Computer-Supported In-Person Assessment with Circular Dynamics and Collaborative Correction

Hylson Vescovi Netto
Instituto Federal Catarinense
Blumenau, Santa Catarina, Brazil
hylson.netto@ifc.edu.br

Ricardo de la Rocha Ladeira
Instituto Federal Catarinense
Blumenau, Santa Catarina, Brazil
ricardo.ladeira@ifc.edu.br

ABSTRACT
Assessment is a critical stage in the learning process and a key component of quality education. Traditional printed assessments are straightforward to administer but often create prolonged stress for students during their implementation. Computer-supported assessment solutions, while promising, are constrained by the limited availability of computers in labs, which are frequently insufficient to accommodate all students and do not effectively mitigate the issue of prolonged tension. This study introduces a novel assessment strategy called **circular dynamics**, where questions are alternated among students through a random selection process. Additionally, a correction method called **collaborative correction** anonymously groups and presents students' answers by question, enabling collaborative grading with students. This approach fosters greater fairness in scoring and provides immediate feedback. A free system prototype named **Serena** was developed in March 2020. Since 2021, it has shown positive results in applying these two strategies.

CCS Concepts
• **Information systems → Information systems applications**
• **Applied computing → Education**

Keywords
Computer-Supported Assessment; Circular Dynamics; Collaborative Correction.

1. INTRODUCTION
The assessment of knowledge taught in the classroom is a fundamental aspect of quality education. Assessments can be conducted either individually or in groups. Group assessments encourage and evaluate communication, teamwork, and the development of interpersonal skills. In contrast, individual assessments, even when incorporated into group work, serve as valuable pedagogical tools that foster learning in both theoretical and practical dimensions [1]. Individual assessments can take various forms, such as written tests, project development, or presentations. Through individual assessments, teachers evaluate what students have learned, provide feedback to clarify concepts, and suggest necessary adjustments to enhance skills, making the process a critical learning opportunity. However, teachers often encounter challenges when conducting individual assessments.

Difficulties in traditional assessment: the printed written test stands out as a common choice for individual assessment. However, when considering assessment as a unique opportunity for learning, there is ongoing exploration for alternatives that are more effective than the traditional written test [2, p.9]. As noted:

> "*The perplexity of teachers is clear, given that they are not offered a reasonable and culturally contextualized alternative to replace traditional tests in the assessment process.*"

While printed written assessments are straightforward and practical, they come with certain drawbacks. For instance, the reliance on printing equipment introduces a dependency that can cause disruptions if the equipment fails. While this issue can be mitigated by preparing and printing assessments well in advance, even this process demands additional time and effort, albeit relatively minor in many cases.

One challenge faced by students during lengthy printed assessments is the tension inherent in such situations. These extended, silent tests demand sustained concentration, with minimal opportunities for breaks, such as brief trips to the bathroom or stretching. As a result, students often remain in fixed positions for the duration of the test, sometimes neglecting to take a moment to breathe and reset. In the context of technical education courses, research indicates that students report stress during written assessments in 56.5% of cases, compared to 8.7% for oral assessments and 34.8% for the organization and management of studies [3].

Difficulties in correcting assessments: manual correction is an inevitable consequence of printed written assessments. Typically, this process involves correcting each test in its entirety. Alternatively, a "per question" approach can be adopted, where the examiner reviews all responses to a single question across all tests before moving on to the next question. This method requires reviewing the tests "n" times, where "n" is the total number of questions. Correction by question is often more efficient, as it helps maintain the "memory" of the answer while grading each question consecutively. Another factor that can influence the correction process is the teacher's awareness of which student provided the answer. Instead of focusing solely on the content of the response, the teacher might, consciously or unconsciously, consider additional aspects such as the student's participation in class, effort throughout the course, and other personal factors [4]. This can hinder an impartial and potentially fairer evaluation, as it may result in varying scores for similar answers. Additionally, in the context of grading criteria, it is common for the teacher who administered the test and taught the content to perform the correction. This is typically done individually and involves subjective judgment, particularly for open-ended or discursive questions.

One way to mitigate the influence of subjective judgment in grading is by using automated marking solutions for printed written tests and response cards. Tools like Gradepen[1] and other

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[1] http://gradepen.com/

systems that utilize answer cards enable automated correction of objective questions, making it a viable approach for such formats [5]. For discourse-based questions, automatic correction can be performed using similarity criteria, either by comparing students' answers to a predefined answer key or by comparing the answers among themselves [6, 7]. Indeed, the automatic grading of exams is a well-known advantage of electronic assessments [8]. However, most automatic grading tools do not incorporate student participation in the correction process. This exclusion deprives learners of a valuable opportunity to receive feedback and engage in a learning moment during the grading stage. Therefore, the need to explore innovative methods of assessment and correction becomes increasingly apparent.

Alternative: computer-supported assessment: computer-supported assessment emerges as a powerful alternative to traditional written tests, offering advantages that often surpass those of conventional methods [9]. The literature highlights several benefits of electronic testing, such as greater reliability, faster administration [10], rapid feedback [8, 9], and the reusability of questions [8]. Numerous computer-based learning systems, known as Learning Management Systems (LMS), support automated assessments. Moodle[2] and Google Classroom[3] are well-known platforms in this domain, with Moodle being particularly popular due to its status as free and open-source software [11]. These systems enable the simulation of written tests conducted directly on computers. Moreover, they offer features to mitigate cheating, such as generating unique versions of exams or shuffling question orders [9, 12]. However, while computer-based assessments address traditional challenges, they do not eliminate the physical strain associated with prolonged test-taking, which now shifts from paper-based to computer-based environments.

Another challenge in the context of computer-supported in-person assessments arises when the number of students exceeds the available computers in the laboratory. This scenario is common in schools in developing countries, such as Brazil, where maintaining computer labs with sufficient resources is often cost-prohibitive [13]. One straightforward solution is to divide the class into smaller groups, but this approach necessitates additional assessment sessions, increasing logistical complexity. Alternatively, conducting the assessment simultaneously in multiple laboratories requires additional personnel to supervise evaluations across different locations. These limitations highlight the need for innovative solutions and proposals to address the challenges of computer-supported assessments.

The next section of this paper presents the contributions of this paper. Next, it shows how these strategies are materialized in a computational system called Serena (Section 3). Results and discussions on the use of Serena are presented (Section 4) and finally conclusions and future work are presented (Section 7).

2. PROPOSAL

This paper introduces a computer-supported assessment approach that employs a rotation strategy among participants, designed to alternate the physical and mental efforts of students while optimizing the use of computer laboratories with fewer computers than the number of respondents. This innovative evaluation method is termed circular dynamics. A second contribution is a novel correction strategy called collaborative correction that enables teachers to evaluate responses with the assistance of an automated recommendation system and, more importantly, in collaboration with the students who participated in the assessment.

Circular Dynamics in Assessment: The proposed strategy for conducting assessments in environments with fewer computers than students rely on a rotation mechanism to evenly distribute the waiting time among all participants. This dynamic operates through a computer system that follows these steps: initially, the system displays a randomly selected student's name on the screen of each computer. The selected student must sit at the computer displaying their name to answer a question. All computers in the laboratory perform this operation simultaneously, ensuring that different names are displayed on each computer during the first round. The question presented to each student is randomly selected from a set of questions created by the teacher, which includes an answer key for each question. The total number of questions each student must answer, as well as the total pool of available questions, is configured in the system. Students not selected in the initial round remain seated in the room, waiting their turn.

The laboratories implementing this practice are arranged in a U-shaped layout, allowing the waiting area to be organized in a circular formation at the center of the room (Figure 1). This layout facilitates student mobility during the assessment and allows the teacher to maintain direct visibility of all computer screens. Consequently, this reduces the need for secure browsing solutions like LockDown Browser or Safe Exam Browser [14].

Figure 1: Students answering questions in a laboratory that has a "U" shaped layout .

When a student finishes answering and submits their response, the system selects another student and displays their name on a computer screen. The student who just completed their response then approaches the newly selected student and directs them to the assigned computer. Afterward, the first student joins the group waiting in the center of the laboratory until their name is drawn again. This process repeats until all students have answered all questions. Occasionally, a student's name may be displayed on multiple computers, or the name of a student currently answering a question might appear on another computer. In such cases, the system simply needs to perform a new draw to resolve the conflict.

Collaborative Correction: This stage involves projecting all the answers provided by the students using a datashow. The answers are grouped by question and anonymized to avoid identifying the respondents. The teacher then assigns scores by analyzing each answer, explaining the rationale behind each assigned grade. During this process, students are encouraged to participate by collectively analyzing the answers, identifying

[2] https://moodle.org/

[3] https://classroom.google.com/

strengths and weaknesses, and proposing adjustments to the grades.

To assist the teacher, for discursive questions, the system automatically suggests a grade by comparing the teacher's answer key with the student's response. Suggested grades range between zero and one, with values closer to one indicating a higher similarity to the answer key. For objective questions, the system assigns a grade of "1" if the student's answer matches the correct alternative. The grade field is editable, allowing the teacher to adjust the scores based on discussions with students during the correction process.

During the collective correction process, the discussions between the teacher and students about each answer serve as a valuable form of feedback. These discussions arise from the need to evaluate responses that, while differing from the answer key, may still be correct, as well as those that might be partially acceptable, among other possibilities. Students actively engage in analyzing all responses, fostering a collaborative learning environment. Once all answers have been reviewed and corrected, the final grade for each respondent can be determined. This grade may then be communicated to each student individually and privately to maintain confidentiality.

3. THE SERENA SYSTEM

The circular dynamics of assessment and collective correction were implemented in a web system called Serena. The system design follows the object-oriented paradigm, with its primary classes including `Circle`, `Question`, `Respondent`, and `Answer`. The `Circle` class represents the presentation of a set of questions to a group of respondents, executed according to the circular dynamic. For each circle, a predefined set of questions is associated through an attribute named `questions` (Figure 2). These questions are then randomly assigned to respondents during the assessment process.

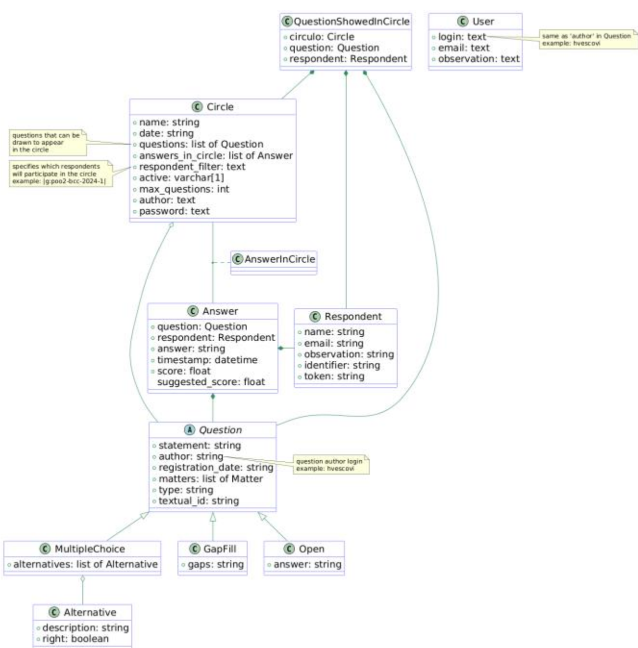

Figure 2: Class Diagram.

Other classes define the nature of a question, which can be multiple-choice (with alternatives), open-ended, or gap-fill. Each question presented to a student during a circle's execution is recorded through the `QuestionShowedOnCircle` class. Similarly, each response is linked to the circle via the `AnswerInCircle` class. This structure allows the system to detect when a question has been viewed but not answered, thereby identifying cases of "skipped questions".

During the execution of circular dynamics, Serena prominently displays the student's name in large letters to facilitate identification and ensure that the student answering the question matches the name shown on the screen (Figure 3). The system does not handle authentication, relying instead on the teacher's visual confirmation of the student's identity as they circulate through the laboratory during the assessment. Below the student's name, the system displays the total number of questions the student has already answered. To begin answering a question, the student must click a blue button to confirm that the name shown on the screen is their own. This confirmation step ensures that the question is only viewed after the student acknowledges their identity, even though this process is simple and not independently verifiable. Additionally, the upper-right corner of the screen displays information about the circle currently in progress.

When the student confirms their identity, the question is displayed on the screen (Figure 4). Once a question appears, the system records this event. If the student chooses not to answer the question and skips it, the teacher may impose a penalty. The system includes a query feature that allows teachers to see how many questions each student has viewed but not answered. For open-ended questions, the student types their response into a text box and clicks the blue "Send Answer" button to submit it.

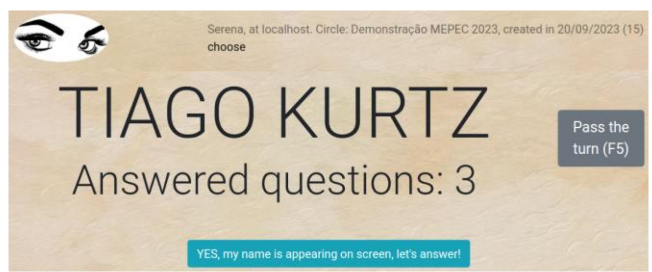

Figure 3: Draw for a student to answer a question on the computer (Fake student name used for testing).

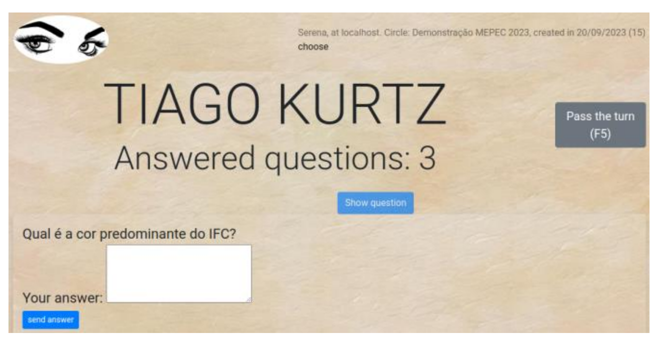

Figure 4: Question presented to the student (Fake student name used for testing).

Collective correction is carried out by displaying each question along with the answers provided by the students (Figure 5). After reviewing each question, the teacher's answer is shown first, followed by the students' responses. A suggested score is displayed next to the correction button, while the teacher can assign a final score by entering it into the corresponding text box for each answer.

The Serena web system was designed to operate on the teacher's computer, while remaining accessible to other computers within a computer laboratory. This architecture ensures that sensitive data, such as grades and answers, is stored locally with the teacher, avoiding potential risks associated with cloud storage and requiring less stringent security measures for online data management. Students access Serena via computers on a local network, eliminating the need for an Internet connection, as all resources required for the system operation are hosted on the teacher's computer. The system was developed using open technologies. The back-end module is written in Python, utilizing the Flask[4] library. Data persistence is handled by an SQLite[5] database, with SQLAlchemy[6] used for object-relational mapping between the database and the system's classes. On the front-end, the system employs HTML, CSS, the Bootstrap[7] library for styling, and JavaScript with the JQuery[8] library. Serena's source code is open and can be found in a public repository[9].

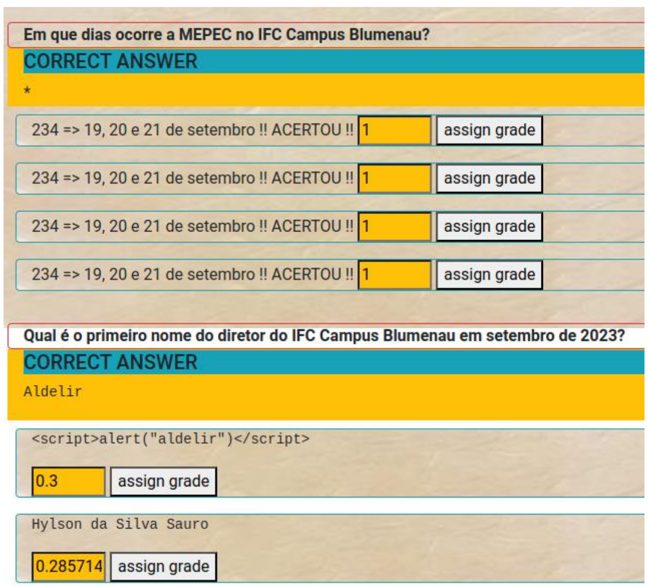

Figure 5: Questions of correction with students using datashow: anonymous answers with suggested scores per question.

[4] https://flask.palletsprojects.com/en/3.0.x/

[5] https://www.sqlite.org/

[6] https://www.sqlalchemy.org/

[7] https://getbootstrap.com/

[8] https://jquery.com/

[9] Available at https://github.com/hvescovi/serena

4. RESULTS AND DISCUSSIONS

Serena was developed in March 2020 during the first month of the COVID-19 pandemic. Its initial practical use occurred in the last quarter of 2021, coinciding with the gradual return of face-to-face classes. Since then, it has been utilized in secondary and higher education classes through 2022, 2023, 2024, and 2025, particularly for assessments in IT-related subjects. Serena has proven effective for conducting conceptual assessments using circular dynamics and facilitating collective correction.

During the circular dynamics, the use of printed reference materials prepared in advance by the students was occasionally permitted. While implementing the assessment, students do not always sit neatly in a circle to await their turn; some may even call out loudly to summon the next participant instead of doing so discreetly. To address this, the teacher can establish clear expectations with the students about acceptable noise levels during the waiting period. It is crucial for the teacher or organizer to emphasize that this is a formal assessment, governed by specific rules. One such rule could be maintaining silence.

Another challenge during the waiting period is that students may observe the questions being answered by others. However, these behaviors can typically be managed by the teacher as the assessment progresses. Finally, as students complete their questions, a situation may arise where a student's name appears multiple times on different computers. This occurs when there are fewer remaining respondents than available computers.

The collective correction stage is typically conducted immediately after the assessment. Performing the correction promptly allows students to take advantage of their natural curiosity about the correctness of their answers, while the content remains fresh in their memory. Research indicates that most students prefer to receive assessment results immediately after completing tests [15].

Using a data projector to display the answers facilitates the correction process, as students can identify their own responses among those provided. Anonymizing the responses is essential to ensure that answers are judged objectively, free from any biases related to the identity of the respondent. According to the literature, anonymization is a feature that computer-supported systems can provide, leading to more reliable results and fostering consistent evaluation practices [11].

It was observed that students actively participate in the point attribution stage. In some cases, students present valid arguments that justify increasing the score initially assigned by the teacher. Conversely, there are instances where students themselves suggest assigning a lower grade instead of an automatic initial score. The literature highlights examples of computer-based written assessments where platforms like the Moodle virtual learning environment enabled faster feedback delivery [11]. This aligns with findings that automation in online assessments facilitates feedback, a feature highly valued by students [15].

For objective questions, the assigned grade generally matches the suggested grade, except in cases where errors are identified in the question, leading to its cancellation. In such situations, the teacher can assign a default value of "1" to all answers. At the end of the correction process, the projector is turned off, and students who wish to know their grades can check them directly with the teacher. The teacher accesses a Serena page designed to display the total scores of students who participated in a specific circle, calculated as the sum of the scores assigned to their answers.

The use of Serena has revealed that students who are proficient in the practical aspects of the content sometimes perform poorly in conceptual assessments. Additionally, the effectiveness of circular dynamics is enhanced when questions are designed to be solved quickly, as this facilitates smoother rotation and movement among participants. Conversely, allowing students to use reference materials tends to increase the time they spend at the computer.

5. LESSONS LEARNED

Serena was used between September 2021 and October 2025 across more than 30 circles and over 300 questions, receiving more than 4,200 answers from more than 300 students. In this section, we discuss experiences and insights gained during this period.

5.1 Cheating during the assessment phase

Once the circle of questions begins, some students waiting for their turn attempt to look at the computer screens to see the questions being displayed. While the waiting period is intended to be a time for students to relax, some engage in conversations or move around the room. Chairs are provided for students to sit, but they are positioned in an outward-facing circle to facilitate mobility during the exam. However, this arrangement often allows students to glance at the computer screens. A possible solution could be to reposition the chairs in an inward-facing circle at the center of the room to reduce the temptation to view the screens.

Another specific behavior observed is "salting" questions. Sometimes, students skip questions in the hope of receiving easier ones in subsequent raffles. Serena provides a report that, during the exam, shows how many questions each student has answered. This report can be displayed using a data projector during the assessment.

When questions are salted, the total number of questions presented may exceed the expected number for the exam. In such cases, the teacher can use the report to identify how many questions were skipped. It is possible to establish an agreement with students, allowing a limited number of skips. However, if a student exceeds the agreed limit, a penalty should be applied. As noted in the literature, "If the cheaters do not receive adequate penalties, then it will be an incentive for the next to risk and also try fraud" [12].

5.2 Students' engagement at the correction phase

During the correction phase, all answers are displayed on the screen, which is projected onto the wall using a projector. The answers are presented anonymously, without revealing the identity of the student, so that each response can be evaluated impartially. Students enjoy assigning grades to the answers. At times, they suggest that a grade should be higher or lower than the one initially proposed, or even different from the grade suggested by the teacher. In addition to proposing new grades, students often provide arguments to support their suggestions, which sometimes leads to class discussions about the content being assessed.

During the grade assignment phase, students are exposed to all the questions answered during the circle. Although the questions are presented in a random order to each student, it is a good practice to create a larger question bank than the number of questions the student is required to answer. For example, consider a scenario where there are 16 questions in the circle, and each of the 30 students answers 10 questions. There is a high probability that each question will be answered by at least one student. This ensures that during the correction phase, all students are presented with all 16 questions, reinforcing their learning through the questions they answered.

Students also pay attention to the remaining 6 questions because they know these could be presented to them, as the question selection process is random. Furthermore, the larger the question bank, the more motivated students are to study all the content, rather than just focusing on review exercises. This is because they are aware that any question in the bank might appear on the exam [12]. However, creating a rich question bank requires more effort, which supports the hypothesis that electronic exams often increase preparation time while reducing grading effort [8].

Sometimes, during the correction phase, incorrect questions are identified. In these cases, students collaborate with the teacher to identify and implement fixes for the question. When a question is found to be incorrect, points may be awarded to all students who answered it, as a reward for their participation in the question analysis. In fact, the first use of a question in a circle serves as a "question quality verification", allowing any issues to be detected and addressed.

5.3 Fault tolerance issues

When executing electronic exams, various issues can arise, such as network failures, internet instability, power outages, and other technical problems. It can be frustrating for the teacher to put in the effort to create a digital exam only for it to be unusable due to these obstacles. From its inception, Serena has been designed to incorporate fault tolerance. Over time, additional improvements have been made as the system was used in real-world scenarios. For example, during one circle, the internet connection failed, and some scripts (such as Bootstrap) could not be loaded. To address this, we downloaded the Bootstrap libraries and switched the links to local files, making Serena independent of an active internet connection.

On another occasion, there was no network available on the computers, preventing the circle from being executed in the traditional way. As a solution, we connected a mobile phone with a 3G signal, shared this connection with the teacher's laptop, and provided the students' mobile phones with access to the network. This enabled the students to take the exam on their mobile devices, as the Serena interface is responsive. Previous studies have highlighted the use of mobile devices for formative evaluation [8]. While the circle dynamics may not be as effective when mobile phones are used instead of computers, the other features of the system still function properly.

5.4 Needing of a non-random mode

As students finish their assessments, more computers become available for the remaining students, and the names of students begin to repeat on multiple computers. The system includes a queue of selected names to prevent the same student from being chosen again in the next raffle. However, as more students complete their tests, name repetition across computers becomes more frequent. This also occurs in scenarios where there are more computers than students.

To address this scenario, we implemented a non-random mode, which can be enabled for a circle at any time. When this mode is activated, after a student answers the first question, they can select their name from a list, and subsequent raffles will choose their name automatically. This functionality is implemented using a simple cookie, which is checked before each raffle. If the cookie indicates that a student's name has already been selected, that name is always chosen. The cookie is only valid for the duration of the browser session, so closing the browser and reopening it will eliminate the cookie.

6. FUTURE WORK

After conducting numerous tests with students, several features have emerged that suggest directions for Serena's growth. Additionally, the literature offers recommendations for improving the quality of assessments.

Mitigate cheating: Serena already shuffles the alternatives in multiple-choice questions, displays one question at a time, and selects random questions from a question bank. However, sometimes students spend a long time on a computer, hoping that a nearby computer will display the same question. This issue could be mitigated by adding a feature that considers the IP addresses of computers, ensuring that the same question does not appear on computers with sequential IP numbers. This solution requires that computers in the laboratory have sequential IP addresses assigned.

Additionally, implementing a timer to limit response time could encourage students to make decisions within an appropriate time frame. Other recommendations include restricting the IP addresses from which the tests can be accessed and using a specific browser that prevents navigation outside the exam environment [12, 14].

As with any individual assessment, instructors must remain vigilant to potential communication between students. This includes scenarios such as verbally sharing answers with a student taking the test on a computer, leaving responses in text documents, or even writing answers in unexpected locations, such as the browser's address bar. Requiring the use of a full-screen browser mode and prohibiting any changes to this view can help minimize such risks. Clear rules should be communicated to students before the evaluation begins to emphasize the importance of academic integrity.

Turning the prototype into a product: teachers from areas such as History or Biology could benefit from using circles as quizzes in their subjects. However, at its current development stage, the system is not easily executable on the teacher's laptop. Despite the fault-tolerant features provided by local server execution, it would be more practical for the system to be hosted on a web server within a local area network. This would relieve the teacher from the technical task of installing and managing the system on their device.

Several concerns must be addressed when making Serena available on a local network system. First, Serena was not originally designed to support multiple tests running simultaneously. To accommodate this, the system's classes need to be enhanced with a User entity. Additionally, since neither the students nor the teacher log into the system due to the circular dynamic, the teacher should be able to set a password to select which circle to start, along with other available tests. This approach is similar to requiring a password to grant access to the tests for students [12].

The teacher should also have the option to export all data locally. It is common for teachers to enter data into tools like Google Sheets or Excel and later transfer the grades into an academic system. This ability to interchange data is crucial to prevent locking the questions, answers, students, and other data within the system. When possible, automatic transfer to the academic system would be a valuable feature [14], though this depends heavily on the characteristics of the academic system.

Additionally, as a product, Serena needs to migrate to a more modern front-end platform. JQuery is becoming less relevant because modern browsers have incorporated many features that were once provided by this library. There are other powerful JavaScript frameworks, such as Vue, React, and Angular, that are better suited for building a scalable front-end.

Questions improvement: New types of questions should also be added as a feature to increase the variety of questions, allowing the same content to be explored in different ways [16]. In this context, another important property of questions should be their level of difficulty. It would be useful for the teacher to specify the distribution of question difficulty in the exam, such as, for example, 3 easy questions, 4 medium-level questions, and 3 hard questions. Additionally, the subject of the question is another relevant property, as it allows the teacher to filter and select questions for an exam based on specific topics.

7. CONCLUSIONS

This article introduced an assessment strategy called circular dynamics, which involves rotating people in computer labs where there are more individuals than computers. Additionally, a correction strategy called collaborative correction was presented. This strategy allows the teacher to project all the answers, grouped by question, using a projector, without identifying the respondents, and with automatically suggested grades.

A prototype called Serena was implemented to facilitate the execution of these two strategies. Students reported a positive experience with Serena, and they expressed a sense of well-being at the end of both the assessment and correction processes.

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