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Research Artikel

CREATING ENGAGING CHEMISTRY LESSONS: PROBLEM BASED LEARNING AND COOPERATIVE LEARNING STRATEGIS TO COMBAT STUDENT BOREDOM IN SECONDARY EDUCATION

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Abstract

Learning difficulties often hinder students from reaching their academic potential, one of which is caused by boredom during the learning process. This boredom can occur if the teaching methods applied are not sufficiently engaging or relevant to the students. This study aims to explore the implementation of Project-Based Learning (PjBL) and Cooperative Learning models used by chemistry teachers to overcome learning difficulties among 10th-grade students at Madrasah Pembangunan. The research approach used in this study is qualitative with a case study design, in which data were collected through in-depth interviews, classroom observations, and documentation. The results indicate Project-Based Learning (PjBL) and Cooperative Learning models can overcome student difficulties in learning chemistry concepts when combining with differentiated instruction and linking learning to real-life issues. The application of these learning models has been proven to increase student engagement in the learning process and facilitate a deeper and more practical understanding of chemical concepts within the context of their daily lives. This study contributes to enriching chemistry teaching practices at the secondary school level with more innovative and applicable approaches.

Keywords*: Chemistry learning; learning difficulties; teaching strategies.*

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INTRODUCTION

Learning difficulties remain a significant barrier preventing students from achieving their full academic potential, especially in complex subjects such as chemistry. A major factor contributing to these difficulties is student boredom, which often arises when teaching methods fail to actively engage learners or connect chemistry concepts to their real-life experiences. This boredom diminishes motivation and focus, critical elements for understanding challenging scientific topics. Research by Tze et al. (2016) underscores boredom's negative effect on academic engagement and achievement in science subjects, including chemistry.

The underlying causes of boredom in chemistry classes are closely related to unvaried instructional approaches and a disconnect between curriculum content and practical applications. When lessons are perceived as monotonous or irrelevant, student interest declines. Research highlights how boredom impairs cognitive processing and retention, especially in secondary education science classrooms where student engagement is essential (Obergriesser & Stoeger, 2020). Moreover, classroom environment and teacher delivery methods significantly influence students' emotional responses, emphasizing the need for dynamic pedagogies that actively involve 10th-grade learners in chemistry (Marca & Longo, 2017).

Learning strategies refer to the specific methods, techniques, or approaches that students use to acquire, comprehend, and retain knowledge. These strategies can be cognitive, metacognitive, or behavioral and are designed to help learners process information more efficiently and meaningfully. In chemistry education, where abstract concepts and problem-solving are prominent, effective learning strategies are critical in overcoming barriers such as misunderstanding complex theories, low engagement, and poor motivation (Zimmerman, 2022).

Research in chemistry education has consistently shown that employing Problem-Based Learning (PBL) and Cooperative Learning methodologies effectively addresses common learning difficulties by enhancing students' problem-solving abilities, creativity, and engagement. Raman et al. (2024), for example, finds that PBL significantly improves problem-solving skills across diverse chemistry education levels, highlighting its broad applicability and effectiveness. Similarly, Cooperative Learning has been found to enhance student engagement and problem-solving by promoting structured peer interaction and collaborative thinking. Studies have shown that group work within Cooperative Learning not only improves problem-solving performance but also nurtures creativity and deeper conceptual understanding among chemistry students (Cardellini, 2014).

Furthermore, integrating collaborative problem-based learning models combines the strengths of both strategies to further promote creative thinking and sustain student motivation, creating a synergistic effect in chemistry education (Hidayah & Dasna, 2022). Together, these pedagogical approaches offer a powerful combination for overcoming learning difficulties in chemistry by fostering active, collaborative, and creative learning environments.

Madrasah Aliyah (MA) Pembangunan is an Islamic secondary school located in a city in the province of Banten, Indonesia. Different from most schools in its neighbourhood, MA Pembangunan provides each student with a laptop as a learning source. In the laptop, there is a built-in Learning Management System (LMS) where modules and materials of all subjects, including chemistry, are ready to use. As chemistry teachers in other schools, chemistry teacher of MA Pembangunan experiences student difficulties in learning chemistry. As a school that is well-equipped in terms of facilities, this research is aimed to see how the school handle students with challenges in learning chemistry. The extent to which the implementation of a Project-Based Learning (PBL) and cooperative learning to help students with difficulties will be investigated. This study will further provide limitation as well as recommendations for further research.

METHOD

This study employed a qualitative case study methodology to explore the perspectives of a chemistry teacher and tenth-grade students at MA Pembangunan, an Islamic senior high school, on the implementation of PBL and cooperative learning to overcome learning challenges. The qualitative case study approach facilitates an in-depth understanding Creswell & Poth (2018) of complex educational practices in real-life contexts.

The primary participant was a chemistry teacher with ten years of teaching experience at this institution. Data were gathered through four classroom observations, spanning two different chemistry lessons, and in-depth interviews with the teacher. Observations provide direct insight into classroom dynamics, instructional practices, and student-teacher interactions, offering rich contextual data that complement interview findings (Tisdell et al., 2025).

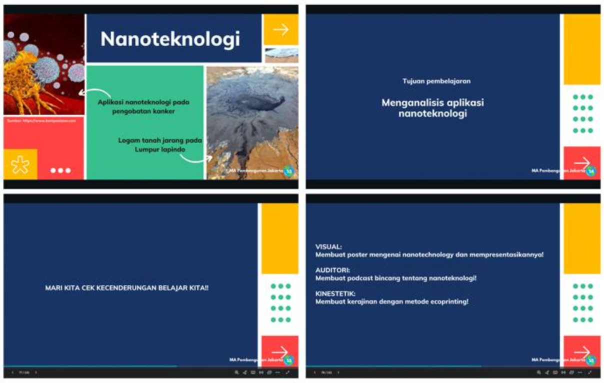
The interview with the teacher focused on the implementation of instructional models and the teacher's views on their effectiveness in supporting students with learning challenges. Questions asked were related to learning environment and learning strategy implementation. Through the learning environment, it was expected that the teacher will explain about her rationale of taking the learning strategies. Whilst for the learning strategies, the teacher was asked to describe how such strategies are implemented and the extent to which the strategies help students to solve their learning challenges.

Observation data were used to triangulate and validate the interview findings. The observation included several aspects in the teacher’s activities, such as, introduction activity, main activity, and closing activity. Triangulating multiple data sources such as observations and interviews strengthens the credibility and validity of qualitative research findings (Tisdell et al., 2025). Data analysis involved data display, reduction, and drawing conclusions to ensure a comprehensive understanding of the phenomena studied. This helps systematically synthesizing data to form well-grounded insights (Creswell & Poth, 2018).

RESULTS AND DISCUSSION

Data from this study was gather from teacher’s interview and observing teaching and learning activity in classroom. Teacher’s interview was focused on two aspects, namely, the learning environment and teaching strategies. From Table 1, it is evident that teachers generally acknowledge the variability in their students' abilities to comprehend chemistry lessons. Teachers gather such ability data through various assessment tools, including dummy tests, matriculation examinations, and the results of the initial daily quizzes. This is inline with a research by Moon (2005) that investigated the need of assessment-based decision making fo determine students’ need and to plan for an appropriate teaching strategy. These data sources are critical for informing the selection of appropriate instructional strategies aimed at optimizing the learning experience and enhancing students' understanding of the material presented. This practice is reaffirming recent findings that emphasize the significance of identifying learner differences to tailor instruction effectively (Pasira, 2022; Smale-Jacobse et al., 2019; Steenbergen-Hu et al., 2016). Pasira (2022) with her research, for example, found that when differentiated learning is done effectively, it will enhance student’s motivation and performance.

Table 1 Summary of teacher's responses during interview on the aspect of learning environment and teaching strategies

Questions	Summary of responses
What initial steps does the teacher take to begin teaching?	Several things are prepared prior to begin teaching chemistry: a. Understanding the result of a DAMI Test Tes DAMI (Diagnostic Assessment Multiple Intelligences). Before starting classes in the first semester, students take a short test called the DAMI Test. The DAMI Test is an interview-based assessment. Its purpose is to identify and map the 8 intelligences of a child. These intelligences include: Intrapersonal Intelligence, Interpersonal Intelligence, Linguistic Intelligence, Logical-Mathematical Intelligence, Spatial-Visual Intelligence, Naturalistic Intelligence, Kinesthetic Intelligence, and Musical Intelligence. This test helps teachers understand the types of intelligence students possess, such as their unique ways of learning and thinking. Based on the test results, teachers can group students according to their intelligence types based on the theory of multiple intelligences. This information is stored in the teaching module on the teacher's tablet. The results of the DAMI Test are very useful for planning lessons, determining how to group students, selecting the best teaching methods, and determining how to monitor student progress.  Figure 1. The teacher administers the DAMI test to determine students' intelligence tendencies. b. Preparing modules and teaching materials. Every teacher must upload their modules and teaching materials for each learning session. For example, we have 16 meetings in one semester. For each meeting, the teacher needs to put in detailed info like the learning goals, objectives, assessments, and the materials they will use.  Figure 2. Modules used by students that contain a variety of differentiated learning instructions

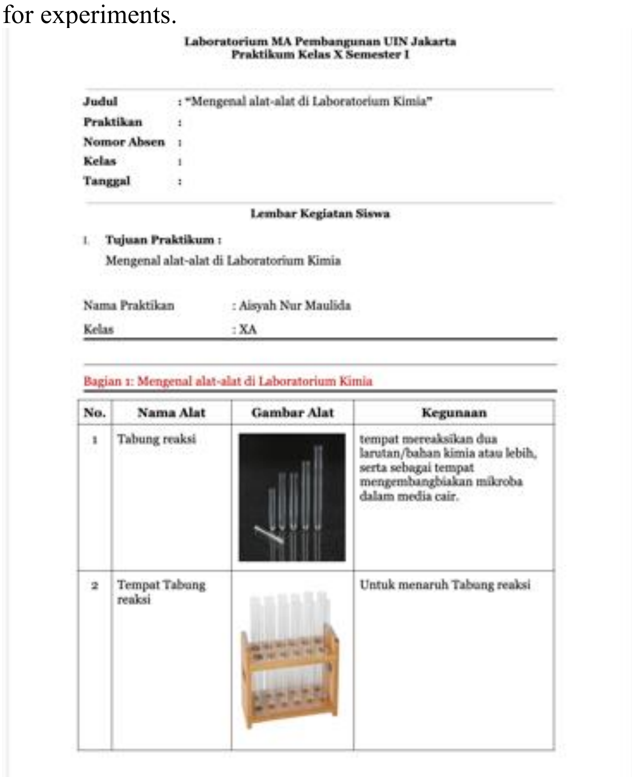
Questions	Summary of responses

Pertemuan 3 *Project Based Learning*

Kegiatan	Tahapan/ Sintak	Kegiatan Pembelajaran	Alokasi Waktu
Pendahuluan	**Memberi Stimulus *(Stimulation)***	1. Guru memberi salam dan mengajak peserta didik berdoa di awal pembelajaran. 2. Guru melakukan presensi. 3. Guru memberikan motivasi "Bagaimana kemajuan dari nanoteknologi?" 4. Peserta didik menyimak tujuan pembelajaran pada materi: struktur atom-nanoteknologi.	10 menit
	***Tahap 4* Memonitor kemajuan proyek**	1. Peserta didik mempresentasikan hasil produk-nya melalui layar TV/Poster/*Eco Printing* untuk ditanggapi oleh guru maupun peserta didik lainnya. 2. Peserta didik menilai peer assessment dengan link: https://bit.ly/PH_Kimia_XA https://bit.ly/PH_Kimia_XB https://bit.ly/PH_Kimia_XC https://bit.ly/PH_Kimia_XD	20 menit
	***Tahap 5* Penilaian hasil**	3. Peserta didik saling memberi masukan dan evaluasi terkait hasil kelompok lain dan memberikan masukan terhadap kelompok yang tampil. 4. Peserta didik bertanya melalui forum kelas besar untuk ditanggapi oleh peserta didik lain dan guru mata pelajaran.	20 menit
	***Tahap 6* Evaluasi Pengalaman**	5. Peserta didik saling melengkapi evaluasi terkait perbaikan yang perlu dilakukan, kendala yang ditemui, serta cara maupun teknik terbaik dalam pembuatan batik ikat celup.	10 menit

Figure 3. Modules used by teacher that contain a variety of differentiated learning instructions

c. Preparation for chemistry practicum (experiment).
If a chemistry experiment is needed, teachers should get all the materials ready for the experiment. So far, MA Pembangunan has well-equipped labs with all the necessary materials and tools for experiments.


Laboratorium MA Pembangunan UIN Jakarta
Praktikum Kelas X Semester I

Judul : "Mengenal alat-alat di Laboratorium Kimia"
Praktikan :
Nomor Absen :
Kelas :
Tanggal :

Lembar Kegiatan Siswa

1. **Tujuan Praktikum :**
Mengenal alat-alat di Laboratorium Kimia

Nama Praktikan : Aisyah Nur Maulida
Kelas : XA

Bagian 1: Mengenal alat-alat di Laboratorium Kimia

No.	Nama Alat	Gambar Alat	Kegunaan
1	Tabung reaksi		tempat mereaksikan dua larutan/bahan kimia atau lebih, serta sebagai tempat mengembangbiakan mikroba dalam media cair.
2	Tempat Tabung reaksi		Untuk menaruh Tabung reaksi

Figure 4. Experiment worksheet for introducing laboratory equipment and chemicals

Questions	Summary of responses
How do you identified students' difficulties in learning chemistry?	There are two ways to identify student difficulties:

1. Matriculation test

Before students join our class, they take a matriculation test. This test looks at what they learned before in junior high school, especially the material related to what we'll be teaching. They also get asked questions to check their math skills and reasoning. The results help us see which students are stronger in science subjects and which ones might do better in non-science areas.

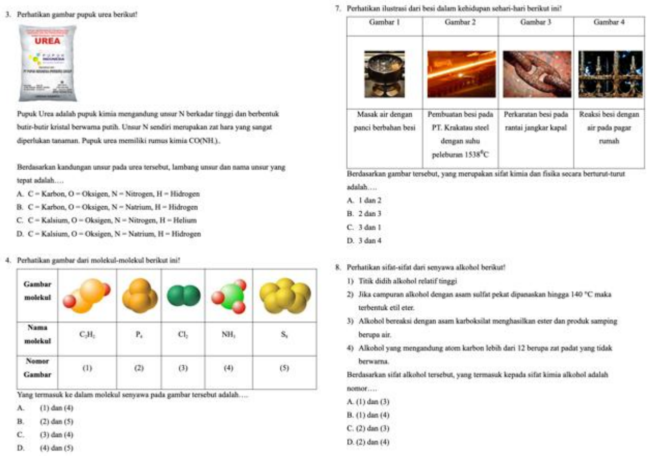


Figure 5. Chemistry Matriculation Test

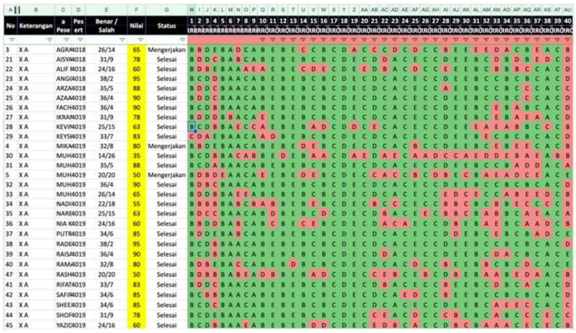


Figure 6. Matriculation Test Results

2. First daily test

If we can't do the matriculation test, then we use data from the first daily test instead. This test helps us see not only how well students understand the material we have taught but also where they are having trouble with chemistry.

Questions	Summary of responses
What are challenges faced by students in learning chemistry?	Learning difficulties usually come from the students themselves. For example, in chemistry, the problems often come from not being strong in math or not paying enough attention in that area.
What are teaching strategies to overcome learning challenges?	There are two approaches to overcome learning challenges:

1. Students are given a remedial teaching

Remedial teaching usually means helping students really understand the material. After that, they are asked to go over and repeat the topics they found tricky. Later on, they get retested to see how much they have improved and mastered the stuff.

2. Teacher uses many teaching strategies

Out of all the teaching strategies, project-based learning and cooperative learning are the ones we use the most. They are popular because they bring a lot of benefits for students. With these strategies, students get to create something, improve their

Questions	Summary of responses
	communication skills, sharpen their analytical thinking, manage their time better, take responsibility, and show what they have learned through their projects. But these two work best when you add in differentiated instruction and connect the learning to real life. Differentiated instruction lets students with different needs and styles grow at their own pace, and linking learning to real life makes the experience more meaningful. For example, in a nanotechnology class, students are grouped into three types: kinesthetic, auditory, and visual learners. Kinesthetic students might work on an Eco printing project, while auditory and visual learners could work on podcasting and poster projects, respectively. All the projects should connect to things in their daily lives.

MA Pembangunan Jakarta
Penilaian Formatif Peserta Didik
Materi Nanoteknologi dalam Struktur Atom
Kelas X

Satuan Pendidikan : MA Pembangunan Jakarta
Topik : Struktur Atom – Keunggulan Nanoteknologi
Kelas/Fase : X / Fase E
Alokasi Waktu : 4 x 45 menit (2 pertemuan)

Elemen	Capaian Pembelajaran
Pemahaman Kimia	Peserta didik mampu memahami struktur atom dan aplikasinya dalam nanoteknologi.

Tujuan pembelajaran:
1. Mendeskripsikan pengertian nanoteknologi
2. Mendeskripsikan pentingnya nanoteknologi

Diferensiasi Proses

- Kelompok Visual
  Setelah mempelajari jurnal, buatlah karya dengan menggunakan hasil gambarmu sendiri untuk mencerminkan nanoteknologi!
- Kelompok Audio
  Setelah mempelajari jurnal, buatlah Podcast tentang nanoteknologi!
- Kelompok Kinestetik
  Setelah mempelajari jurnal, buatlah karya dengan aplikasi nanoteknologi – *green chemistry* pada *eco-printing*!

Figure 7. Differentiated Learning Assessment Sheet

Questions	Summary of responses
What are the rationales behind the chosen strategies?	We use Project-Based Learning (PjBL) because the material, like nanotechnology, is pretty complex and needs a deep understanding. Just listening to lectures isn't enough; students need to experience it for themselves to really get it. On the other hand, differentiated cooperative learning means grouping students from the start based on their abilities and learning styles—like auditory, visual, and kinesthetic learners. Teachers conducted non-cognitive diagnostic assessments to obtain information regarding students' learning styles. This assessment was carried out by administering a questionnaire to the students. An example of the questionnaire are presented in Figure 8. Knowing this, teachers can make the learning experience more effective by using this info to help each student in the best way possible.

Questions	Summary of responses

1. Ketika berbicara, kecenderungan gaya bicara saya...
A. Cepat B. Berirama C. Lambat
2. Saya...
A. Mampu merencanakan dan mengatur kegiatan jangka panjang dengan baik B. Mampu mengulang dan menirukan nada, perubahan, dan warna suara C. Mahir dalam mengerjakan puzzle, teka-teki, menyusun potongan-potongan gambar
3. Saya dapat mengingat dengan baik informasi yang...
A. Tertulis di papan tulis atau yang diberikan melalui tugas membaca B. Disampaikan melalui penjelasan guru, diskusi, atau rekaman C. Diberikan dengan cara menuliskannya berkali-kali
4. Saya menghafal sesuatu...
A. Dengan membayangkannya B. Dengan mengucapkannya dengan suara yang keras C. Sambil berjalan dan melihat-lihat keadaan sekeliling

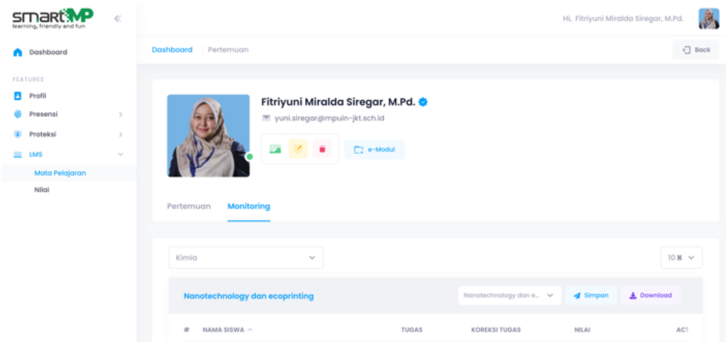
Figure 8. The example of the questions about determining learning styles that was shown in chemistry class

After distributing the learning style questionnaires to the students, the teacher collected the responses and processed the data to obtain information regarding the students' learning styles. The results of the learning style analysis are presented in Figure 9.

11	MDA	Visual
12	MA	Kinestetik
13	MFSAS	Visual
14	MGA	Kinestetik
15	MRH	Kinestetik
16	MRF	Auditori
17	NF	Auditori
18	NRM	Kinestetik
19	NKP	Kinestetik
20	PKR	Visual
21	RDRH	Kinestetik
22	RA	Auditori
23	RRB	Visual
24	RP	Auditori
25	RK	Kinestetik
26	SA	Auditori

Figure 9. The result of students' learning styles

Prior to administering the learning style test, the teacher provided an explanation of learning styles to the students to ensure their understanding. This instructional activity is illustrated in Figure 10.

Questions	Summary of responses
	 Figure 10. The teacher explains the three learning styles. Knowing this, teachers can make the learning experience more effective by using this info to help each student in the best way possible.
How to assess students' successful on overcoming their challenges?	The LMS helps us keep track of who already gets the material and who does not. For those who don't, we usually give them some extra help or have their classmates explain it to them. When it comes to testing, we pick the students who will be teaching others based on the daily quiz results. After the first daily test, those who did well get to help their friends who didn't do as well.  Figure 11. SMART MP: LMS developed by Madrasah Pembangunan

Based on the available data, one common challenge faced by students in learning chemistry is their proficiency in mathematics and reasoning skills (Table 1). These challenges are typically identified from matriculation data and the results of the first daily test. Consequently, even at the early stage of instruction, teachers plan to implement more effective learning strategies. Students' difficulty in mathematical analysis and reasoning skills are common when teaching chemistry. This has been investigated by many scholars (Gultepe et al., 2013). Yet, research conducted previously on mathematical reasoning suggests that proficiency in mathematics can predict success in chemistry (Bain et al., 2019; Bain & Towns, 2016; Becker & Towns, 2012; Rosa & Lewis, 2018).

Among the various strategies available, the teacher decided to apply project-based learning (PjBL) combined with cooperative learning. These two strategies were chosen based on several considerations, including the complexity of the material and the significant differences in students' learning styles. According to the teacher, PBL was selected to provide a deeper understanding of complex material, while cooperative learning was intended to reinforce shared experiences among students (Table 1).

Nevertheless, these strategies are expected to yield better learning outcomes when combined with differentiated instruction and connections to real-life contexts. The teacher implements differentiated instruction by dividing the class into three groups based on predominant learning styles: auditory, kinaesthetic, and visual learners. Within the same thematic context—nanotechnology—each group receives distinct project assignments aligned with their differentiated grouping. Wahyuni et al. (2025) confirmed that teaching students according to their learning style may result in better learning outcomes. Likewise, Zulfiani et al. (2021) stated that learning styles affect learning outcomes and adjustments to student needs can increase their effectiveness. Android technology as a learning medium supports various learning styles, allowing students to learn independently and interactively. Although conventional and technological approaches are different, both can complement each other to create a more effective learning experience according to student needs.

The teacher stated that this approach optimizes learning because students can exert their maximum effort according to their individual abilities. This was confirmed through classroom observations. For example, as illustrated in Table 2, each group was able to optimally actualize their abilities to gain a deep understanding of the same material. The auditory group produced a podcast on nanotechnology issues; the kinaesthetic group implemented nanotechnology by creating eco-paintings; and the visual group designed posters illustrating the environmental impact of nanotechnology.

Table 2. The process of differentiated learning according to student' learning style

Differentiated Learning According to Students' Learning Style	**Documentations of Differentiated Learning According to Students' Learning Style**
Auditory students are doing a podcasting on nanotechnology issues.	 Figure 12. Group of auditory students
Kinaesthetic students are presenting their work on eco printing. They printed leaves and flowers on the canva materials.	

Figure 13. Group of kinaesthetic students

Visual students are presenting their poster on nanotechnology

Figure 14. Group of visual students

From these activities, it was observed, as shown in Figure 15, that students were more actively engaged in learning activities through question-and-answer sessions. Nearly all students appeared eager to respond.

Figure 15. A portrait of Q&A session

As has been investigated by Subandiyah et al. (2025) and Zulfiani et al. (2021) that students who were taught using differentiated instruction and in accordance with the student' learning style showed notably better academic results, higher levels of engagement in class, and more active participation than those in the control group where no differentiated instruction applied.

To ensure that the teacher's strategy can help students face difficulties in learning chemistry, the teacher uses various assessments. Based on interview, the teacher explained that assessments are conducted in various ways and on different occasions. In relation to ensuring students gain a good understanding, the teacher carries out cognitive assessments. Cognitive assessments are divided into three types: daily assessments, mid-semester assessments, and final semester assessments. Assessments are generally conducted within the LMS (Learning Management System). Because all assessments are conducted within the LMS, the teacher can easily see the progress of the students. "The LMS helps us keep track of who already gets the material and who does not. For those who don't, we usually give them some extra help or have their classmates explain it to them" (Table 1). This practice is similar to what have been studies by many scholars. Oguguo et al. (2021), for example, has found that an LMS helped teacher to identify students' performance and such data is important to develop better learning strategies.

CONCLUSION

This study focused on examining the use of Problem-Based Learning (PBL) and cooperative learning to address challenges students face in chemistry education. The findings indicated that to maximize benefits, these strategies should be applied through a differentiated instructional approach that ties lessons to everyday real-life contexts. Being a case study, the research suggests that further investigations are necessary to explore how best to integrate differentiated instruction and contextual learning within PBL and cooperative learning frameworks. Additionally, it is recommended to study methods for assessing how effectively these new teaching strategies can help students overcome difficulties in learning chemistry.

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