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# An Agile Learning Methodology to Support Inclusive Education

*Una metodología de aprendizaje ágil como apoyo a la educación inclusiva*

Jaime Muñoz-Arteaga, jaime.munoz@edu.uaa

Gabriela Citlalli López-Torres, gabriela.lopez@edu.uaa.mx

Ángel Eduardo Muñoz-Zavala, eduardo.munoz@edu.uaa.mx

Universidad Autónoma de Aguascalientes (Mexico)

## Abstract

Inclusive education is complex due to adapting the learning process to specific learning needs. Besides, some current national education models for inclusive education lack an agile, flexible, and collaborative methodology where all relevant participants, like parents, educators' instructors, and even information technology (IT) developers, can be involved. COVID-19 accelerated e-learning but established new challenges. This research method includes the test of a proposed scrum-agile learning methodology in an elementary education institute for three students with dyscalculia based on Scrum as an agile methodology proposed to adapt inclusive education processes. Among the benefits of the proposed methodology is the testing of the iterative design and application of an agile approach, quick adaptation, and formation of IT applications and contents. Also, the student's learning improvements were measured in this research experience, demonstrating that the proposed methodology supports inclusive education by improving collaborative interventions, flexible curriculum, attention to learning needs, IT integration, and instructor training. Thus, it can be argued that the proposed methodology can meet the new challenges of the evolution of inclusive education and national models, such as accelerated IT integration, collaborators' involvement, and specific students' attitudes and needs. This methodology can evolve to an 'agile and inclusive learning methodology'.

**Keywords:** Agile learning, Inclusive education, Scrum, e-learning, COVID-19 contingency.

## *Resumen*

*La educación inclusiva es compleja debido a la necesidad de adaptar procesos a necesidades individuales de aprendizaje. Además, los actuales modelos educativos nacionales para la educación inclusiva carecen de una metodología ágil, flexible y colaborativa en la que participen tanto, padres, educadores, e incluso desarrolladores de tecnología de información (IT). COVID-19 aceleró e-learning, pero generó nuevos retos. El método de investigación incluye la prueba de una propuesta de metodología de aprendizaje ágil en un instituto de educación primaria para tres alumnos con discalculia. Entre los beneficios de la metodología propuesta está la comprobación del diseño iterativo, la aplicación de un enfoque ágil, la rápida adaptación y la adaptación y formación sobre aplicaciones y contenido. En esta experiencia de investigación se midieron las mejoras en el aprendizaje de los estudiantes, demostrando que la metodología apoya la educación inclusiva, mejorando intervenciones colaborativas, currículo flexible, atención a necesidades de aprendizaje, integración de las TI y formación de instructores. Así, la metodología propuesta responde a retos de la evolución en la educación inclusiva y modelos nacionales, integrando TI rapidamente, implicando a los colaboradores, y adaptandose a actitudes y necesidades específicas de aprendizaje, pudiendo evolucionar hacia una "metodología de aprendizaje ágil e integradora".*

***Palabras clave:*** *Aprendizaje ágil, educación inclusiva, Scrum, e-Learning, contingencia COVID-19.*

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# 1. INTRODUCTION

*Agile Learning* (AL) combines e-learning and agile processes that adapt learning to Information and Communication Technologies (ICT). Whereas *e-learning* supports students' learning as an ICT and is considered a "new teaching-learning ecosystem", AL has become essential for improving learning for various learning styles, especially during the COVID-19 pandemic, where ICT in education became vital (Cologon, 2020). AL integrates rapid adaptation to change (Ackles, 2018), user and developer involvement, and continuous evaluation (Cáceres-Muñoz et al., 2020). However, the implementation of AL in education institutes remains limited, and the increasing use of ICT may complicate the learning processes (Kim et al., 2018; Mundiri et al., 2021).

On the other hand, today, inclusive education aims to provide quality education for everyone, regardless of adversities. For instance, the Salamanca Statement emphasizes the right to education for everyone, especially children with special learning needs. Hence, international research emphasizes policies and operational care for students with disabilities. Then, inclusive education must go beyond policy frameworks and become practical.

Nevertheless, developing countries like Mexico face challenges in implementing inclusive education due to, among others, insufficient ICT support. Then, education instructors require flexibility, collaboration, simplicity, and student specificity to implement "Individualised Education Plans" (IEP). Various approaches in the literature support AL in education, highlighting its benefits in facing uncertainty and allowing quick adaptation to change. Some research explores mechanisms for combining learning styles and system design improvements, like Agile Software or the Scrum model (Schwaber & Sutherland, 2020), an agile project management approach. However, case studies demonstrating how agile frameworks support inclusive education are scarce in the literature. Therefore, a case study is proposed to address this gap, applying an agile learning approach following an inclusive education model in a developing country's elementary school in Mexico. Therefore, the research question is:

- *How can a Scrum-Agile Learning (AL) Methodology be demonstrated to support e-learning in Inclusive Education?*

In Mexico, a government program called the "Regular Education Support Service Units" (USAER from its acronym in Spanish) program supports integrating students with special education needs into regular education (Rapp & Corral-Granados, 2021). Also, the 'Educational Rehabilitation Process Model' (ERPM) helps diagnose, intervene, implement, and assess interventions for these students (SEP 2020). However, the ERPM lacks integration of ICT despite its good definition of activities and registration process. Therefore, it is necessary to improve these strategies because they should incorporate digital content and involve ICT experts in the USAER team. Additionally, integrating students' families into the school community is essential. Focusing on creating an inclusive environment that fosters all students' participation, the government USAER retrieves information from various sources, such as teacher planning, classroom observation, and student interviews. However, integrating ICT specialists for inclusive education remains complex (Naveed et al., 2021).

New educational technologies as educational applications offer motivating and adaptable content for students in the classroom and at home. This research includes analyzing and evaluating technologies, online educational applications, and sources aimed at effectively implementing these in the teaching-learning process. Also, more collaboration networks enable sharing experiences, successful processes, and measures to overcome challenges, enriching the involvement of all stakeholders. This research evaluation process involves objective analysis, subjective appreciation, and opinions of techno-educational experts. The expected results include a comprehensive profile of strategies, processes, and tools.

The current approaches, like the USAER, do not fully consider adapting to new factors like post-COVID-19 realities (Barua, 2020), changes in school conditions, demotivation due to breaks, or shifts in learning environments. Therefore, the need for flexibility and adaptation in the inclusive education–classroom processes become evident, ensuring optimal monitoring and adaptation for students' progress. Implementing measures becomes essential to address the challenges of various factors, such as the limited USAER's three-week timeframe to adapt content for students at different levels in a staggered presence. An evaluation process involving objective analysis, subjective appreciation, and input from techno-educational experts is necessary to address this problem. This research analyses a comprehensive profile of strategies, processes, and tools to seamlessly integrate human and technological resources into teaching-learning for inclusive education. This approach can help to simplify the support offered by the Scrum-Agile Learning (AL) Methodology to e-learning in Inclusive Education.

Therefore, this research demonstrates how a Scrum-Agile Learning (AL) Methodology supports special learning needs, like dyscalculia, fostering collaboration and flexible tech integration. Its value lies in time efficiency, parental involvement, professional coordination, inclusive practices, and quick learning adaptations. The paper has five sections: context introduction, research proposal, methodology, results, discussion, and conclusions with future work.

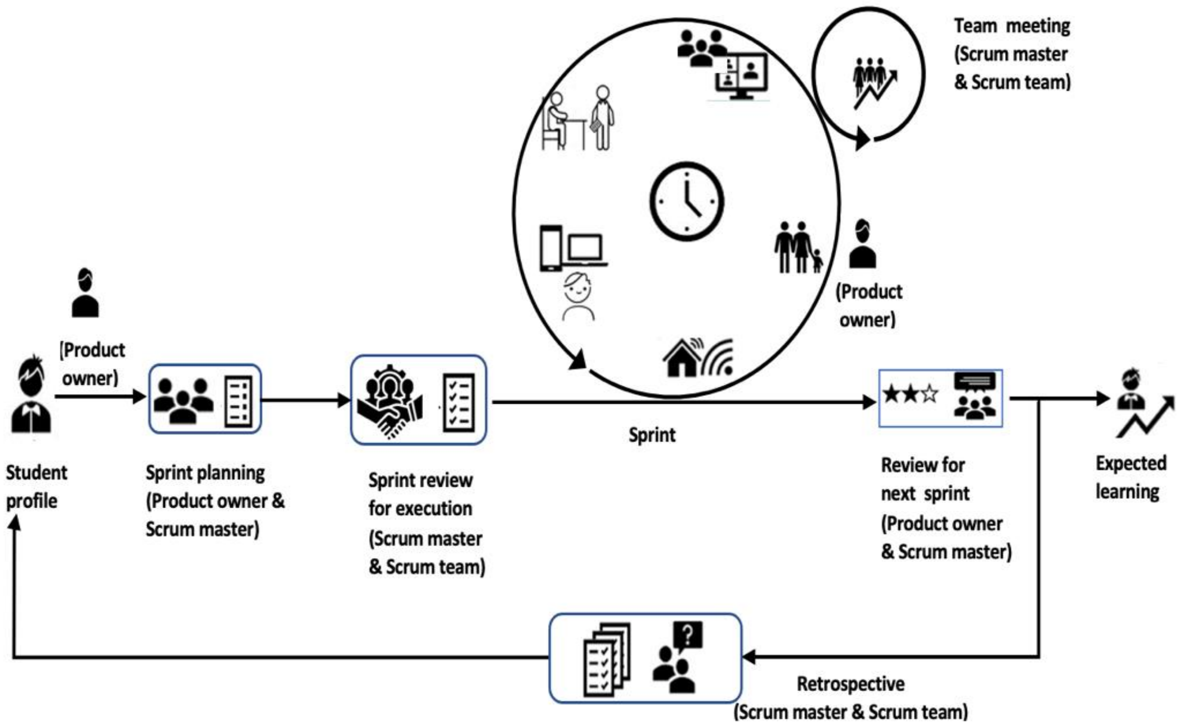
## 2. METHOD

During COVID-19 the education dynamics at home had to be adapted to an online modality. For instance, the Mexican Ministry of Public Education limited face-to-face school activities to avoid the risk of contagion among students and teachers. These changes significantly impacted students who already had special learning needs like dyslexia and dyscalculia. Therefore, it is necessary to quickly produce educational content that considers the user's learning needs, educative services available on the internet for their generation, user's characteristics, and the application context of inclusive education (Martínez-Domínguez & Fierros-González, 2022).

This research presents the new Scrum-Agile Methodology for three students with a certain level of dyscalculia. Figure 1 presents the model to mitigate the educational delay of 15 students in an elementary school in Aguascalientes City, Mexico, for six months in 2021. The following subsections describe the student profiles and *sprints* related to the proposed methodology. The methodology includes the *Scrum* process model of already known roles, values, ceremonies, and instruments. The *Scrum roles* are parents and students as *the users,* the USAER principal, the *Product Owner*, and the project manager as the *Scrum Master.* Moreover, the *Scrum Team* consists of the ICT members, regular and inclusive teachers, psychologists, pedagogues, social workers, and speech therapists. Figure 1 shows the *Scrum* process model (Cui et al., 2021) as a framework for the USAER to use educational content and services online. The *USAER Team* can communicate with parents, students, principals, and colleagues through the cloud services designed to support inclusive education.

Figure 1.

*The proposed Scrum-Agile Learning Methodology to support e-learning in inclusive education.*




The University Autonomous of Aguascalientes (UAA) group and the multidisciplinary USAER team composed the *Scrum Team* in this research. The UAA team is an ICT team consisting of a software project manager, a tester, and a programmer. The multidisciplinary *USAER team* from Aguascalientes City, Mexico, included a psychologist, a special education pedagogue, a speech therapist, and a social worker.

The fundamental research problem is that many differences exist between students, learning objectives, continuous attitudinal changes, and social uncertainty. Basis of solution: Each student is a project, intending to have significant learning according to their capabilities. Therefore, all actions focused on providing the best tools to achieve the prioritized learning goals. So, this involves roles, activities, and artefacts (see Table 1).

Table 1

*The roles, activities, and artefacts executed by the main Scrum actors*

| SCRUM Team's Roles | Enterprise (School -case-) Team Roles | Responsibilities from the Scrum Approach | Activities Performed in the Case for Agile Learning | Artifacts |
|---|---|---|---|---|
| Product Owner | USAER's Principal. | To develop and communicate (product backlog) the objective of the product. | Sprint planning.<br>Diagnose or assess the student's needs and develop a student profile or report. | Learning needs |
| Scrum Master | USAER's Mentor. | To plan and verify the Scrum effectiveness and practices. | Detection of student needs.<br>Monitoring learning.<br>Retrospective. | Adapted curricula |
| Scrum Team | ICT Team: Analyst, designer and programmer. | To make technological innovation. | Sprint execution. Learning activities execution.<br>Analyse, program, and evaluate the educational applications, artifacts, and designs that support the student profiles of learning needs. | Learning objectives backlog.<br>Sprint backlog. |
| | The USAER's Team: Inclusive teacher, psycho-pedagogue, speech therapist, and social worker. | To make pedagogical innovation. | Team meeting. Learning objective adequation. | Learning activities. |
| User | Student and Family. | To assist the children with special learning needs. | Student profile.<br>Sprint review.<br>Sprint work. | Learning outcomes. |

## 2.3 Data Analysis

### *2.3.1 Student Profiles*

Firstly, as seen in Figure 1, the USAER principal, as the *Product Owner,* received information about the three students, in this case, with dyscalculia from the 2$^{nd}$ level of primary school. Then, the *Product Owner* asked the USAER team to get the students' profiles and the users' learning needs. As a result, USAER teachers have defined the profile of each student (see Table 2) by specifying the development of specific hypothetical cognitive structures-logical and infralogical groupings proposed by Piaget ( Morales Peláez et al., 2017) related to basic math skills.

USAER teachers have correlated the expected learning for each student's mathematical skill with specific variables. Appendix 1 outlines the profile scores of students with different levels of development in mathematical skills according to the Piaget test (Morales Peláez et al., 2017). For instance, student 1 excels in spatio-temporal identification but faces challenges in numerical ordering and sequencing. Student 2 demonstrates strong short- and long-term memory but struggles with language disorders. Student 3 excels in spatio-temporal management, numerical ordering, and sorting but experiences difficulties in numerical recognition and mathematical operations. Although the students' learning needs are not necessarily similar, Piaget's theory emphasizes that everyone constructs knowledge uniquely through abstract experiences in their environment, even if they share the same surroundings, teachers, age, and food.

### *2.3.2 Sprint Planning*

In the second cycle of primary education, the basic mathematics curriculum involves learning four basic operations. However, considering the profile of the students, teachers made a curricular adaptation, focusing on specific skills for each student. Student one focused on ordering and serialization, student two on verbal processing of numbers, and student three on recognizing numbers and operators. The research concentrated on students' math skills and expected learning or variables (see Table 2).

Table 2

*Reasonable accommodations made by USAER teachers*

| ID | Math skills | Expected learning (variable) | Eval. #1 |
|---|---|---|---|
| **Student 1** | Ordering and serialization | 17. Comparing collections of objects | 2 |
| | | 18. Sort numbers based on size, shape, color, or weight | 2 |
| | | 19. Compare two numbers, which is more extensive, and which is smaller | 1 |
| **Student 2** | Verbal processing of numbers | 22. The correct pronunciation of numbers and arithmetic symbols | 2 |
| | | 23. Dictation of numerical quantities and arithmetic symbols | 1 |
| | | 27. Represent numeric symbols in object quantities | 2 |
| | | 28. Represent object quantities in numeric symbols | 1 |
| **Student 3** | Recognition of numbers and operators | 13. Number values, meaning, and representation of a number | 1 |
| | | 14. Recognition of digits | 2 |
| | | 15.Learning to count discrete objects | 3 |
| | | 16. Recognition of basic operators | 1 |

Thus, the USAER teachers, applying a flexible curriculum, focused on strengthening the skills related to performing addition and subtraction operations. In this case, Student 1 needed to work on ordering and serializing, Student 2 worked on verbal number processing, and Student 3 worked on number recognition and operators.

*2.3.3 Sprint Review for Execution*

Parents have played a crucial role in assisting their children during distance learning, helping with technology use, and participating in the learning activities requested by primary education teachers. The USAER principal, acting as the Scrum Owner, effectively communicated with parents about learning activities and provided timely preparation reminders. Elementary school students in Mexico attended online courses conducted by their teachers through platforms like "Aprende en Casa" provided by the Secretary of Public Education (SEP).

*2.3.4 Sprint 1*

*2.3.4.1 Work*

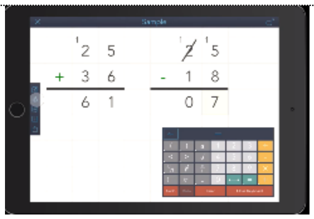
The *sprint work* is the most crucial stage in the Scrum process model. The *Scrum Team* (inclusive teacher, psycho-pedagogue, speech therapist, and social worker specified in Table 1) offered educational services to users as students and parents. The multidisciplinary team members have learned that many practical learning applications are available in online repositories such as the 'Arasaac' website (Arasaac, 2022). Therefore, the *ICT Team* has proposed a series of online educational applications for primary mathematics learning needs (see Table 3).

The educational application pictogram agenda (Arasaac, 2022) was proposed for student 1 to collect and order objects based on size, shape, color, or weight (see Figure 2). As shown in Figure 3, the educational application 'Adapro' (ITER, 2022) was used with student 3 to represent numerical symbols in quantities of objects. Represent quantities of objects in number symbols. As illustrated in Figure 4, the application 'ModMath' (ModMath, 2022) was proposed for student 3 to poEEse and solve mathematical problems with addition and subtraction operations.

Table 3

*Online educational applications to assist students of this case study*

| ID | Math skills | Expected Learning | Online Educational Applications | Eval. #2 |
|---|---|---|---|---|
| **Student 1** | Ordering and serialization | 17.Comparing collections of objects |  Figure 2. Agenda pictogram | 4 |
| | | 18.Sort numbers based on size, shape, color, or weight | | 4 |
| | | 19.Compare between two numbers, which is larger, and which is smaller | | 2 |
| **Student 2** | Verbal processing of numbers | 22.The correct pronunciation of numbers and arithmetic symbols. | | 3 |
| | | 23.Dictation of numerical quantities and arithmetic symbols | | 2 |

| ID | Math skills | Expected Learning | Online Educational Applications | Eval. #2 |
|---|---|---|---|---|
| | | 27.Represent numeric symbols in object quantities |  Figure 3. Adapro | 4 |
| | | 28.Represent object quantities in numeric symbols | | 3 |
| Student 3 | Recognition of numbers and operators. | 13.Number values, meaning, and representation of a number |  Figure 4. ModMath | 5 |
| | | 14.Recognition of digits | | 6 |
| | | 15.Learning to count discrete objects | | 4 |
| | | 16.Recognition of basic operators | | 4 |

*2.3.4.2 Team Meeting*

During the team meeting, some activities were analyzed, where the parent gave the directions required to develop the learning activity using an educational application, where the student listened, repeated, and selected the correct item using a tablet. Once the three students had used the online ludic applications, the parents and the Scrum Team observed that these applications were not helpful, as they did not have a native language version and covered the specific learning needs of each student. Therefore, these applications either do not have a version available in the native language of the learners, or the others do not meet the instructional design required for this case study. Even if an improvement was obtained in specific logical-mathematical skills, however, some parents and USAER teachers noted that while the applications were helpful, there was a need for new educational applications that have native language versions and are designed to meet each student's expected learning.

*2.3.5 Sprint 2*

2.3.5.1 Work

At this stage, the *Product Owner* and the *USAER Team* requested new educational applications to support the teaching activities. Consequently, the *ICT Team has* proposed developing new software (Table 4), so designing and developing some educational applications according to the student's learning needs was necessary. Therefore, the *ICT Team* has proposed a series of prototypes of an educational application regarding wireframes.

Table 4

*The wireframe of educational applications proposed by ICT team.*

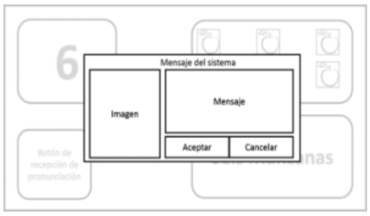
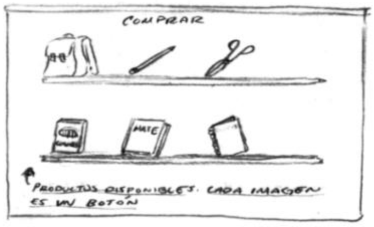
| ID | Math skills | Expected learning | Prototypes |
|---|---|---|---|
| Student 1 | Ordering and serialization | 17. Comparing collections of objects<br>18. Sort numbers based on size, shape, color, or weight<br>19. Compare two numbers, which is larger, and which is smaller |  <br>Figure 5. Trees in order. |
| Student 2 | Verbal processing of numbers | 22. The correct pronunciation of numbers and arithmetic symbols<br>23. Dictation of numerical quantities and arithmetic symbols<br>27. Represent numeric symbols in object quantities<br>28. Represent object quantities in numeric symbols |  <br>Figure 6. Pronouncing a series of numbers. |
| Student 3 | Recognition of numbers and operators | 13. Number values, meaning, and representation of a number<br>14. Recognition of digits<br>15. Learning to count discrete objects<br>16. Recognition of basic operators |  <br>Figure 7. Shopping scholar items simulator |

Table 4 describes how the learning needs of each student were addressed with priority as part of the reasonable accommodations proposed by the *USAER teachers*. Table 4 helped the *ICT team* to outline sketches from the characteristics of the new applications that respond to the learning needs of each student. The wireframe of Figure 5 specifies that a student can select and put a set of trees in order. In general, the order goes from the smallest to the tallest tree. Figure 6 shows a prototype to display a symbolic and graphical representation of numbers in math. In addition, a message is displayed about the validation of user input. Finally, Figure 7 shows an online shopping simulation where the *user* is trained to buy several scholarly items such as notebooks, pencils, scissors, glue, and backpacks.

*2.3.5.2 Team Meeting*

The development of new educational applications requires being available to users. For this purpose, the ICT team has developed a repository that allows access to a whole set of educational applications to cover learning activities related to basic mathematics classes. The USAER teacher obtains these applications through various cloud services to facilitate access, updating and integration of users with mobile devices.

*2.3.6 Sprint 3*

This sprint three was necessary to finally get the student experience using the new educational applications developed by the *ICT Team* (see Table 5).

2.3.6.1 Work

Figure 8 presents the new educational application proposed to student 1, who can interactively select trees to put in order from the most miniature tree to the tallest. If there is a good selection, the application sends a confirmation message; if not, the student is invited to reorder the trees.

Table 5

*Developed educational applications used by students.*

| ID | Math skills | Expected learning | Educational Applications | Eval. #3 |
|---|---|---|---|---|
| **Student 1** | Ordering and serialization | 17. Comparing collections of objects |  **Figure 8. Trees in order.** | 5 |
| | | 18. Sort numbers based on size, shape, color, or weight | | 8 |
| | | 19. Compare two numbers, which is larger, and which is smaller | | 6 |
| **Student 2** | Verbal processing of numbers | 22. The correct pronunciation of numbers and arithmetic symbols. |   **Figure.9. Pronouncing series of numbers** | 7 |
| | | 23. Dictation of numerical quantities and arithmetic symbols | | 5 |
| | | 27. Represent numeric symbols in object quantities | | 8 |
| | | 28. Represent object quantities in numeric symbols | | 6 |
| **Student 3** | Recognition of numbers and operators | 13. Number values, meaning, and representation of numbers | | 9 |
| | | 14. Recognition of digits | | 8 |

| ID | Math skills | Expected learning | Educational Applications | Eval. #3 |
|---|---|---|---|---|
| | | 15. Learning to count discrete objects |  Figure 10. Shopping scholar items simulator | 7 |
| | | 16. Recognition of basic operators | | 7 |

Figure 9 shows the user interface of the new educational application where student 2 selects and pronounces the number eight, and then this number is reproduced and displayed as the number eight and a set of eight red apples from a tree. The application offers control to a *user* over the volume level and content navigation. In addition, a message is displayed about the result of user input validation. Finally, student 3 used the educational application 'La Tienda' (Figure 10), where the student can pay by adding and subtracting various coins to buy a backpack online with 126.00 Mexican pesos. This application helped the student better understand and represent numbers and operations in daily life activities.

### *2.3.7 Team Meeting*

The USAER teachers recorded the performance during the team meeting and evaluated their students' math skills using educational applications. For this purpose, the teachers were also getting to know and carefully analyzing the new applications' performance in the repository.

### *2.3.8 Expected Learning*

In this phase, the *Scrum Team* and the *Scrum Master* discussed how they performed the project work, including activities from the initial stages and information and results from the fourth phase, the sprint work. Table 6 demonstrates the students' specific evolution in basic math after using the educational applications developed for the student's learning activities.

Table 6

*Student profiles specifying slight progress related to basic math skills*

| ID | Math skills | Expected learning outcomes | Eval. #1 | Eval. #2 | Eval. #3 |
|---|---|---|---|---|---|
| **Student 1** | Ordering and serialization | 17. Comparing collections of objects | 2 | 4 | 5 |
| | | 18. Sort numbers based on size, shape, color, or weight. | 2 | 4 | 8* |
| | | 19. Compare two numbers, which is larger, and which is smaller. | 1 | 2 | 6 |
| **Student 2** | Verbal processing of numbers | 22. The correct pronunciation of numbers and arithmetic symbols. | 2 | 3 | 7 |
| | | 23. Dictation of numerical quantities and arithmetic symbols. | 1 | 1 | 5 |
| | | 27. Represent numeric symbols in object quantities. | 2 | 4 | 8* |
| | | 28. Represent object quantities in numeric symbols. | 1 | 3 | 6 |
| **Student 3** | Recognition of numbers and operators | 13. Number values, meaning, and representation of a number. | 1 | 5 | 9* |
| | | 14. Recognition of digits. | 2 | 6 | 8 |
| | | 15. Learning to count discrete objects. | 3 | 4 | 7 |
| | | 16. Recognition of basic operators. | 1 | 4 | 7 |

*Greatest learning improvements.

To validate the integration of the most critical current learning objectives, Table 6 compares the initial evaluation versus the evaluations after using educational applications for each student who made noticeable progress in some of the expected learning outcomes in basic math skills. Student 1 came to identify numbers in space quantities, with more significant progress in some expected learning outcomes. For example, in recognizing differences in sizes and quantity, rising to eight points in the post-evaluation from four points obtained in the pre-evaluation; also, in recognizing where is more, where is less (5 to 7 points, see Table 6). Student 2 showed better performance in ordering and serialization, improving learning on making comparisons among numbers, rising to five in the post-evaluation from initially three points in the pre-evaluation. In the math skill of recognizing numbers and operators, student 3 demonstrated significant progress in the three basic mathematical operations, rising to eight points in the post-evaluation from initially obtaining 4 points in the pre-evaluation. The USAER team notified that these learning outcomes progress to their respective parents.

*2.3.9 Retrospective*

The *Scrum Master* calls the *Scrum Team* and the *Product Owner* to celebrate a retrospective meeting, representing an academic space to analyze, criticize, reflect, and argue about the results emanating from the contexts investigated, in the logic of promoting a change of perspective in interdisciplinary work. Furthermore, how it translates into an organization's shared mission and vision that benefits diversity and not only people with disabilities. Finally, the students of this case study can continue to work with their teachers, adding more educational applications to reduce much more math troubles.

## 3. RESULTS

The present research demonstrated the application and benefits of a Scrum-agile learning methodology in an inclusive education school (see column C in Table 7) using the Scrum approach. Applying the proposed methodology provides a rapid adequation of educational content for each student evaluated, achieving their specific and critical learning objectives. Additionally, this research demonstrated how an AL approach is a feasible alternative for inclusive education to incorporate ICT effectively while promoting continuous and iterative work and curriculum re-evaluation. Finally, an "agile inclusive learning" for future research should be developed, where each element can achieve its optimal levels (as shown in column D in Table 7); for example, full parental and community involvement and necessary training of all participants (e.g., teachers, parents), where the ICT use and collaboration are continuously evaluated and flexible. Hence, more research demonstrating "agile inclusive learning" will allow its implementation and further support inclusive education.

Table 7

*Synthesis of the main approaches related to the present research (Column C).*

| | A-While Covid-19 | B-Literature Review | C-Present Research | D-Future Research |
|---|---|---|---|---|
| E-Learning Goals Inclusive Education | Current Inclusive Education | Agile Learning | Scrum-Agile Learning Methodology | Inclusive Agile Learning |
| 1. Flexible curriculum | Poor | Flexible instruction and assessment | Flexible Curriculum | Flexible curriculum and instruction |
| 2. Collaborative interventions | Poor | Good | Good | All groups |
| 3. Attention to special learning needs | Poor | Attention to employees | Good | Fully attended |
| 4. Learning time | Long | Save time | Regular | Optimal |
| 5. Online courses | Minimal | Training courses | Online courses | Hybrid |
| 6. Attention to learning needs | No | Competencies | Basic logical math skills | Completely |
| 7. Content adaptation | Minimal | Good | Good | Reasonable adjustments |
| 8. ICT integration | Minimal | Good | Good | Good |
| 9. Training for teachers and employees | Poor | Employees' training | Teachers' training | Integral training |

Table 7 presents an analysis of the evolution of some elements of the researched concepts. First, column A contains some "inclusive education" characteristics that were aggravated during the COVID-19 pandemic. Besides, inclusive education needs the 'continuous and personalized' construction of educational content for diverse students' learning needs, evaluation, and collaboration of parents and the community. Although teachers were not trained in inclusive education in pandemic situations, at least a little flexibility in the curriculum was achieved. Thus, it requires more flexible approaches to respond and work effectively. Then, in column B, the "Agile Learning" approach from the literature review appears to be a feasible solution with the accommodation of content for better inclusive education, demonstrating principles of continuous and flexible integration of tasks, tools, and people.

The students in this research put into practice the learning instructions in the online class section with the family and individually. As a result, students have improved reasoning, attention, comparison, and recognition of mathematical operations using objects related to daily life activities. The progress of each student, specified in Table 7, has been possible by carrying out the technology adaptations in each sprint and by the collaborative interventions between parents, the ICT team, teachers, and school administrators. In other words, the radar graphs (Figures 11-13) explicitly show slight improvements in each of the variables related to dyscalculia that make up the profile of each student participant.

**Figure 11**
*Evolution related to Student*

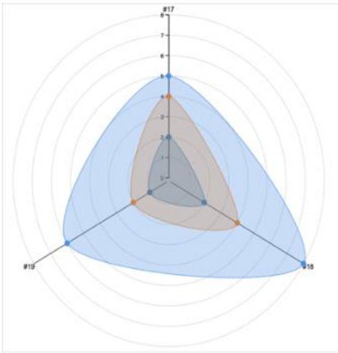


**Figure 12**
*Evolution related to Student 2*

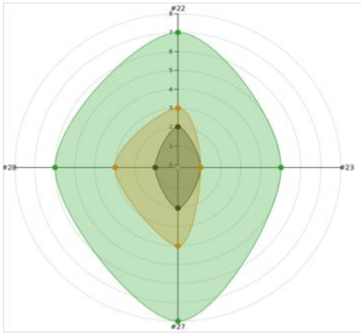
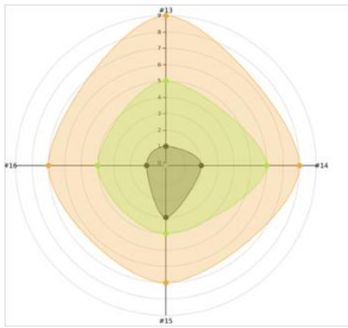


**Figure 13**
*Evolution related to Student 3*



In Figures 11–13, the dark blue regions represent Evaluation#1 of each student, and the light blue regions represent Evaluation#3 (Sprint#3), which is statistically better according to the Wilcoxon signed-rank test (Conover, 1999). Then, the students in this case study need to continue working with other educational applications recommended by teachers to reduce elementary math troubles.

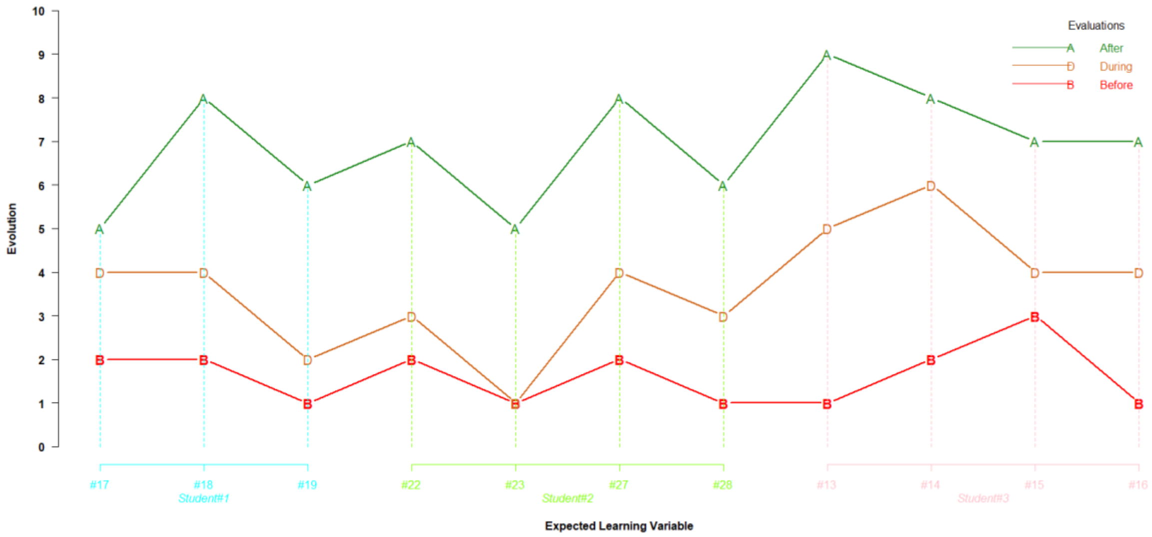
The Expected Learning variables of each student are different, so these variables are independent of each other. Figure 14 shows the evolution of the eleven Expected Learning variables in the three evaluations (Before, During and After). The student's performance in the second evaluation (During) is better than in the first evaluation (Before), except in Expected Learning #23. In the same case, the student's performance in the third evaluation (After) is better than in the second evaluation (During); for all Expected Learning variables. However, a Wilcoxon test was applied between consecutive evaluations to validate the results.

The Wilcoxon signed-rank test is a nonparametric statistical test that compares two paired groups. The test calculates the difference between sets of pairs and analyses these differences to establish whether they are statistically significant. Paired samples imply that each observation of one sample has a unique member in the other sample (Conover, 1999).

The advantage of the Wilcoxon signed-rank test is that it neither depends on the form of parent distribution nor its parameters. It does not require any assumption about the shape of the distribution.

Figure 14

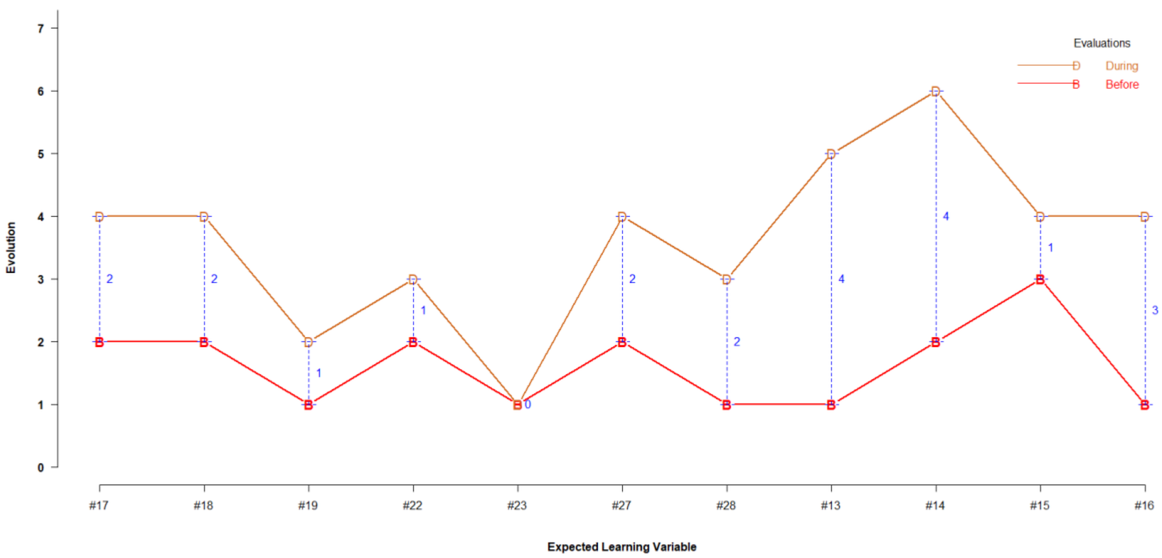
*Evolution Related to the Expected Learning Variables by Student.*




In the first instance, the initial profiles of the three students (See Table 7) related to basic math skills in Evaluation#1 (Before) were contrasted against the results obtained in Evaluation#2 (During). Figure#15 presents the difference between both evaluations for each Expected Learning variable. This paper compared a significance level of 0.05 against the p-value obtained in each statistical test. The hypothesis for the Wilcoxon signed-rank test for paired data is as follows:

Figure 15

*Evaluation#1 (Before) VS Evaluation#2 (During)*




$H_0$: *Online educational applications do not enhance learning (Before).*

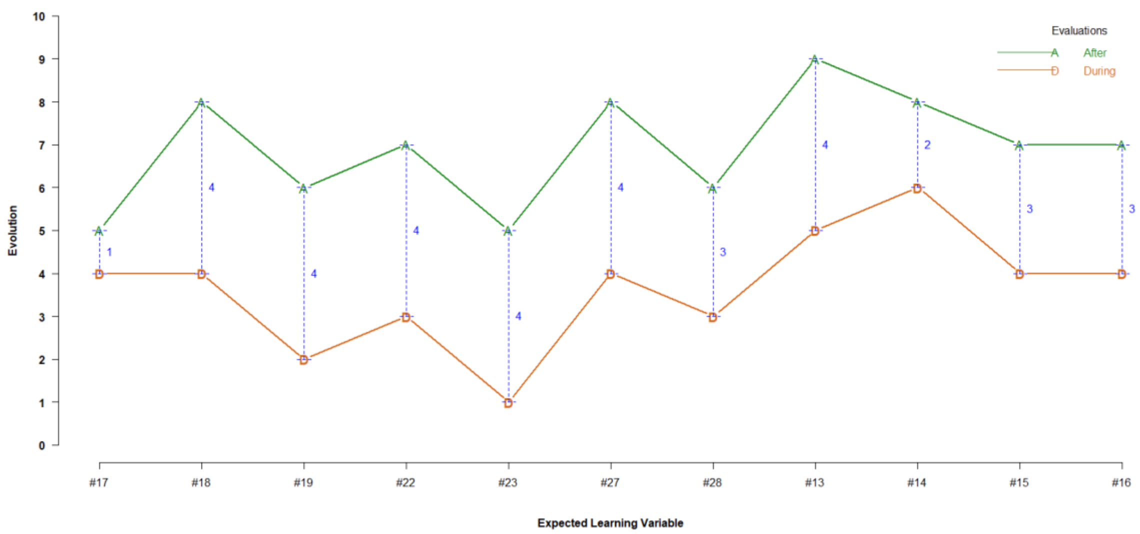
$H_a$: *Online educational applications enhance learning (During).*

The p-value for this test was 0.002724, so the null hypothesis ($H_0$) is rejected. Then, the set of proposed online educational applications improved the learning of the three students.

The results obtained in Evaluation#2 (During) were contrasted against the results obtained in Evaluation#3 (After). Figure 16 presents the difference between both evaluations for each Expected Learning variable. The hypothesis for the Wilcoxon signed-rank test for paired data is as follows:

**Figure 16**

*Evaluation#2 (During) VS Evaluation#3 (After)*




$H_0$: *Educational applications developed by the ICT Team do not enhance learning (During).*
$H_a$: *Educational applications developed by the ICT Team enhance learning (After).*

The p-value for this test was 0.001605, so the null hypothesis ($H_0$) is rejected. Therefore, the set of educational applications developed by the ICT Team enhanced the learning of the three students in all Expected Learning variables.

## 4. DISCUSSION AND CONCLUSIONS

The COVID-19 pandemic underscored the importance of technology integration in education. The literature review identified e-learning and agile learning advances and offered alternative approaches to improve education. However, 'inclusive education' poses challenges in quickly integrating technology, improving learning, and fostering continuous collaboration among various stakeholders (parents, teachers, administrators, and assessors). This research specifies a scrum-agile learning (AL) methodology by which inclusive education actors can agile and collaboratively improve their learning processes; it contributes to improving coordination, assessment, infrastructure, and timesaving for better student learning and motivation. In this research case, the focus was on students with dyscalculia in a Mexican elementary education institution.

Through this research, the Scrum-Agile Learning (AL) Methodology was applied to support e-learning in Inclusive Education, offering a comprehensive framework for promoting inclusive e-learning by adding the principles of Scrum (Cui et al., 2021; Leffingwell, 2010) with distance learning strategies. The advantages of the AL approach included a user-centred perspective, allowing diverse and synchronized techno-pedagogical strategies with parental involvement. The Scrum process model is pivotal in fostering collaboration and is essential for implementing effective learning strategies. Therefore, with Scrum at its core, this proposed Scrum-AL methodology aimed to develop personalized educational resources, representing a vital strategy in the COVID-19 pandemic, where traditional education shifted to remote delivery. The proposed methodology serves as a guide for ensuring continuity in face-to-face education, facilitating informed decision-making based on learning objectives, student characteristics, and the social context.

The proposed Scrum-AL methodology combines multidisciplinary and collaborative teamwork within each sprint, which allows for rapid solutions tailored to elementary education users' specific learning needs. It also facilitated agile integration of IT and collaboration among essential groups, such as parents, students, administrators, and programmers, who could participate in designing and testing applications aligned with the learning strategy. Virtual meeting platforms have proven instrumental in facilitating positive interactions between Scrum Team members and families. The Scrum-agile learning methodology facilitated functionality assessment through stakeholder engagement, identifying team strengths and weaknesses during Sprints and enabling essential user-centric adjustments. Then, practical interventions by the Product Owner, involving students and parents in cloud-based accessibility, were crucial.

However, this research has limitations, such as the focus on the students' dyscalculia disability, suggesting future research should encompass a broader range of learning disabilities. Besides, incorporating user experience design, such as virtual reality, could enhance learning solutions further and adapt to evolving educational needs. Overall, the proposed Scrum-AL methodology has displayed potential for agile development and inclusive learning solutions, marking a significant step towards agile and inclusive education in the digital age.

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## APPENDIX 1 Profiles of three students related to basic math skills.

| Students | Math skills | Expected learning (variable) | Eval. 1 |
|---|---|---|---|
| Student 1 | Time-spatial discrimination | 1. Recognizes forward-backward, up-down, in-out, near-far, and left-right | 5 |
| | | 2.Recognizes small-medium-big, many-few, etc. | 4 |
| | | 3. Recognises day, Recognises night, yesterday-today-tomorrow, days of the week, months of the year, clock | 3 |
| | | 4. Recognizes greater than, less than, equal to | 2 |
| | | 5. Recognition of the environment | 4 |
| | | 6. Recognizing where there is more, where there is less | 6 |
| | | 7. Recognition of the main parts of the body | 7 |
| | Graphical information processing | 8. Recognition of geometric figures | 4 |
| | | 9. Recognition of colors | 4 |
| | | 10. Recognition of shapes | 2 |
| | | 11. Grouping objects by color, size, or shape | 5 |
| | | 12. Distinguishing objects of the same semantic field, for example, mechanical tools | 4 |
| | Recognition of numbers and operators | 13. Number values, meaning, and representation of a number | 5 |
| | | 14. Recognition of digits | 3 |
| | | 15. Learning to count discrete objects | 5 |
| | | 16. Recognition of basic operators | 3 |
| | Ordering and serialization | 17. Comparing collections of objects | 2 |
| | | 18. Sort numbers based on size, shape, color, or weight | 2 |
| | | 19. Compare two numbers, which is larger, and which is smaller | 1 |
| | Verbal processing of numbers | 22. The correct pronunciation of numbers and arithmetic symbols. | 4 |
| | | 23. Dictation of numerical quantities and arithmetic symbols | 2 |
| | | 24. Reading and writing numerical quantities | 2 |
| | Number-symbol-text representation. | 25. Change numbers from symbol to text | 1 |
| | | 26. Change numbers from text to the symbol | 1 |
| | | 27. Represent numeric symbols in object quantities | 2 |
| | | 28. Represent object quantities in numeric symbols | 4 |
| Student 2 | Recognition of Numbers and Operators. | 13. Number values, meaning, and representation of a number | 2 |
| | | 14. Recognition of digits | 5 |
| | | 15. Learning to count discrete objects | 5 |
| | | 16. Recognition of basic operators | 3 |
| | | 17. Comparing collections of objects | 2 |

| | | | |
|---|---|---|---|
| | Ordering and serialization. | 18. Sort numbers based on size, shape, color, or weight | 5 |
| | | 19. Compare two numbers, which is larger, and which is smaller | 3 |
| | | 20. Counting in units, tens and hundreds, Distinguishing place value | 4 |
| | Verbal processing of numbers | 22. The correct pronunciation of numbers and arithmetic symbols | 2 |
| | | 23. Dictation of numerical quantities and arithmetic symbols | 1 |
| | | 27. Represent numeric symbols in object quantities | 2 |
| | | 28. Represent object quantities in numeric symbols | 1 |
| | Short and long-term memory | 29. Recall the functions of the basic operators | 6 |
| | | 30. Recall everyday operations such as 2+2, multiplication tables | 3 |
| | Arithmetic Problems | 32. Operations with addition and subtraction | 3 |
| | | 39. Solving time problems | 4 |
| **Student 3** | Time-Space Discrimination | 2. Recognizes small-medium-big, many-few, etc. | 3 |
| | | 4. Recognizes greater than, less than, equal to | 5 |
| | | 6. Recognizing where there is more, where there is less | 3 |
| | Graphical Information Processing | 7. Recognition of the main parts of the body | 4 |
| | | 8. Recognition of geometric figures | 3 |
| | | 9. Recognition of colors | 4 |
| | | 10. Recognition of shapes | 2 |
| | Verbal processing of numbers | 24. Reading and writing numerical quantities | 5 |
| | Recognition of numbers and operators | 13. Number values, meaning, and representation of a number | 1 |
| | | 14. Recognition of digits | 2 |
| | | 15. Learning to count discrete objects | 3 |
| | | 16. Recognition of basic operators | 1 |
| | Ordering and Seriation | 17. Comparing collections of objects | 3 |
| | | 18. Sort numbers based on size, shape, color, or weight | 5 |
| | | 19. Compare two numbers, which is larger, and which is smaller | 2 |
| | Short and long-term memory. | 30. Recall of everyday operations such as 2+2, multiplication tables | 3 |
| | Arithmetic Problems. | 32. Operations with additions, subtractions, and multiplications of 2 or more digits | 3 |
| | | 34. Operations with fractions | 1 |
| | | 39. Solving time problems | 1 |