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Exploring Students' Perceptions of Learning through Active Methodologies and Digital Technologies[1]

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ABSTRACT

The aim of this article is to present the potentialities of integrating Flipped Classroom (FC) and Just-in-Time Teaching (JiTT) active methodologies, with a focus on the use of Digital Technologies (DT), from the perspective of students' perceptions. The methodological integration was applied in chemistry education for first-year high school students at a private school in Curitiba, Brazil. The research adopted a quantitative approach and participatory research procedure, using observation and a questionnaire as data collection instruments, with the latter analyzed using SPSS (Statistical Package for the Social Sciences) software. Results indicate that all questionnaire statements received above-average agreement from participants, particularly regarding changes in the learning process, interaction with content and peers, and increased motivation through the use of DT.

KEYWORDS: Active Methodologies. Digital Technologies. Chemistry Education.

1 INTRODUCTION

Digital Technologies (DT), according to Kenski (2018), have generated transformations in society that directly impact studies on the learning process in the school context. The ease of access to information and the possibilities for new forms of interaction and communication through these technologies have led to new ways of learning in various contexts. These DTs can be effectively utilized in the school context through Active Methodologies (AM), as they aim to make students active participants in their learning process, fostering autonomy, responsibility, and dedication for their development.

According to Moran (2016), AMs are starting points for advancing more mature processes of reflection, cognitive integration, and the re-elaboration of new pedagogical practices. Therefore, AMs facilitate the construction of a critical and reflective teaching environment, where the focus is on the student, and the teacher acts as a mediator of knowledge. This helps students develop skills such as teamwork, critical thinking, and problem-solving. Recently, the use of AMs has grown considerably, offering a wide range of possibilities for classroom use. However, the success of implementing these methodologies depends on careful and coherent planning by the teacher, considering the educational needs of the class, the content to be taught, and the students' experiences. After all, AMs aim to intensify cooperative learning, allowing students to learn together and build knowledge collaboratively (FÉLIX; LIMA, 2021).

In this field, Ferrarini, Saheb and Torres (2019) state that there are various possibilities for applying AMs, including Peer Instruction (PI), Flipped Classroom (FC), Just-in-Time Teaching (JiTT), Design Thinking, Project-Based Learning (PBL), Gamification, Case Study, and Inquiry-Based Learning. Each methodology seeks to maximize student learning in different ways, highlighting their strengths and weaknesses. Combining two or more AMs can reduce weaknesses and enhance the strengths of each methodology compared to when they are applied separately. For example, in the FC approach, the teacher identifies students' doubts only during the in-person class, which can compromise the time allocated for conceptual review and doubt clarification. By complementing FC with JiTT, the teacher can identify students' difficulties before the in-person class, making the lesson planning more personalized for the class. JiTT, in turn, can be complemented by PI, as the teacher can apply new problems during class to better recognize conceptual improvements through PI's references for control and diagnosis.

Therefore, integrating AMs maximizes class time, student learning, teacher diagnosis, review sessions, and interaction moments. From this perspective, this article aims to present reflective elements based on students' perceptions of a pedagogical intervention that integrates the AMs of Flipped Classroom and Just-in-Time Teaching, aiming to incorporate Digital Technologies (DT) into chemistry teaching.

2 THEORETICAL CONTRIBUTIONS

Active Methodologies (AM) are teaching methods that emphasize practice, reality, and contextualization, especially in the classroom, making the student the author of their cognitive development (BERBEL, 2011). According to Valente (2018), AMs are pedagogical alternatives that place the focus of teaching and learning processes on the learner, involving them in discovery, investigation, or problem-solving learning. Similarly, Moran (2016) mentions that AMs are guidelines that promote effective teaching and learning processes through concrete, specific, and differentiated strategies, approaches, and techniques.

Supporting this, Oliveira and collaborators (2012) assert that AMs replace traditional methods by positioning the student as the main instrument in the educational process. The goal is to make the student the protagonist of their own learning process, as AMs promote learning through real-world problems and situations that students will later encounter in their professional lives (MORÁN, 2015).

Active Methodologies can be implemented through Problem-Based Learning (PBL), Project-Oriented Learning (POL), Peer Instruction (PI), Team-Based Learning (TBL), Just-in-Time Teaching (JiTT), and Flipped Classroom (FC) (OlIVEIRA *et al*., 2012).

The first AM of interest in this research is the FC, created by American teachers Aaron Sams and Jonathan Bergmann at a rural school in Colorado (USA). The other AM explored in this research is JiTT, developed by Professor Novak at Indiana University (USA).

2.1 Methodological Integration between Active Methodologies ACI and JiTT

Flipping the classroom essentially involves performing at home what is traditionally done in class. Schneiders (2018) mentions that activities related to concept transmission are done at home using digital resources. In the classroom, activities are focused on knowledge assimilation, such as solving problems and group work. This allows the teacher to consolidate concepts, content, and knowledge, as well as guide and support students by clarifying doubts to promote learning.

Knuth (2016) states that FC occurs in three main stages: i) The first stage involves home study, described as self-study. Technologies can be used through internet-enabled devices, social networks, or learning platforms; ii) The second stage involves group work in the classroom, where students exchange information (usually in small groups or pairs); iii) The third stage involves the socialization of learning, presentation in a discussion circle, sharing ideas, and making critiques and self-critiques.

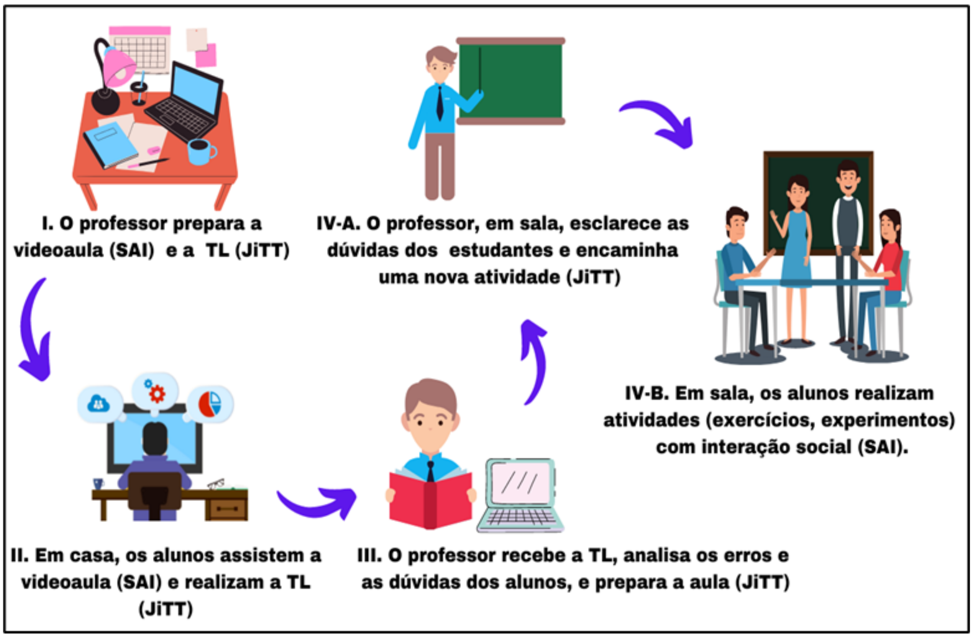
Similarly, Just-in-Time Teaching (JiTT), originally developed by Professor Gregory M. Novak in 1996 at Indiana University Purdue University Indianapolis (IUPUI) and the United States Air Force Academy to help physics students and teachers, proposes that students conduct preliminary studies at home. For this purpose, the teacher prepares reading materials or suggests research on the content, and students answer questions related to the Reading Assignment (RA) concerning the concepts that will be discussed in class. The reading activities aim to familiarize students with the subject matter, encouraging autonomous knowledge-seeking and making them responsible for their own learning process, while enabling the teacher to facilitate meaningful student learning (NOVAK; MIDDENDORF, 2004).

According to Pastorio and collaborators (2020), JiTT can be divided into three stages:

i) Reading Assignments (RA): In this stage, the teacher asks students to study a material, which could be a video, article, or similar, and then solve conceptual questions about the topic. Responses must be submitted to the teacher in advance; ii) Analysis of RAs by the teacher: Upon receiving the responses, the teacher analyzes the students' main difficulties and prepares lessons with strategies to address these specific challenges; iii) Lesson Development: The teacher can present the concepts to be covered, focusing on those where students showed the most difficulties. Student responses can be used to direct discussions among them.

The two active methodologies presented, FC and JiTT, with their particularities and specificities, aim to make teaching practices more dynamic and student-focused, making them active in the learning process. When FC is applied alone, the teacher accesses students' doubts and difficulties only during the in-person class. Thus, a significant part of the class is spent rectifying misunderstood concepts. However, if the teacher also assigns a task that applies these concepts, which should be completed before the next class, students' difficulties can be recognized in advance, allowing for more targeted in-person instruction. By doing this, the teacher integrates FC and JiTT methodologies for better class performance, improved student learning, and increased intervention opportunities, as illustrated in Figure 1.

Figure 1: Scheme for Implementing the Integration between Flipped Classroom (FC) and Just-in-Time Teaching (JiTT) Methodologies



Source: The authors, 2022.

In this special case, the integration between the FC and JiTT methodologies presents a significant opportunity, as students have two specific moments at home: studying the concept (proposed by FC) and applying their understanding of that concept (proposed by JiTT) through the Reading Assignments (RA). In this format, the individual learning process occurs at home. The teacher, through the students' RA responses submitted before the class, can identify gaps in the students' understanding of the studied concept, allowing them to plan and prepare the lesson with a focus on these gaps.

Thus, the teacher plans their lesson emphasizing the students' presented doubts, enabling specific and precise intervention in the classroom. With optimized classroom time, students have more opportunities for interaction and concept application, now clarified and redefined by the teacher. Classroom activities can be dynamic and problem-based, requiring teamwork, motor skills (in laboratory activities), and other actions that transpose concepts to other contexts. Therefore, integrating these two methodologies is possible and necessary. By assigning the stages of presentation, conceptualization, and application of concepts as homework, the teacher and students can use classroom time for analysis, conclusion, and evaluation of the studied content, with different dynamics of interaction and construction.

2.2 Digital Technologies and Active Methodologies

According to Gewehr (2016), the concept of Information and Communication Technology (ICT) is used to express the convergence between computing and telecommunications, encompassing computational tools and telecommunication media such as radio, television, video, and the internet, which facilitate the dissemination of information. With technological advancement and development, another term emerges, Digital Information and Communication Technologies (DICT), which, according to Kenski (2012), refers to electronic devices that operate using binary code language, allowing for information, communication, interaction, and learning. In this context, these technologies can be summarized as DT.

This phenomenon is exemplified by the emergence of platforms like YouTube, Rumble, Twitch, Facebook, Instagram, Twitter, Spotify, Wikipedia, and video streaming services such as Netflix, Amazon Prime, and Disney+, as well as interaction apps like WhatsApp, Telegram, and ClubHouse. According to Bedin, Locatelli and Bedin (2016, p. 268), technologies "expand knowledge and proliferate understanding, linking technological practice with continuous teacher education." They further assert that this process aims to develop "competencies and skills in various languages, information, and communications, as well as the different representations used in various technologies to enhance teaching and learning processes".

The recognition of the importance of using DT in schools is embedded in the new National Common Curricular Base (BNCC), which states that a general competency of basic education is for students to engage with, interact with, and produce knowledge aligned with DT. Students should understand, use, and create digital technologies of information and communication critically, meaningfully, reflectively, and ethically in various social practices (including school) to communicate, access, and disseminate information, produce knowledge, solve problems, and exercise protagonism and authorship in personal and collective life (BRASIL, 2017). Thus, the school, responsible for students' ethical, scientific, and technological education, according to Bedin (2017a), cannot disconnect from reality and related technologies, as they facilitate closer interaction and collaborative learning among individuals (BEDIN, 2017b).

As technological evolution progresses, schools must incorporate new languages and their operational modes, unveiling communication possibilities for more conscious participation in the so-called digital culture (BRASIL, 2017). Therefore, leveraging DT should be a priority for schools, given that students have become media-savvy, frequently consuming them. DT is an essential tool in the educational process, bringing students closer to reality and the world of science, as they "provide a new perspective on thinking and learning through technological pedagogical practices" (KURZ; BEDIN, 2019, p. 215).

Digital technological resources are tools that can contribute to social, economic, cultural, and intellectual promotion, as they can innovate and positively impact the learning process (STINGHEN, 2016), with digital applications serving as conduits for proposed activities. For instance, in activities where a teacher needs to assess the class's conceptual understanding, apps like Google Forms can provide more precise statistical results. Kahoot, on the other hand, can generate greater interaction when students apply their concepts due to its dynamic nature.

According to Silva and Ferreira (2014), technology can enable the school to be fully integrated into the student's life, in different environments or learning spaces. The teaching applied to students at school is insufficient to change social coexistence. The student needs to develop more skills than the time at school allows, such as scientific knowledge, socialization, responsibility, leadership, among others. In this aspect, Moran (2016) points out that DT bring enormous challenges because they decentralize the knowledge management processes, as the learning space proliferates, and the student decides the best time and place for study.

The ways of teaching and learning change, placing the teacher as a mediator, as an organizer of more open and collaborative processes through the evolutionary use of DT; a "central and important character in disseminating and connecting scientific knowledge to substantial elements of the student's context" (BEDIN; DEL PINO, 2019, p. 54). Rodrigues, Oliveira and Scherer (2021) consider the evolutionary idea of DT in two aspects: progress and development. In the aspect of progress, it is understood as a continuous and progressive process of technique improvement, which changes the state and condition of the technologies' use by the teacher. This process aims to promote improvements in various areas, including education, where technological evolution has been associated with transformations in school curricula to keep up with human evolution itself. In the aspect of development, the idea is that DT used in education are constantly improved, providing new opportunities and challenges for teachers and students. Thus, changes in school curricula become necessary to adapt to these transformations and ensure that students acquire the skills and knowledge needed to operate in an increasingly technological world.

From this context, the importance of DT in the school environment and the advantages that using these resources can generate in teaching methodologies are evident. AM, which focus on making the student the protagonist of their knowledge, can use DT as a great complement for their applications in the classroom. It is necessary to recognize that AM are not DT, nor are they exclusively dependent on them, as, for example, PBL and EC already existed before DT.

However, it is noticeable that there are trends of association between DT and AM, and these can be enhanced by using DT (FERRARINI; SAHEB; TORRES, 2019).

However, as already mentioned, simply using DT does not allow them to be conceptualized as AM. Watching video lessons and answering objective questions, even digitally, are typical activities of traditional methodologies, that is, those still centered on the teacher's figure and the transmission of knowledge. School activities, when using DT, should prioritize autonomy, conceptual development, interaction between student/student and student/teacher, and applications such as Kahoot, Plickers, Jumble, and Phet can generate more student engagement with the content, instigating more interaction between them, fostering student formation, and placing them as protagonists of the process, where DT would be assisting and complementing the AM employed by the teacher. The Kahoot application used in this research consists of an interactive technological tool that incorporates elements used in game design to engage users in learning (Silva *et al*., 2018).

2.3 Just-in-Time Flipped Classroom and the Solutions Content

The content of Solutions, within the structure of the National Common Curricular Base, is traditionally addressed in chemistry education, both in regular and technical educational institutions, during the second year of high school. Although the new high school curriculum does not explicitly mention "solutions" as an isolated content area, its relevance extends to various contexts, such as the study of water (rivers, seas, treatment, and sanitation), medications (many of which are aqueous formulations), and a wide range of homogeneous mixtures present in our daily lives.

This content is of utmost importance to students, not only from a cognitive and mathematical perspective but also for its contextualized applicability. It is noticeable that many common products are identified and understood through concepts related to concentration, including medications, mineral water, alcoholic beverages, vinegars, soft drinks, disinfectant products, and analyses of contaminants in aquatic, terrestrial, and atmospheric ecosystems, among others.

Therefore, the need to address potential difficulties in performing mathematical calculations related to the content of solutions becomes evident. For this purpose, adopting active methodologies such as Flipped Classroom (FC) and Just-in-Time Teaching (JiTT) is advantageous. These approaches not only provide more time for problematizing and contextualizing the topic but also foster a more dynamic interaction among students and between students and the teacher.

3 METHODOLOGY

The research was conducted in a private high school in Curitiba, located in the Santa Felicidade neighborhood. A first-year high school class, consisting of 21 students, was selected; it was the only class in 2021 with students in the 100% in-person modality (due to the COVID-19 pandemic), in the subject of Chemistry, focusing on aqueous solutions.

To conduct the research, the researcher traveled to the location where the methodological integration of FC and JiTT was applied to explain the objectives and importance of its development. The research was approved by the Human Research Ethics Committee of the Federal University of Paraná, under the number CAAE 46356421.5.0000.0102. After approval, the Consent Letter was presented to the responsible director of the institution, the Informed Consent Form to the parents, as well as the Assent Form to the students of the selected class, authorizing the development of the study.

3.1 Application of Methodological Integration

The researcher's perceptions during the execution of the activity occurred through observation, which allowed an understanding of the dynamics of merging methodologies in a teaching process that lasted for four weeks, with three in-person classes per week. The activity lasted for 4 weeks, totaling 13 in-person classes. Seventy-two hours before each in-person class, students had access to a video lesson (available on YouTube) and a Reading Assignment (RA). In the video chat, students could ask questions about the video lesson topic and then answer a questionnaire on the material studied. The summaries of the classes are presented in Table 1.

Table 1: Summary of the Application of Methodological Integration

CLASSROOM	IN-CLASS ACTIVITY	HOME ACTIVITY
01	Teacher explained the research project and the methodologies used, handing out the informed consent forms to students.	Watch video lesson 01, interact in the chat, and answer the questionnaire (Forms) on the topic.
02	Class planned based on students' questions from video lesson 01, with review of concepts and information recording; new activities were proposed.	Read the Reading Assignment (RA) on the practical lesson to be conducted in class 03 and record questions in Forms.
03	After reviewing the practical lesson plan, the class was held in the laboratory, applying the topic: Preparation of aqueous solutions.	Watch video lesson 02, interact in the chat, and answer the questionnaire (Forms) on the topic.
04	Class planned based on students' questions from video lesson 02, with review of concepts and information recording.	
05	Exercise resolution from the didactic material, related to video lesson 02, in pairs, with teacher mediation.	Read the RA on the practical lesson to be conducted in class 06.
06	After reviewing the practical lesson plan, the class was held in the laboratory, applying the topic: Calculation of concentrations.	Watch video lesson 03, interact in the chat, and answer the questionnaire (Forms) on the topic.

07	Class planned based on students' questions from video lesson 03, with review of concepts and information recording.	
08	Exercise resolution from the didactic material, related to video lesson 03, in groups, with teacher mediation.	Read the RA on the practical lesson to be conducted in class 09.
09	After reviewing the practical lesson plan, the class was held in the laboratory, on the topic: Dilutions.	Read the article related to aqueous solutions and develop scientific questions.
10	Class planned based on students' questions about the article read. In teams, students presented parts of the article, relating it to the studied concept.	Interpret a video/experiment based on the dilution content to produce an explanatory text.
11	The teacher conducted a final exposition of the contents, a gamified review activity using the Kahoot app	Video lesson indicated by the teacher, showing how to build a mind map.
12	Class dedicated to the construction of a mind map by the students, relating the worked topics, with teacher mediation.	Watch video lesson 04 - summary for the final assessment.
13	Administration of the written exam on the content. Sending of the link to the questionnaire on the integration of methodologies.	

Source: Research Data (2022).

After the application of the methodological integration, which led to the creation of IsM (Customized Flipping), all students responded to the questionnaire, which consisted of 14 assertive questions. The first two assertive statements were related to the age and gender of the participants. Subsequently, there were twelve assertive statements related to the students' perceptions of IsM regarding learning, motivation, interaction with peers, autonomy, use of digital technologies, and comparison with conventional methodologies. These included assertive questions about their perception of the teaching process used.

Specifically, quantitative questionnaires that result in statistical data allow researchers to verify trends, identify behavior patterns, predict results, analyze prevalences and risks, define action strategies, and develop analysis models. The analysis can be performed using specific software such as the Statistical Package for the Social Sciences (SPSS) (MEIRELLES, 2014).

The questionnaire was administered using Microsoft Forms®. The assertive statements were structured and organized based on the five-point Likert Scale, where respondents were asked to rate their level of agreement with each statement, ranging from 1 to 5. Number 1 represented the highest level of disagreement, number 5 the highest level of agreement, and number 3 represented neutrality towards the statement, as shown in Table 2. It is noteworthy that the Likert scale is a type of psychometric response scale commonly used in questionnaires and opinion surveys, aiming to measure the degree of agreement with a response and/or the respondent's affinity with a given statement related to a specific attribute being measured.

Table 2 - Codes and Assertions Provided in the Online Form

Code	Assertions
A	The dynamics used were noticeably different from those used in general classes (lectures and homework).
B	The dynamics used made the process of understanding scientific content more optimized, intuitive, and organized.
C	The dynamics used contributed positively to my learning.
D	From the dynamics used in class, I became more proactive and participative, helping my classmates and engaging more with the teacher.
E	The classes became more relevant with the dynamics used because the teacher addressed my doubts.
F	Doing exercises, classwork, and having content presented through video lessons and reading tasks improved my performance with the content.
G	Studying at home to actively participate in class improved my skills such as autonomy, responsibility, and interaction with my peers
H	The dynamics used to learn chemistry were sufficiently rich because I became more active in the way I studied.
I	I would like more content to be delivered using the dynamics used, and for other subjects to adopt this way of working.
J	The dynamics used provided moments to learn individually and also moments to learn collectively (exercises in pairs and trios, laboratory).
K	Regarding the digital technologies used (video lessons - YouTube, reading tasks - Forms, gamification - Kahoot): I felt more motivated to learn.
L	With the help of the technologies used, I developed more autonomy.

Source: Research Data (2022).

Moreover, this research with a quantitative approach is characterized by the use of quantification in both the construction and treatment of data through statistical techniques. According to Fonseca (2002), this approach focuses on objectivity, using mathematical language to describe the causes of a phenomenon, the relationships between variables, etc. For data analysis, statistical analysis via SPSS software was chosen, and the analysis was supported by elements observed during the implementation of the activity.

4 RESULTS

With the assertions answered by the 21 students, it was possible to perform a descriptive statistics analysis, showing the minimum and maximum scores obtained in each assertion, the average agreement of the participants, and the related standard deviation, as shown in Table 1.

Table 1 – Statistical Analysis of Assertive Questionnaire

Assertive	Minimum	Maximum	Average	Standard Deviation
A	4	5	4.67	0.483
B	2	5	3.86	1.014

C	2	5	3.86	0.964
D	2	5	3.76	1.136
E	3	5	4.43	0.676
F	2	5	3.24	0.995
G	2	5	3.81	0.981
H	2	5	3.52	1.030
I	1	5	3.48	1.401
J	3	5	4.62	0.669
K	2	5	4.29	0.956
L	3	5	4.05	0.669

Source: Research Data (2022).

Upon analyzing the data in Table 1, it is evident that all assertions had a mean score above 3 (neutral), indicating that, on average, the subjects agree with the questions presented in each assertion, providing positive feedback on the methodological fusion. The assertions aimed to assess students' perceptions of their learning through IsM. Notably, in assertion A, the minimum score reported was 4, indicating that all students recognized a considerable difference in the dynamics used between the methodological fusion and traditional classes.

Assertions E (which asks if classes became more relevant due to the professor addressing content based on student doubts), J (which asks if the methodological fusion provided moments for both individual and collective learning), and L (which asks if the use of DT increased student autonomy) indicate that no student disagreed with the question, as the minimum response was 3. Moreover, judging by the mean score of each assertion, there is significant agreement regarding their respective inquiries.

Regarding assertion K, which questioned whether the use of DT increased motivation for learning, it had an average score of 4.29. Therefore, it is understood that the use of DT is well-received by students. During the observation of the methodological fusion's implementation, especially concerning the used video lectures (approximately 20 minutes each), students reported that because these lectures were shorter than traditional classes, it was easier to stay focused and grasp concepts, with the ability to pause, fast forward, or rewind the video as needed. Since the lectures were pre-recorded and edited, time was optimized, and the teacher could explain the same content in less time than a traditional class would require. Thus, DT provided students with opportunities to spend less time specifically engaged in concept building.

Furthermore, the activities conducted through Microsoft Forms®, with automatic correction and student and class accuracy rates, also enabled diagnostics not only for the teacher but also for the students, helping them better identify their errors. The use of Kahoot for review, for instance, generated high student engagement, with much more interaction and participation than in reviews conducted without the use of DT. Moreover, it is adjudged that with less time concentrated on content to allocate for interaction with peers and experimental classes, the use of DT aided in actively shaping students' learning processes, while they engaged in discussions and interactions with knowledge already built at home.

Regarding Table 1, it is noted that the other assertions presented divergent values, with students responding 1 (only in I) or 2 up to responses with a value of

5 (all). Therefore, there are subjects who disagree, just as there are those who agree with the statements presented in the assertions. Based on the averages, all above 3, the number of students who disagree with the questions presented is smaller than the number who agree.

The assertion with the lowest average score (M = 3.24) was F (which related methodological integration to increased academic performance). This contrasts with the other assertions, as students recognized improvements in autonomy, learning, interaction, and motivation; however, academic performance based on grades still encountered resistance from them. Observation indicated that students could orally explain content, relate it to contexts, apply it in lab classes, but faced challenges in basic mathematics. The "solutions" content addressed in the methodological fusion requires basic mathematical knowledge at various points to calculate solution concentrations ($g.L^{-1}$; $mol.L^{-1}$; %). It is also valid to highlight that in this methodological fusion, efforts were made to make students more autonomous, demanding more responsibility and proactivity from them. Therefore, it is believed that the written assessment, with vestibular questions, had limited performance due to mathematics, leading students to indicate that the methodological fusion did not fulfill this part.

Assertion I (which addressed whether students would like this methodological fusion in other subjects or disciplines) was the only one with scores as low as 1, having the highest standard deviation (SD = 1.4), indicating greater variation in Likert scale scores compared to other assertions. Thus, it is concluded that some students prefer a more traditional dynamic with lectures in class and homework exercises. Upon observing the implementation of methodological fusion in the classroom, it was noted that most students recognized their participatory evolution in the process, with more moments of interaction with concepts and peers, and through the optimization of the process by using DT, more opportunities to explore content.

Additionally, it is noteworthy that assertions B (which questions whether there was better organization in learning when using methodological fusion) and C (which questions whether there was positive feedback from learning through methodological fusion) had the same average response (M = 3.6), albeit with different standard deviations. Assertion C had a lower standard deviation, indicating closer responses to each other, i.e., less dispersion and greater convergence; hence, more responses fell between grades 3 or 4.

Finally, it is apparent that IsM, from the quantitative perspective indicated by the subjects, was well accepted, with agreement that methodological integration brought multiple benefits (learning, performance, interpersonal interactions, autonomy, participation in content development). Furthermore, in line with the statements proposed in the assertions, it is evident that the assertions with the highest agreement were: A, E, J, and K. These assertions with averages above 4 strongly indicate that students perceived a change in the learning process, with more dynamic classes and greater rigor in problem-solving during doubt-resolution periods, fostering moments of both individual and collective learning through the use of DT.

Moreover, it is inferred that more applications of this fusion may mature students' understanding through other methodologies, as different uses of DT in the classroom can motivate students to want to learn, facilitating a process closer to reality immersed in digital environments to truly understand the intrinsic relationship established between learning, performance, DT use, and active methodologies.

5 DISCUSSION

The quantitative analysis of student responses and observations during the implementation of the activity highlight the impact of methodological integration between FC and JiTT, resulting in the creation of IsM. This integration introduces a new approach to teaching, where IsM empowers students in the learning process. This empowerment is fostered by the demand for autonomy, responsibility, and organization on the part of students to effectively understand and apply content, while decentralizing the role of the teacher in the educational process.

This perception finds support in a systematic review conducted by Misseyanni *et al*. (2018), which demonstrates the effectiveness of active learning methodologies in enhancing students' understanding of complex concepts, stimulating greater autonomy, cognitive engagement, and the development of critical and analytical skills.

The organization of students to complete the steps of understanding and applying content before face-to-face classes was crucial for the success of the learning process. This organization was intrinsically linked to autonomy, manifested in the freedom of the student to determine the most suitable time for study, according to their perception of concentration. In this context, students recognized that the center of learning lies within themselves, corroborating Bedin's (2021) view on active methodologies as means to empower students in their own learning process, promoting autonomy, responsibility, and dedication.

It is important to note that failure to complete pre-class comprehension and application activities could compromise the student's ability to keep up with subsequent stages of face-to-face classes. After all, face-to-face classes in IsM offered students the opportunity to analyze errors, receive and/or provide assistance to other colleagues, which contributed to the development of teamwork skills, expression, and collaborative teaching. Furthermore, this moment enabled closer interaction between teacher and student, focused on specific content-related doubts, allowing the application of concepts in new contexts such as laboratory activities aimed at problem-solving. Thus, through IsM, students were able to self-assess their learning.

In this context, IsM represents and demarcates an approach that brings new possibilities to teaching, as suggested by its own designation "Customized Inversion". The term "Inversion" indicates that the teacher plans activities traditionally conducted in the classroom to be done at home, such as lectures and tasks for understanding and applying content. These activities are closely monitored by the teacher, who has access to individual or collective student performance, allowing tailored adaptation of teaching to meet the specific needs of the class or each student.

This "Customized" aspect demands that the teacher carefully analyze student responses in online activities, adapting teaching according to identified needs. This adaptation is enhanced during face-to-face classes, where the teacher can address student doubts and verify if they have been resolved through solving new problems. Therefore, it is essential for the teacher to provide clear support for the methodological stages to occur effectively, including setting deadlines and describing activities in each stage. Thus, IsM stands out for providing a dynamic learning environment centered on the student, while decentralizing the role of the teacher, assigning them a guiding and supportive role in specific moments of the educational process.

Specifically regarding student perceptions related to the assertions in Table 2, with agreement averages in Table 1, it can be affirmed that the dynamics adopted in IsM presented perceptible differences compared to traditional teaching methods, such as usual lectures followed by homework exercises. This shift in pedagogical approach made the process of understanding scientific content more streamlined, intuitive, and organized, reflecting positively on student learning. IsM positively contributed to promoting learning, fostering greater student participation and proactivity, as they began to assist colleagues and engage more with the teacher during classes. Moreover, personalized teaching based on student doubts made classes more relevant and adapted to individual needs, demonstrating the effectiveness of IsM.

The various proposed activities, such as in-class exercises, content exposition through video lectures, reading tasks, and the use of digital technologies, contributed to improving student performance in the studied content, highlighting the richness and effectiveness of IsM. Individual study at home to actively participate in classes also improved students' skills, such as autonomy, responsibility, and interaction with peers, demonstrating the benefits of autonomy provided by active methodologies.

Furthermore, the positive feedback from students revealed a desire for more content to be administered following IsM, indicating a preference for the adopted pedagogical approach. Moreover, the dynamics provided moments for both individual and collective learning through group activities, enriching the educational experience for students. The use of digital technologies also increased student motivation to learn and contributed to the development of autonomy in learning.

6 FINAL CONSIDERATIONS

The methodological integration between FC and JiTT was well accepted and utilized by students, providing a different experience in the learning process compared to the traditional approach, where students typically take a more passive role. Students felt more active, and with fewer traditional lectures, they had more engagement with various aspects of the content such as contexts, problem-solving, analysis, laboratory skills, interaction with peers, and gamification.

Moreover, the majority of students engaged well with the proposed fusion, evidenced by the fact that video lectures had more than double the number of views compared to the number of students. Additionally, based on the responses obtained in the assertive questionnaire, all assertions had an average score above 3 (neutral), indicating that, on average, subjects agree with the issues presented in each assertion, providing positive feedback on methodological integration.

Finally, it is noteworthy that one of the limitations of this work might be the dynamics itself, as some students, having not previously engaged in a learning process via active methodologies, experienced organizational difficulties. These difficulties included completing activities at the designated times and recognizing the importance of autonomy and responsibility in the process. In this regard, further research could emerge from this study with different perspectives, such as other applications, results, potentialities, and challenges of integrating active methodologies. Additionally, future studies could consider the students' perspectives through interviews for subsequent discourse analysis.

EXPLORANDO AS PERCEPÇÕES DOS ALUNOS SOBRE APRENDIZAGEM POR MEIO DE METODOLOGIAS ATIVAS E TECNOLOGIAS DIGITAIS

RESUMO

O objetivo deste artigo é apresentar as potencialidades da integração entre as metodologias ativas de Sala de Aula Invertida (SAI) e *Just-in-Time Teaching* (JiTT), com ênfase no uso de recursos tecnológicos, sob a perspectiva das percepções dos alunos. A integração metodológica foi aplicada no ensino de química para alunos da primeira série do ensino médio em uma escola privada de Curitiba/PR. A pesquisa adotou uma abordagem quantitativa e o procedimento de pesquisa participante, utilizando como instrumentos de constituição de dados a observação e questionário, este último analisado por meio do *software* SPSS (*Statistical Package for the Social Sciences*). Os resultados indicam que todas as assertivas do questionário receberam concordância acima da média dos participantes, principalmente em relação a mudanças no processo de aprendizagem, interação com conteúdo e colegas, e mais motivação no processo de aprendizagem pelo uso das TD.

PALAVRAS-CHAVE: Inversão sob Medida. Prática Tecnológica. Ensino de Química.

NOTE

1. This article is a completed, revised, and detailed version of a work presented and published at the scientific event Simpósio Nacional de Ensino de Ciências e Tecnologia (National Symposium on Science and Technology Education - SINECT).

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