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# Improving temporal behavior based on students' traces in online-based learning environments

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**Abstract:** Various factors can enhance students' learning outcomes in e-learning environments. Time management is a crucial aspect of effective learning, as it enables students to prioritize their tasks and achieve their goals within the given time frame. To improve time management ability students can benefit from feedback, which is a powerful tool to increase self-awareness and encourage positive temporal behavior. Feedback can take different forms such as regular evaluations, progress reports, and reminders of deadlines. By providing students with constructive feedback, they can become more aware of their strengths and weaknesses and adjust their time management strategies. This study proposes a technique based on students' temporal traces and the production of automatic feedback in an online learning environment. The experiment was conducted with 40 students enrolled in an online course on a developed system to validate the proposed approach. The results demonstrate that using feedback is an effective strategy to encourage students to better manage their time in online learning environments.

**Keywords:** E-learning environment**,** Temporal traces, Temporal behavior, Time management, Feedback
**Categories:** L.2, J.4
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## 1 Introduction

Recently, and particularly during the COVID-19 pandemic, e-learning has become increasingly popular in universities as a complementary or alternative mode of teaching due to its flexibility regarding time and space constraints compared to traditional face-to-face teaching with a fixed schedule. However, the focus on completing activities by students through e-learning may result in neglecting other crucial dimensions that can affect overall performance. Among these dimensions, we find the importance of respecting time by students when completing their tasks or interacting with others. In reality, the disregard of time can be demotivating for students, as they may believe that they have unlimited time to complete activities, which may result in procrastination and ultimately poor performance. Furthermore, students who receive no information regarding their delays in meeting deadlines or punctuality may not appreciate the importance of considering time management. Although training to give time its value allows students to succeed in their academic and professional lives, the notion of time is not taken into account during online learning. In fact, one of the roles of higher education is the development of students' academic skills by proposing new methods of learning or using some mechanisms such as the use of feedback, dashboards… etc. The importance of feedback in the improvement of students has been explored and received particular attention from several researchers [Li et al., 2020, Nicol and Macfarlane-Dick, 2006]. As the use of online learning increases, the teacher cannot ensure the production of personalized and appropriate feedback and this task becomes more complex [Pardo et al., 2019]. For this, some researchers propose the use of automatic feedback as a solution that is used to allow support and assistance by producing the information necessary to help students improve their skills.

Furthermore, automatic feedback is strongly linked to distant learning where students interact with different learning technologies, they create digital traces [Tadjer et al., 2022, Mehenaoui et al., 2022] that can be captured and analysed. These traces can be exploited to facilitate the production of automated and personalized feedback to support and help students [D'antoni et al.,2015, Karavirta et al., 2012, Kruscheand Seitz, 2018]. It is in this context that this work is integrated, which aims to develop a system for producing automatic feedback based on the temporal traces in order to help students to improve their respect of time. To achieve this objective, several challenges and questions can be asked. For example, how to improve the respect of time by a student during his engagements in an online learning environment?

In order to answer this question, we propose in this paper an approach that aims to provide opportunities for students to identify the gap between current and desired performance regarding the respecting of time. This is done to adjust their temporal behavior, which consequently improves learning. In this approach, we use automatic feedback where we have proposed some assessment indicators based on the temporal traces made by each student during each cycle in the learning process. According to the evaluation obtained during the current cycle, feedback will be provided to the student that can lead him to reflect on their current respect for time and to adapt their self-regulation of time in a more optimal way next cycle. This method has been examined by Computer Science students at Guelma University, Algeria.

The paper is divided into five sections, as follows. The second section covers related works on automatic feedback and time management in educational settings. The proposed method is presented in detail in the third section, with explanations. The fourth section presents and discusses the results of the experiment, including an evaluation of the proposed method. Finally, the paper concludes with a summary of the key findings, suggestions for future research in this area, and the potential benefits of the proposed method for educators and students.

## 2 Background

### 2.1 Feedback in the educational context

Feedback has been widely investigated in literature [Medina et al., 2016, Latifi et al., 2021, Zheng et al., 2022, Banihashem et al., 2022] and identified as one of the most important factors influencing students' success in learning. According to [Wang et al., 2019], feedback is the information that can be provided about the current state of learning and how to close the gap between it and the goal. This helps learners to adjust their cognition or behavior to promote learning. In a traditional educational setting, the production of feedback requires the intervention of the teacher to provide a set of feedback according to the behavior observed for each student in a class, and with the growth of the application of distance learning, this becomes a heavy task for the teacher. In this context, many studies have proposed a technological solution that consists of producing automatic and personalized feedback since teachers and students are geographically and physically separated [Pardo et al., 2019]. In their study, [Krusche and Seitz, 2018] concluded that automatic feedback increased student participation in exercises and the submission of solutions. They also reported that more than 60% of the students successfully completed the course’s tasks. [Akçapınar, 2015] has developed an automatic feedback system in order to reduce the plagiarism behavior of students in written tasks based on text mining analysis. [Van Popta et al., 2017] mentioned in their work that feedback is important for students to stay connected in online courses. In another work presented by [Utomo and Santoso, 2015], the authors propose an idea that consists of developing a pedagogical agent to help the facilitators provide automatic feedback to motivate the students and according to their behavior in online learning systems.

### 2.2 Time management in the educational context

In the educational context, time management refers to students' ability to use their time effectively to achieve their goals in a period of time [Lim et al., 2021, Nguyen et al., 2018]. In recent years, the time aspect has become a successful key in student’s life and has attracted the attention of many researchers where several studies [Broadbent and Poon, 2015, Kim and Seo, 2015] demonstrate that the strategy of time management is positively correlated with academic performance. Furthermore, many researchers have confirmed that students who cannot manage their time effectively cannot efficiently achieve their academic tasks [Cerezo et al., 2017]. Students who can manage their time effectively do not risk being late in completing required academic activities [Wolters et al., 2017]. Therefore, they can meet deadlines and be punctual. In their study, [Pardo et al., 2019] investigated to what extent students’ timing of engagement aligned with instructor learning design, and how engagement varied across different levels of performance. The study done by [Adams and Blair, 2019] examines the self-reported time management behaviors of undergraduate engineering students using the time management behavior scale. This study contributes to the understanding of students’ time management behaviors according to their academic performance.

After consulting the literature review, we found that almost all works focused on time as an important aspect, however, none of them attempted to automatically assess and improve the temporal behavior of learners. Therefore, we have proposed a new technique based on temporal traces to help students improve their temporal behavior.

# 3 Materials and methods

### 3.1. Research questions

The findings of studies found in the literature have provided researchers with an understanding about the use of feedback mechanisms and time management skills in the educational field. However, we found that it was clear that the majority of researches presented experimental results related to the impact of time management on students' performance. Nevertheless, none of them attempted to improve student time respect and management in online learning and helped them to enhance their level of awareness regarding the importance of time.

Therefore, we have proposed in this research a technique based on the temporal behavior of students and the production of automatic feedback in online learning environments.

In brief, the purpose of this research paper is to answer the following questions:

**RQ1.** Does providing automatic feedback enhance a student's ability to meet deadlines and be punctual?

**RQ2.** Does providing automatic feedback on meeting deadlines and punctuality affect the academic performance of students?

### 3.2. Study design procedure

This work aims to present an approach based on the exploitation of temporal traces to facilitate the production of timely and personalized feedback to help students adjust their time management during the learning process to better meet time-bound goals. In our research, we consider a temporal trace as being the time taken by a student to accomplish the activity or action. In this approach (Figure 1), we use a set of indicators based on the temporal traces left by students. These students must engage in a course that is structured in units where each one is carried out within a time period (cycle). The purpose of these cycles is to provide automatic and personalized feedback at the end of each cycle to help students improve their temporal behavior in the next cycle. Generally, if a student recognizes that his temporal behavior (such as task completion time) is slower than desired, he can make an effort to improve it in the following cycle.

In fact, during each cycle, the activities are defined by a time period determined by the instructor. The cycle (figure 2) begins with the consultation of pedagogical resources where a course unit is presented in the form of either file/video or both. Then, for each course unit, the students can use different tools of interaction such as virtual meetings, emailing…etc in order to interact to understand the concepts proposed in the presented course unit. The last activity is devoted to the evaluation of the knowledge acquired (an online quiz).

Throughout the cycle, temporal traces that represent a detailed account of the temporal behavior of students will be collected. According to these traces, automatic feedback is produced concerning the respect of time by a student.

In this research, we use the following activities:

- Pedagogical resource consultation (file/video).

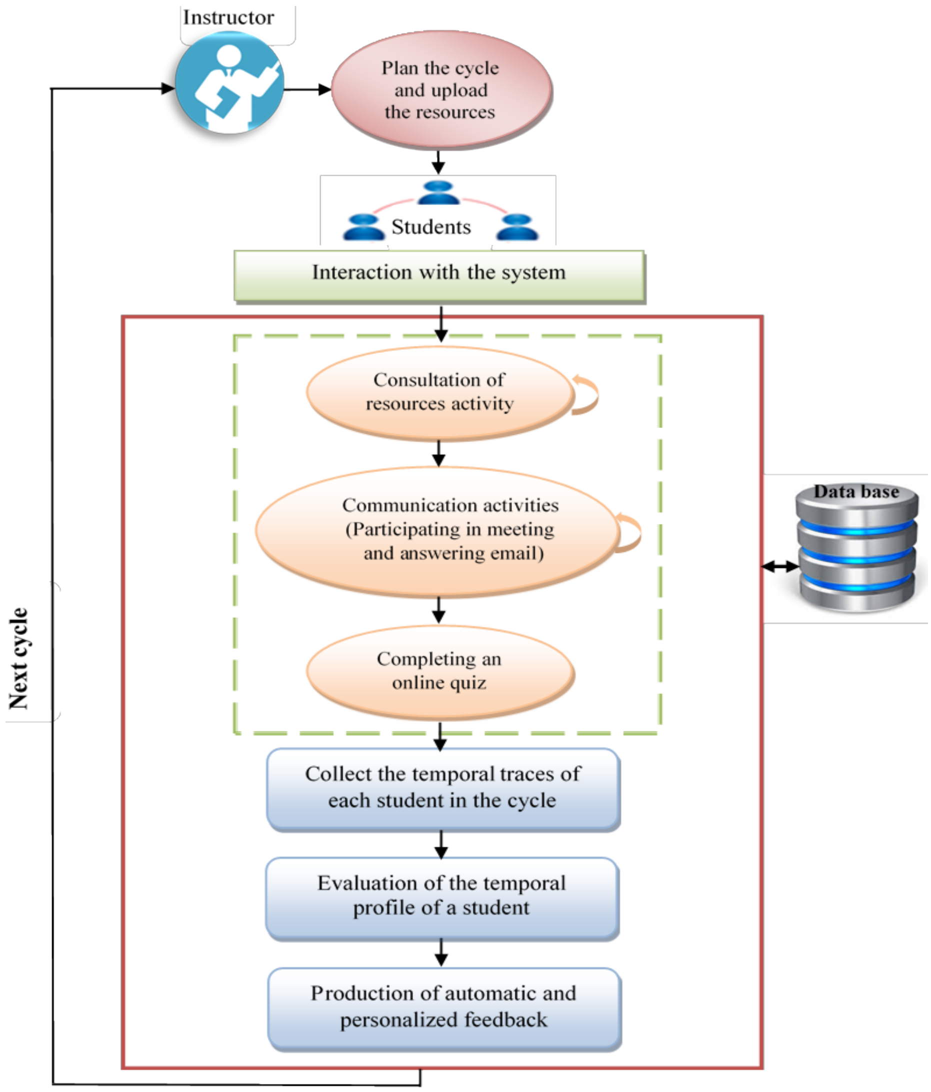


*Figure 1: An overview of the proposed approach*

- Participating in virtual meetings.
- Answering emails.
- Completing an online quiz.

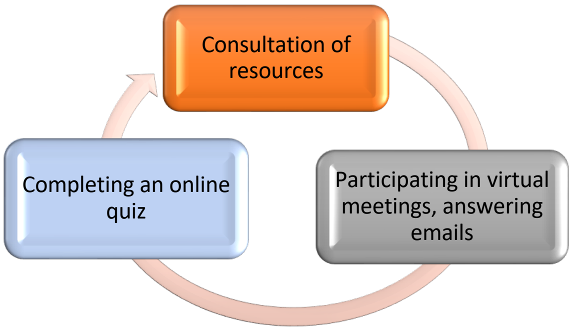


*Figure 2: Activities during a cycle*

For each cycle, a schedule must be proposed by the instructor who can estimate the time needed to complete each activity (table 1). Students must follow this schedule in order to learn how to manage their time in a good way.

*Table 1: Cycle planning*

| Activity | Example of the recommended time |
|---|---|
| Consulting pedagogical resources | Deadline for the consultation of a file/ video |
| Participate in a virtual meeting | Meeting starting time |
| Answering emails | Response time for an email sent by the sender |
| Completed an online quiz | Deadline to complete the online quiz |

In this work, we concentrate on the automatic collection of student's temporal traces during the online learning process. This is done to exploit them to provide a set of automatic and personalized feedback. The production of these feedbacks is based on a set of proposed indicators.

### 3.2.1 Evaluation of the temporal profile of a student

The evaluation of the temporal behavior of each student is based on the analytical criteria evaluation grid. This type of evaluation is carried out in detail based on each criterion separately [Intayoad, 2014, Yetiş, 2017, Brookhart, 2013]. In the following table, we present our proposed evaluation grid.

| | Temporal behavior scoring criteria | Scale |
|---|---|---|
| Cycle i | C1: Respect the time of pedagogical resource consultation | 0 to 6 points |
| | *C2*: Respect the time of participation in virtual meetings | |
| | *C3*: Respect the time to answer emails | |
| | *C4*: Respect the time of completing an online quiz | |

*Table 2: Proposed evaluation grid*

Here below, we will explain the importance of time for each activity.

- *Consultation of pedagogical resources*. For the consultation of resources activity, the instructor prepares and submits all the learning resources concerning the course unit in the form of a file/video or both. Then, each student must consult these resources in order to understand the different concepts of this unit. In fact, consulting a resource late can have negative consequences for the student. It can make them lose valuable time to understand the concepts of the teaching unit. Moreover, it can give the impression that the student is not organized or engaged enough in his/her learning. Therefore, it is important for students to plan their consultation time effectively to maximize their understanding and success in the course. For this activity, we propose to collect the temporal traces made by the student for the consultation activity in the cycle.
- *Participation in virtual meetings*. A virtual meeting is one of the means of communication between students that can be found in most online learning platforms where students can discuss, change ideas, and understand different concepts. Indeed, arriving late to a meeting can have an impact on the integration of a student. It can give the impression that the student does not place much importance on the meeting or lacks respect for other participants. It can also affect their relationship with other students and the perception of their participation and engagement in the group. Therefore, students need to be punctual to meetings to demonstrate their commitment and respect for other group members. For this purpose, we propose in our work to evaluate the temporal behavior of a student in virtual meetings.
- *Answering emails*. Nowadays, using e-mail has taken more and more importance with its extension in mobile technologies since it allows the transmission of messages in an efficient way. However, some students do not give importance to time to respond to emails which are sometimes critical and need to be answered as soon as possible. Furthermore, a student's delay in responding to an email can also give the impression that the student is not sufficiently engaged or motivated in his/her learning, or that this latter does not take the information or requests conveyed by the sender seriously. In addition, it can cause delays in teamwork or group projects if the email concerns a task or a collective mission. In general, students need to respond to emails from their instructors and classmates within appropriate deadlines to maintain effective communication and a positive learning environment. To make students more aware of time, we suggest adding an option when sending emails which consists of specifying the desirable time to have an answer if a student or an instructor needs an answer as soon as possible (deadline).
- *Completing an online quiz*. The delay in completing an online quiz can create a scheduling conflict for the student. This can also result in a loss of valuable time. Therefore, students need to be on time for tests to avoid any inconvenience. In this approach, a student must respect the schedule of the activities. Therefore, he/she can only complete an online quiz after the completion of the previous activities. Each student must answer a quiz submitted by an instructor concerning the course unit.

In this approach, we assess a student's temporal behavior based on their respect for time. We define the term "respect of time" as the ability to meet deadlines (completing an activity within a specified and agreed-upon time frame such as respecting the time for completing an online quiz) and the ability to be punctual (arriving as scheduled such as starting a virtual meeting). This respect of time is evaluated by the delay level of the student.

We propose to evaluate the temporal behavior of a student on twenty-four (24) points which are dispersed through four criteria (*C1*, *C2, C3*, and *C4*). The attribution of scores is done automatically based on a set of indicators. Each criterion is scored between 0 and 6 points. We will show how to elaborate these different evaluations afterward.

***Evaluation of the temporal profile of a student about each activity***

For each activity, the delay level $DL_{aj}$ of a learner is evaluated according to the formula 1.

$$DL_{aj} = Delay_j(s_i)/MDA_j \qquad (1)$$

Where:

$MDA_j$: Maximum delay allowed for the concerned activity *j*

$$Delay_j(s_i) = RT_j(s_i) - DT_j(s_i) \qquad (2)$$

With:

$RT_j(s_i)$: The real-time of the achievement of the activity *j* by a student *i*.

$DT_j(s_i)$: The desired time fixed in the planning to achieve the activity *j* by a student *i*.

In the following table, we present the real-time, the desired time, and the maximum delay allowed for different activities.

| Activity | Real-time (RT) | Desired time (DT) | A maximum delay allowed (MDA) |
|---|---|---|---|
| Consultation | The time taken by a student to finish the consultation of file/video. | The proposed time for the consultation of resources set by the instructor in the planning. | A maximum delay allowed for the consultation of a resource. |
| Participation in virtual meetings | The time when the student attends the virtual meeting. | The time of starting the meeting. | A maximum delay allowed for the student to attend the virtual meeting. |
| Answering emails | The response time for an email by a receiver student *i*. | The proposed time to answer an email sent by a sender (student *i* or instructor ). | A maximum delay allowed for the student to send a response. |
| Activity | Real-time (RT) | Desired time (DT) | A maximum delay allowed (MDA) |

| | | | |
|---|---|---|---|
| Completing online quiz | The time of submission of the answers by the student. | The fixed deadline for the submission. | A maximum delay allowed for the student to submit the answers. |

*Table 3: Activities with real-time, desired time, and maximum delay*

According to the obtained $DL_{aj}$, a score of temporal behaviour (STB) for each student will be attributed using the following algorithm:

***Algorithm 1: Student's score***

***Input:*** $DL_{aj}$= A student's delay level.
***Output:*** $STB_{aj}$=Appropriate score of temporal behavior.

*Begin*

*If* $DL_{aj} <= 0$ *then* $STB_{aj} := 6$
*Else if* $DL_{aj} < 0.2$ *then* $STB_{aj} :=5$
*Else if* $DL_{aj} < 0.4$ *then* $STB_{aj} :=4$
*Else if* $DL_{aj} < 0.6$ *then* $STB_{aj} :=3$
*Else if* $DL_{aj} < 0.8$ *then* $STB_{aj} :=2$
*Else if* $DL_{aj} < =1$ *then* $STB_{aj} :=1$
*Else if* $DL_{aj} > 1$ *then* $STB_{aj} :=0$
*End if*
*End.*

During a cycle, an activity can be repeated several times, for example programming more than one virtual meeting. So, a final score for each student is calculated at the end of the cycle as follows:

$$ASTB_{aj}(s_i) = \sum_{j=1}^{n} {STB_{aj}(s_i)}/{n} \quad (3)$$

Where:
$ASTB_{aj}(s_i)$: The average score for activity *j*.
$n$: Frequency number of an activity in a cycle, for example, the number of virtual meetings or the number of resource consultations.

The overall score of temporal behavior ($\mathrm{OSTB}(s_i)$) is the sum of the $\mathrm{ASTB}_{aj}(s_i)$. So, we use the following formula:

$$\mathrm{OSTB}(s_i) = \sum_{j=1}^{n} \mathrm{ASTB}_{aj}(s_i) \quad (4)$$

Where n is the number of activities (in our work we have four activities).

### 3.2.2 Proposed feedback after the evaluation of each activity

The purpose of providing automatic feedback is to help students improve their temporal behavior. Therefore, in order to provide the appropriate feedback the system can classify the student according to the value in the interval [0, 6]. We propose to decompose the interval [0, 6] into 6 sub-intervals [0, 1[, [1, 2 [, [2, 3[, [3, 4[, [4, 5[and [5, 6]. These feedback are provided by applying the following algorithm (*Algorithm*2):

***Algorithm 2: Student's feedback for an activity after each cycle***

**Input**:$ASTB_{aj}$ = The average score.
**Output**: AF = Appropriate feedback.

**Begin**

**If $ASTB_{aj}$< 1 then** AF: = "*Your delay is extreme and it has hindered your learning. To avoid this happening again, make sure to plan your time more realistically, take measures to manage your time better, and ensure that you are ready to fully participate in activities from the start*".

**Else if $ASTB_{aj}$< 2 then** AF: = "*Your delay has had a more significant impact. To avoid this happening again, it is important that you take measures to manage your time better and prepare in advance for the activity*".

**Else if $ASTB_{aj}$< 3 then** AF: = "*Your delay has had an impact on your learning. To avoid this happening again, make sure to manage your time effectively, be on time, and prepare for the activity*".

**Else if $ASTB_{aj}$< 4 then** AF: = "*You were late for the activity. For next time, try to allow enough time to prepare so that you can be on time for the activity*".

**Else if $ASTB_{aj}$< 5 then** AF: = "*You were a little bit late for this activity. For next time, think about managing your time more effectively to avoid this kind of delay. Try to start a little bit earlier next time*".

**Else if $ASTB_{aj}$<= 6 then** AF: = "*You are excellent at respecting your time, continue like this*".
**End if**
**End.**

## 4 Experiment Study: Results and Discussion

To validate our contributions, an experiment is carried out at the Department of Computer Science at the University of Guelma, Algeria. The experiment aims to test the proposed approach, which has been adopted by the system called ***AFeedPS (Automatic Feedback Production System)***.

### 4.1 Participants

This experiment involves second-year students from the Department of Computer Science at the University of Guelma, Algeria as its main sample. The students have an average age of nearly 19 years and are all in their second year of undergraduate studies in the computer science specialty. The number of students is 40 with a distribution of 21 males (52.5%) and 19 females (47.5%). The experiment was conducted on randomly selected students. In addition, the students have no prior knowledge of the course.

## 4.2 Methodology

These students are asked, through this process of experimentation, to engage in an online course: "Databases" subject. This course is divided into a set of units, each one is accomplished in a period of time (cycle). In each cycle, the students must consult the resources submitted by the instructor and they will interact with their pairs where they have to discuss the proposed content. Finally, they completed an online quiz to assess their acquisition of knowledge at the end of each unit of the course.

This experiment was conducted during the second semester of the 2021-2022 academic year and carried out over two stages. In the first stage, students followed the course online using the platform, but without adopting the proposed approach (without taking into consideration the time factor and consequently without using automatic feedback), while the second one was done using the platform with the adoption of the proposed approach (taking into account the temporal traces of students). According to these traces, the students receive the appropriate feedback at the end of each cycle of the learning process.

The students can use the developed system after a simple enrolment from any web browser.

## 4.3 Data collection

### 4.3.1 Meeting deadlines and punctuality

As we indicated before, our experiment was conducted in two stages. The proposed approach was adopted by the AFeedPS system in the second stage. In this stage, the temporal traces of students were collected to use for assessing the ability of students to meet deadlines and punctuality in the following activities: pedagogical resource consultation, participating in virtual meetings, answering emails, and completing an online quiz. At the end of the cycle, a score for each student is calculated for each activity.

### 4.3.2 Academic performance

Our experiment was conducted in two stages. In the first stage, students used the platform without the proposed approach, whereas in the second stage, students utilized the platform with the proposed approach. At the end of each stage, the academic performance of students must be evaluated. The assessment process involved the distribution of questionnaires consisting of a set of multiple-choice questionnaires to the students related to the learning objects "databases" and was proposed by the instructor responsible for the course. The administration of these questionnaires will take place in a face-to-face setting, with an allotted time for students to complete them. The decision to conduct the test face-to-face was made to ensure uniform testing conditions for all students, there by enhancing the validity of the obtained results. Each questionnaire is provided at the end of a stage. For this, the students answered the first proposed questionnaire (pre-test) at the end of the first stage and answered the second proposed questionnaire (post-test) at the end of the second stage.

The course instructor marked the questionnaires. The evaluation was based on the correctness of the selected responses by students rather than the use of a separate measuring instrument. Therefore according to these answers, each student was assigned a score (assessment mark). These scores ranged from 0 (very poor) to 10 (excellent) and counted towards each student's final assessment.

## 4.4 Results and discussion

### 4.4.1 Results about the improvement of temporal behavior for each criterion

An important objective of this experiment is to test whether automatic feedback production enhances a student's ability to meet deadlines and punctuality in online learning. For this purpose, a paired z-test is applied to calculate the difference in the value of each time respect level in two consecutive cycles. The tests were carried out separately for each activity, with the null hypothesis for each test as follows:

- **$H0^1$**:Providing automatic feedback cannot enhance students' ability to meet deadlines regarding the consultation of pedagogical resources.
- **$H0^2$**:Providing automatic feedback cannot enhance students' ability to be punctual when participating in virtual meetings.
- **$H0^3$**:Providing automatic feedback cannot enhance students' ability to meet deadlines about answering emails.
- **$H0^4$**:Providing automatic feedback cannot enhance students' ability to meet deadlines about completing an online quiz.

The results for temporal behaviour in each activity are presented in the table below (table 4).

| | Situation | N | Mean | SD | Difference | $z_{score}$ | P-value |
|---|---|---|---|---|---|---|---|
| Consultation of the pedagogical resources | Cycle 1 | 40 | 0,325 | 0,506 | -0,305 | -3,911 | <0,0001 |
| | Cycle 2 | 40 | 0,850 | 0,834 | | | |
| Participating in virtual meetings | Cycle 1 | 40 | 1,275 | 1,086 | -1,500 | -6,708 | <0,0001 |
| | Cycle 2 | 40 | 2,775 | 0,800 | | | |
| Answering emails | Cycle 1 | 40 | 0,050 | 0,316 | -0,400 | -2,726 | 0,006 |
| | Cycle 2 | 40 | 0,450 | 0,846 | | | |
| Completing an online quiz | Cycle 1 | 40 | 0,875 | 0,404 | -0,025 | -0,255 | 0,799 |
| | Cycle 2 | 40 | 0,900 | 0,441 | | | |

*Table 4: z-test experimentation results*

The paired student's z-test table shows a significant difference between:

- The cycle 1 mean of the students (Mean = 0,325; SD = 0,506) and the cycle 2 mean of thestudents (Mean=0,850; SD = 0,834) for the consultations of resources.
- The cycle 1 mean of the students (Mean =1,275; SD =1,086) and the cycle 2 mean of the students (Mean= 2,775; SD= 0,800) for participating in virtual meetings.

- The cycle 1 mean of the students (Mean= 0,050; SD = 0,316) and the cycle 2 mean of the students (Mean = 0,450; SD = 0,846) for answering emails.

About completing an online quiz by the student, table 4 shows that there is no significant difference between the cycle 1 mean of the students (Mean = 0,875; SD = 0,404) and the cycle 2 mean of the students (Mean= 0,900; SD = 0,441).

As a result of this test, the difference is statically significant for the activity of consultation of the pedagogical resources, participating in the virtual meetings, and answering emails. Also, the computed p-value is less than the significance level (alpha = 0.05), we should reject the null hypothesis $H0^1$, $H0^{2,}$ and $H0^3$ and accept the alternative hypothesis. Consequently, the alternative hypothesis is proven and we can affirm that providing automatic feedback can help students to improve their ability to meet deadlines and be punctual in online learning.

For completing an online quiz activity, the calculated p-value is greater than the significance level alpha = 0.05 ($P > 0.05$). So, we cannot reject the null hypothesis $H0^4$. Therefore, the ability to meet deadlines and be punctual of the students does not significantly increase. This could be due to the fact that the student dedicates more time to researching and providing accurate responses rather than adhering to deadlines.

Figure 3 represents a chart for each activity. This chart demonstrates a comparison of the average score of levels for these temporal behaviors that were made right away after cycle 1 and cycle 2. According to the results portrayed in the chart, the average score of participating in virtual meetings, answering emails, and consultation of resources is quite different after the two cycles, however. For the completing an online quiz, there is a slightly observable difference.

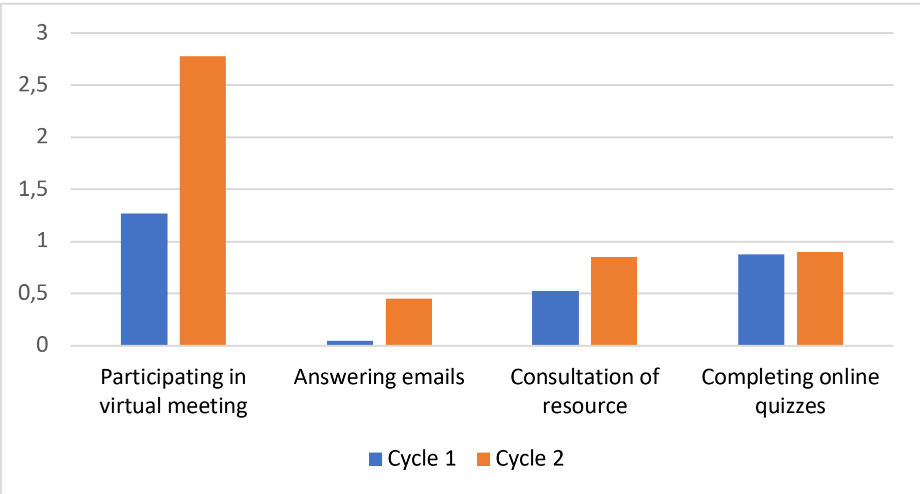


*Figure 3: A comparison chart of results after cycle 1 and after cycle 2*

### 4.4.2 Results of student's global temporal behavior

In this section, we evaluate the global temporal behavior of the students. In addition, we present the obtained results using the following research hypothesis:

- **H0[5]**: The use of the proposed approach cannot help students to improve their overall temporal behavior.

After having applied the student-paired z-test, we obtained the given results. A significant effect was found ($z_{score} = -7{,}220$, $P_{value} < 0.0001$) with a confidence level of 95% ($\alpha = 0.05$). In addition, a significant difference has been established between the cycle 1 mean (Mean = 2,725, SD = 1,154) and the cycle 2 mean (Mean = 4,975, SD = 1,561). So, the difference was significantly improved, as the computed p-value is lower than the significance level alpha = 0.05.

| | Situation | N | Mean | SD | Difference | Zscore | P value |
|---|---|---|---|---|---|---|---|
| Temporal behavior (DL) | *Cycle 1* | 40 | 2,725 | 1,154 | -2,250 | -7,220 | < 0.0001 |
| | *Cycle2* | 40 | 4,975 | 1,561 | | | |

*Table 5: Summary statistics of student paired z-test*

Therefore, the null hypothesis H0[5] is rejected in favour of the alternative hypothesis. So, the use of the proposed approach can help students to improve their overall temporal behavior.

About the comparison of overall temporal behavior after cycle1 and cycle2, the results are portrayed in the chart (Figure 4). According to these results, there is an observable difference between the two cycles.

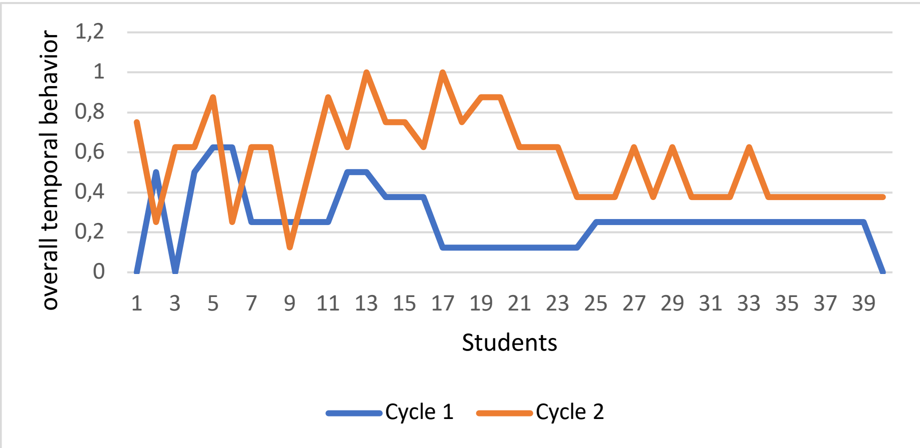


*Figure 4: A comparison chart of results about global temporal behavior after cycle1 and cycle2*

#### 4.4.3 Results about the students' academic performance

In this section, we evaluate the impact of providing automatic feedback to students about their meeting deadlines and punctuality abilities on the improvement of their academic performance in online environments. We present the obtained results with a real test of our system, using the following research hypothesis:

- Null hypothesis H0: Producing automatic feedback to students about their meeting deadlines and punctuality has no effect on the improvement of their academic performance.
- Alternative hypothesis H1: Producing automatic feedback to students about their meeting deadlines and punctuality has an effect on the improvement of their academic performance.

As the pre-test and post-test data are quantitative, we used one of the parametric tests. As the size of the samples is greater than 30, we used a paired student z-test.

Following the utilization of the XLSTAT software, the outcomes presented in Table 6 were mentioned.

As shown in Table 6, a significant effect was found ($z_{score}$ =-9,595, $P_{value}$<0.0001) with a confidence level of 95% ($\alpha$ = 0.05). In addition, a significant difference has been established between the pre-test mean (Mean = 5,000, SD = 1,132) and the post-test mean (Mean = 7,400, SD = 1,081). Therefore, the difference was significantly improved, as the computed p-value is lower than the significance level alpha = 0.05.

| Situation | N | Mean | SD | $Z_{score}$ | P value |
|---|---|---|---|---|---|
| Before | 40 | 5,000 | 1,132 | -9,595 | <0.0001 |
| After | 40 | 7,400 | 1,081 | | |

*Table 6: Summary statistics of student paired z-test*

Therefore, the null hypothesis H0 is rejected in favor of the alternative hypothesis H1, and we can affirm that producing automatic feedback to students about their meeting deadlines and punctuality has an effect on the improvement of their academic performance.

## 5 Conclusion and future work

In this study, we proposed a new approach to enhance the temporal behavior of students in online learning environments, recognizing the significance of time as a crucial factor. Our approach involves capturing temporal traces of students' learning activities, there by enabling the automatic generation of personalized feedback for each student. We specifically concentrate on four activities, namely accessing educational resources, attending virtual meetings, responding to emails, and completing an online quiz.

Our approach also aims to promote enduring learning and enhance students' ability to meet deadlines. By receiving feedback about meeting deadlines and punctuality, the student is encouraged to reflect on his time management habits and practices (planning, prioritizing, and setting goals) to be more punctual next time. This feedback promotes personal awareness and recognition of behaviors that require adjustments. Therefore the students are better prepared to apply these principles in various aspects of their academic, professional, and social lives, thus contributing to their long-term success in meeting deadlines and achieving their goals.

During the learning process, the course is structured into units in which students are required to participate for a predetermined period which is referred to as a cycle. At the end of each cycle, the temporal traces of each student are collected in order to facilitate the automatic production of personalized feedback aimed at enhancing their temporal behavior in the subsequent cycle. This approach has been incorporated into an online learning environment known as AFeedPS (Automatic Feedback Production System). The system detects the temporal traces of enrolled students in the course based on their actions. To evaluate the effectiveness of the proposed approach, an experiment was conducted involving 40 students from the 8 Mai 1945 University of Guelma (Algeria). The results were very encouraging, with participants expressing high satisfaction with the system. The study revealed that the proposed approach can effectively improve the temporal behavior and academic performance of students.

The obtained results indicate that the production of automatic feedback assists students in improving their temporal behavior when accessing educational resources, participating in virtual meetings, and responding to emails. However, the improvement was not significant in completing an online quiz.

Therefore, we conclude that the production of automatic feedback was beneficial for the majority of students.

In future works, we intend to apply and assess the proposed approach in other courses with a large population. Moreover, we will take into consideration additional activities such as submitting homework (assignments, presentations, etc.). Moreover, we aim to explore deeper into understanding why students did not demonstrate any significant improvement in their temporal behavior for the knowledge evaluation activity.

In addition, as future work, we plan to measure if our proposed approach depends or not on the technology.

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