.
2. Compliance monitoring: we seek to assess how well the event data match a given reference model.
3. Process improvement: the main objective is to improve the process view, i.e.by improving process models based on facts derived from event data [36].

To run Process Mining algorithms, it is necessary to have data that detail the different tasks performed as part of the learning process. Thanks to Process Mining techniques, we can ensure an analysis of the learning process, which is established automatically based on real and objective data. Process Mining can be exhaustive even on a very large amount of data. Mapping is an ultra-fast analysis compared to traditional means and approaches of process description and analysis. Educational process mining (EPM) is an emerging field of educational data mining (EDM). This is a challenge to be met when processing and analyzing educational data.

In the following paragraph, we will introduce EPM and explain the potential of this technology in the field of education: PM is also known as Workflow Mining (WM). Most work on PM has focused on (business) workflow systems and the discovery of Petri nets representative of workflows [37]. The PM applied to educational data is called EPM. The combination of learning technologies and PM offers considerable potential [38]. EPM can build complete models of the educational process, reproduce all observed behaviors, check whether the modeled behavior corresponds to the observed behavior or not, and project the information extracted from the recordings into the model to facilitate the understanding of the process situation [37]. Similarly, the term Learn flow Mining with Workflow Mining was used by some authors in the research works [39,40], while the authors of [41,42] preferred the term EPM in connection with the PM, which was the most used term.

In the following Table 4, we will try to provide a more in depth description of the data, the potential difficulties, and the software solutions used to carry out a PM analysis in education.

The starting point of the PM is a log file [43]. This file can be an Excel spreadsheet, a database table or a simple file containing a track/sequence of events. Each event is a line in the event log having an ID, activity name, time (timestamp), and sometimes additional information. In general, they must be transformed into specific formats for storing logs such as XES (eXtensible Event Stream) or MXML (Mining eXtensible Markup Language) in order to be used by a PM tool [44].

There are some specific tools, which allow the conversion of different data sources to these formats, such as ProMimport [45]. Educational log files can be collected from a wide variety of virtual online learning environments such as learning management systems (LMS), online courses (MOOC), tutoring systems (ITS), and adaptive hypermedia systems (AHS). In the related works, some authors focused on the first technique of PM to solve the problems encountered in education, while others relied on the second technique of PM.

Table 4. The three PM Techniques.

Techniques	Description	Application in Education

Process Discovery	It is the construction of acomplete process model capable of reproducing the behavior of the process actors (teacher and learners) seen in the log file.	The teacher can visualize the model of the learner's behavior during the course sessions, which helps to know the detailed process.
Compliance Checking	It refers to the detection of discrepancies between the behaviors observed in the log files and the generated process models.	The teacher can analyze whether the model matches the pattern of the behavior according to the log files or not,for example, to detect outliers.
Process improvement	It aims to improve or extend a given process model based on the information extracted from specific log files related to the same process.	The teacher can detect bottlenecks or mis understandings by students. We can thus merge learning tasks in the process or extend them.

In the following part, we will make a comparative study between the two PM techniques used in the educational process: "Process Discovery" and "Compliance Checking".

1. Process Discovery technique

The goal is to identify and establish a process model, i.e. a formal behavioral description that describes the process as captured by the event data. There are many algorithms in PM for discovering underlying processes from log files, but the most commonly used in the educational field are the Alpha Miner algorithm, Heuristic Miner algorithm, Genetic Miner algorithm, and Inductive Miner algorithm.

2. Compliance Checking technique

The goal of Compliance Checking is to find discrepancies between the modeled behavior and the observed one.

In the related works, two techniques are distinguished: Linear Temporal Logic (LTL) Checking: checks whether the logs satisfy a certain linear temporal logic (LTL) formula [46]. LTL checking does not compare a model with the log but a set of requirements described by the linear logic. Temporal logic (LTL): Compliance checking requires a model in addition to an event log. It reformulates the set of events into a Petri net model by collecting all the diagnostic information that can be accessed later [47].

In Table 5 we present a classification of some works according to the choice of PM techniques.

Table 5. Classification of some works according to the choice of PM techniques.

Author and Date of the Paper	**Discovery of the Process**	**Compliance Checking**
Perez-Rodriguez et al. (2009) [40]	x	
Bannert et al. (2014) [36]	x	x
Reimann P et al. (2009) [54]	x	
Trcka N et al. (2009) [37]		x
Southavilay V et al. (2010) [60]	x	
Trcka N et al. (2011) [41]	x	x
Porouhan P et al. (2017) [59]	x	

In the next section, we move on to the presentation of the operational framework where we present the PM algorithms and how they were able to solve some problems encountered in the learning processes proposed by some research works. We also present a schematization of our new proposed approach.

4. Obtained Results for Educational Processes

4.1. The Educational Process

Our main objective in our research work is to ensure continuous control and improvement of the learning process regardless of the simulation environment used (smart tutor, interactive tutor, remote platform, Computer-supported collaborative learning (CSCL), etc.) while respecting the agility and BPM principle discussed and approved in papers [8,9]. Thus, the only concern is the recovery of data and tracking files throughout the educational process. In this section, we will classify the target of the data retrieved from the educational processes encountered in the literature. Consequently, Education and

training centers have made their vocational training courses more agile to meet the changing needs of the labor market, employment and time requirements [48]. Consequently, PM has been used in different types of vocational training courses. Cairns et al. [49] showed how PM techniques could be used to monitor and improve educational processes. Massive Open Online Courses (MOOCs), Learning Management Systems (LMS), hypermedia, and similar online learning environments offer easy-to-monitor learning opportunities thanks to the log files generated by these systems that give us insight into how learners are following the course, when they are watching videos or lectures, or when they are handing in tasks. The authors in [50] illustrated the application of PM and described how to extract data from LMSs with only´ learners' reviews. In the research work [44], the authors used data from Moodle logs and relied on clustering to generate more specific and accurate process models of learners' behavior. For the same reason, in a similar environment, Reiman et al. [51] proposed to use track files to study self-regulated learning.

In another research, Mukala et al.[52] used PM techniques to track and analyze the learning habits of MOOC data. Computer-supported collaborative learning (CSCL) is characterized by the sharing and construction of knowledge among participants using technology as the primary means of communication. PM is applied to computer-supported collaborative learning to provide learners with feedback on their decision-making processes [53]. A curriculum is a teaching method designed by an institution to achieve certain objectives. Curricula normally suggest that learners can follow different paths from beginning to end, thanks to a wide range of possibilities [54]. A domain-based PM educational approach was proposed by Trcka and Pechenizkiy [37], to properly ensure an exploration of the curriculum data. They proposed a framework, which assumes that a set of pathway models can be predefined based on what the teacher proposes and on the analysis of formally modeled processes. In another related research, Wang and Zaiane [54] found a "curricular" process model of students taking courses andcompared the paths of successful and less successful students.

We present in the following Table 6 a list of works that attempted to solve some educational problems based on PM.

The only concern is the recovery of data and log files throughout the educational process. Process mining can be used in an iterative way, which helps us to build more detailed data records (actors' names, notes, dates, etc.). The learning process to be followed will allow us to quickly identify the problems encountered and remedy them in the future. As cited in Table 6.

The authors in [55] were able to solve the various problems encountered during the presentation of the lesson with the MOOCs tool and generate new rules to follow. Besides [50] were able to better understand the used educational process, while [39,53] were able to generate a new educational process to follow.

In the following section we will present and outline our approach to overcome the limits encountered, which can be summarized in the following questions: how to make the educational process intelligent and adaptive while combining the 3 basic concepts Agile BPM and PM?

Table 6. Educational Solutions proposed by some research studies.

STUDIES	**Applications**		**Solutions**			
	MOOCs LMS	**Computer Supported Collaborative Learning**	**Curriculum Mining**	**Detect Learning Difficulties**	**Generate Rules or Tips for Students**	**Understand Better the Educational Process**	**Discovering Learning Flows**
Mukala et al. (2015) [52]	x			x	x		
Bogarin et al. (2014) [44]	x					x	
Trcka et al. (2011) [50]	x						x
Bannert et al. (2014) [36]	x			x			
Reimann et al. (2009) [51]		x					x
Bergenthum et al. (2015) [39]		x					x
Porouhan et al. (2017) [56]		x				x	
Southavilay et al. (2010) [57]		x				x	
Trcka et al. (2009) [37]			x			x	
Wang et al. (2015) [54]			x			x	

4.2. Overview of the Proposed Framework

The general idea of our research work is to combine all the concepts presented in the previous sections BPM, PM, Education, and Agility in order to ensure the continuous and adaptive improvement of the learning processes and associated strategies, which promote an implementation of the adaptability of the learning process in intelligent education.

We propose in Figure 3 an overview of the proposed framework.

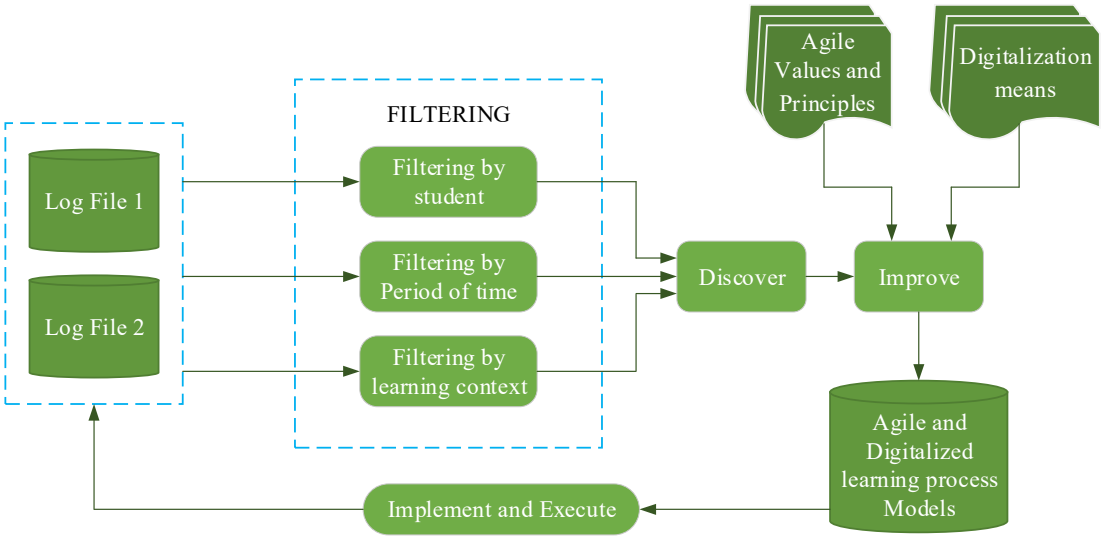

Figure 3. Overview of the framework.

The next step of our research work is to apply our model based on the PM discovery technique to identify and establish a behavioral description that describes the educational process as captured by log files. Then go through a multiple or selective filtering according to our needs by implementing the PM genetic algorithm, which provides process models built on causal matrices (input and output dependence for each activity).

The specificity of this algorithm is that it accepts as input all types of data, even noise and incomplete data.

After the application of the three types of filtering presented in the process (by student, by period, by context). We can either combine 2 types of filtering at the same time, or just apply only one type. Consequently, we will have as output our first adaptive educational process, which at its turn can be improved by using the 4 values and 12 agile principles and/or digital learning of all types.

Finally, we re-implement our improved educational process from which we will have new log files like Input and in this way; we guarantee the dynamism of our educational process.

5. Conclusions

Based on a literature review conducted using the PRISMA Methodology we covered, in this paper, research works dealing with the educational processes. We first concentrated on those relying on agility, then those interested in BPM, and processes.

Moreover, based on our previous works, agility and BPM were discussed and approved to be beneficial for agile and adaptive educational processes.

A remaining challenge is data recovery from the log files of educational processes, through applying the techniques of Process Mining and applying the necessary filterings so that the adaptability of the learning process will be fostered. A preliminary description was given for a framework fostering agile and adaptive educational processes. Accordingly, in our future work, we will further detail the proposed Framework for promoting adaptive and agile education, while developing a prototype supporting our framework and conducting a case study with real students.

Author Contributions

Conceptualization, N.B. and S.A.G.; methodology, N.B; validation, S.A.G.; investigation, N.B.; writing—original draft preparation, N.B; writing—review and editing, S.A.G.; visualization, N.B.; supervision, S.A.G. All authors have read and agreed to the published version of the manuscript.

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