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Chemoenterpreneurship-Based Deep Learning and MSME Partnerships: Improving Chemistry Learning Outcomes and Graduate Profile

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Abstract

Deep learning has become one of the strategic approaches promoted by the Indonesian Ministry of Primary and Secondary Education to enhance meaningful learning. This study aims to analyze the implementation of chemoentrepreneurship-based deep learning and learning partnerships toward improving learning outcomes and the graduate profile dimensions. A quasi-experimental method with a pretest-posttest control group design was employed involving 59 twelfth-grade students at Al Azhar 14 Islamic Senior High School, Semarang. Data were collected using objective tests to assess learning outcomes and critical reasoning, while observation sheets were used to evaluate creativity, collaboration, and communication. The research instruments have been tested for validity and reliability. The results showed that the implementation of deep learning was able to improve students' learning outcomes and graduate profile dimensions compared with conventional instruction. The experimental group achieved high N-Gain scores for chemistry learning outcomes (0.81) and critical reasoning (0.75), and the independent sample t-test confirmed a significant difference between groups (t = 4.799, $p < 0.001$). It can be concluded that integrating deep learning with chemoenterpreneurship and MSME partnerships effectively promotes meaningful chemistry learning. This study contributes an innovative instructional model that combines authentic industry partnerships and chemoenterpreneurship to strengthen both academic achievement and graduate profile dimensions.

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INTRODUCTION

21st-century education faces increasingly complex challenges in shaping graduates who are not only academically excellent but also able to adapt to technological developments, the world of work, and global social dynamics. The characteristics of current learning no longer focus solely on rote memorization, but encourage students to develop critical, creative, collaborative, and communicative thinking skills that are relevant to global dynamics and the development of digital technology(Taar & Palojoki, 2022). In line with this, education is required to transform from a mere transfer of knowledge toward the development of applicative abilities and the formation of student character (Shek et al., 2025). In the context of Golden Indonesia 2045, education plays a strategic role in preparing human resources that are adaptive to technological developments, the world of work, and global challenges.

The Ministry of Primary and Secondary Education is striving quickly and precisely to accelerate the impact of education through various learning approaches, one of which is Deep Learning (PM). Deep Learning is an honoring approach that emphasizes creating a learning environment and a learning process that is conscious, meaningful, and joyful through a holistic and integrated exercise of thought, heart, feel, and body (Kemendikdasmen, 2025). This approach prevents fragmented understanding, where information is received separately without a complete and meaningful connection (McGregor, 2020). This approach aims to foster the character of lifelong learners who are capable of facing the complexities and dynamics of life adaptively and reflectively (Rahmawati et al., 2025).

The implementation of deep learning at every educational level needs to be supported by a conducive learning ecosystem, broad and meaningful learning partnerships, and the effective utilization of digital technology so that learning with full consciousness and attention, meaningful and relevant learning, as well as learning with joy, enthusiasm, and spirit can be realized. The PM framework consists of four components: (1) graduate profile dimensions, (2) learning principles, (3) learning experiences, and (4) learning frameworks. The graduate profile consists of eight dimensions: (1) faith and piety towards God Almighty, (2) citizenship, (3) critical reasoning, (4) creativity, (5) collaboration, (6) independence, (7) health, and (8) communication. The graduate profile dimension is a complete competence that every student must possess after completing the learning and education process (Kemendikdasmen, 2025).

The implementation of deep learning in chemistry learning becomes highly important because the characteristics of chemistry materials are abstract, complex, and involve relationships between macroscopic, microscopic, and symbolic representations. Chemistry learning is not enough to just emphasize the memorization of concepts and formulas, but needs to encourage students to understand concepts meaningfully, connect knowledge with real phenomena, and be able to apply these concepts in solving everyday life problems (Jere & Mpeta, 2024). The deep learning approach helps students build a deeper conceptual understanding through critical, reflective, investigative, and contextual thinking activities so that learning becomes more meaningful and student-centered (Naseer et al., 2024).

Strategies such as project-based learning, discovery learning, inquiry learning, and problem-based learning have a crucial role in realizing deep learning because they encourage students not only to process information but also to collaborate and design innovative solutions to contextual issues (Albani, 2025). Discovery learning is a learning model that encourages students to actively and independently discover concepts, principles, or new knowledge on their own. In this method, the teacher acts as a facilitator who provides stimulation, while students investigate, analyze, and formulate conclusions based on their findings.

The Chemoentrepreneurship (CEP) approach is a chemistry approach that connects chemistry learning with real objects or phenomena around human daily life, and at the same time provides opportunities for students to learn the process of processing a material into a product that is useful and has economic value (Arfin et al., 2018). Through this approach, students do not only study chemistry theory conceptually, but also understand the application of chemistry in daily life and the business world. CEP-based learning encourages students to develop critical thinking skills, creativity, problem-solving, communication, and the ability to produce products that have economic value (Igwe et al., 2022).

Learning partnership is defined as teacher learning that brings in other parties to have a collaborative partnership in the classroom. The concept of learning in partnership adopts Prosser's theory (Prosser & Allen, 1925) that delivering material through direct practice in schools is more easily understood by learners and is in line with the principle "Education is life itself".

Teachers who are willing to organize open learning, by bringing in other parties to discuss and reflect on learning outcomes, correlate significantly and positively with the progress of learning outcomes (Suharno, 2020). Learning partnerships form collaborative relationships to provide learning experiences, novel information, and feedback to students through contextual and real knowledge. Learning partnerships form dynamic relationships among teachers, students, parents, communities, and professional partners. This approach shifts the control of learning from just the teacher to a shared collaboration (Kemendikdasmen, 2025).

Based on the results of initial observations at Al Azhar 14 Islamic SHS, chemistry learning still faces several challenges, especially in connecting material concepts with students' real lives. Most of the learning is still oriented toward theory mastery and problem-solving, so student active involvement in the learning process is not yet optimal. In the alkane derivative compounds material (esterification reaction), which is abstract because it involves macroscopic, microscopic, and symbolic representations, students are able to follow lab procedures but do not yet fully understand the concept of the reaction mechanism. As a result, some students consider chemistry material difficult, abstract, and less relevant to daily life. In addition, the strengthening of graduate profile dimensions such as critical reasoning, creativity, collaboration, and communication has not been maximally facilitated in learning activities. On the other hand, the school has environmental potential and local partnership networks that can be utilized as contextual learning resources.

One approach that can be used to overcome these problems is deep learning, which is learning that emphasizes meaningful, reflective, and contextual learning experiences. In chemistry learning, the chemo-entrepreneurship (CEP) approach can connect chemistry concepts with entrepreneurial activities so that students do not only understand concepts theoretically but are also able to produce products of economic value. Strengthening learning becomes more authentic through local partnerships with perfume MSMEs, which provide real experiences to students regarding the application of the esterification concept in daily life and applying it in productive and economically valuable activities.

The novelty of this study lies in the application of a deep learning approach based on local partnerships and chemo-entrepreneurship, which has not been widely studied in previous research. So far, research related to chemo-entrepreneurship has focused more on developing teaching modules and increasing entrepreneurial spirit. However, research that integrates deep learning based on chemo-entrepreneurship with local perfume MSME partnerships in an effort to develop graduate profile dimensions such as critical reasoning, creativity, collaboration, and communication is still limited. In addition, the implementation of this approach on esterification material based on perfume making has not been widely studied. The purpose of this study is to analyze the increase in students' graduate profile dimensions, which include critical reasoning, creativity, collaboration, and communication, and to analyze the effect of implementing deep learning based on local partnerships and chemo-entrepreneurship on the improvement of student learning outcomes after the implementation of deep learning based on local partnerships and chemo-entrepreneurship on the Alkane Derivative Compounds material (Esterification Reaction).

METHOD

The research was conducted using a quasi-experimental method. The research design used was the Pretest-Posttest Control Group Design, where this design involves two groups, namely the experimental group and the control group. Measurements were taken before and after the treatment, and the effect was measured from the difference between the initial measurement and the final measurement. The population in this study consisted of class XII students at Al Azhar 14 Islamic SHS Semarang for the 2025/2026 academic year, totaling 88 students. The research sample was determined by a purposive sampling technique, where the researcher took 2 classes whose characteristics were somewhat similar, namely classes that had a comparable average outcome score as seen from the odd semester grade documents. The sample of this study was class XII 2 as the experimental class totaling 29 students and class XII 1 as the control class totaling 30 students.

The independent variable in this study was deep learning based on CEP and MSME partnerships. The dependent variables were learning outcomes and graduate profile dimensions. Control variables included material, learning time, teacher, and instruments. The experimental class was given treatment with the application of deep learning based on chemoentrepreneurship and MSME partnerships using the discovery learning syntax. The intervention was conducted over four instructional sessions (10 × 45 minutes) on topic of Alkane Derivatives (Esterification Reaction), learning activities were implemented as follows.

Session 1 (Stimulation and Problem Identification)

Students completed a pretest, explored the fundamental concepts of esterification, and conducted an esterification experiment. The learning partnership at this stage involved the laboratory technician, who assisted in preparing the laboratory equipment and chemicals.

Apparatus

Test tubes, test tube rack, dropping pipettes, 250 mL beaker, 100 mL graduated cylinder, test tube holder, tripod stand, wire gauze, Bunsen burner, matches, and thermometer.

Chemicals

2 mL of 96% ethanol, 2 mL of 99% glacial acetic acid, three drops of 95% concentrated sulfuric acid as the catalyst, distilled water for the water bath and rinsing, and 10 mL of 5% (w/v) sodium bicarbonate ($NaHCO_3$) solution to neutralize the remaining acid.

Experimental Procedure

Prepare a clean, dry test tube. Using a measuring pipette, transfer 2 mL of 96% ethanol into the test tube. Add 2 mL of 99% glacial acetic acid, followed by three drops (approximately 0.15 mL) of 95% concentrated H_2SO_4 as the catalyst. Gently shake the mixture until homogeneous. Prepare a water bath at 70–80°C, immerse the test tube, and heat the reaction mixture for 8–10 minutes. Remove the test tube using a test tube holder and allow it to cool for 2–3 minutes. If available, add approximately 10 mL of 5% $NaHCO_3$ solution to neutralize any remaining acid, then observe the formation of separate liquid layers. Identify the odor of the product using the wafting technique by gently fanning the vapors toward the nose rather than inhaling directly from the test tube. Record the aroma of the product and any observable changes during the reaction (Otera & Nishikido, 2009).

By the end of Session 1, students were expected to explain the principles of the esterification reaction between an alcohol and a carboxylic acid, analyze the functions of the laboratory apparatus and chemicals used in the experiment, write the balanced esterification reaction, and describe the applications of esterification in everyday life as foundational knowledge for the subsequent learning sessions.

Session 2 (Data Collection)

A representative from the partner perfume MSME was invited to the classroom as a guest speaker to explain the perfume production process, raw material selection, blending techniques, marketing strategies, and production cost analysis. Students participated in interviews and discussions to explore the relationship between the concept of esterification and the perfume industry.

Session 3 (Data Processing and Verification)

Students worked collaboratively in groups to produce a simple perfume based on the principles of the esterification reaction by modifying the composition of the ingredients according to the outcomes of their discussions with the SME partner. Each group determined its formulation, calculated the proportions of the ingredients, produced the perfume, evaluated its fragrance, discussed the product's market potential, and designed a product logo. Throughout the activity, both the teacher and the SME partner provided guidance and constructive feedback.

Session 4 (Generalization)

Each group presented its perfume product, explained the underlying chemical concepts, presented a production cost analysis, and discussed the business potential of the product. The learning sequence concluded with a posttest and a reflective learning activity.

Meanwhile, the control class followed conventional learning with discussion and lecture methods without chemoentrepreneurship and MSME partnerships. The data collection techniques used in this study were test and non-test. The test technique here was in the form of multiple-choice objective tests (pretest and posttest) to measure student learning outcomes, and student worksheets to measure critical reasoning, while the non-test method used student observation sheets to measure the graduate profile dimensions of creativity, collaboration, and communication. The indicators in measuring these graduate profile dimensions were taken from BSKAP Kemendikdasmen No 058/H/KR/2025 with the criteria of developing, competent, and proficient. The creativity dimension includes sub-dimensions of new ideas, flexibility of thinking, and creation. The collaboration dimension includes sub-dimensions of caring, sharing, and cooperation. Meanwhile, the communication dimension includes sub-dimensions of listening, speaking, reading, and writing.

The chemistry learning outcome instrument used to retrieve cognitive knowledge data in deep learning based on local partnerships and chemoentrepreneurship was in the form of multiple-choice questions with five alternative answers, and each question had only one correct answer. The core material used was Alkane Derivative Compounds (Esterification) covering cognitive aspects C1, C2, C3, and C4,5,6. Analysis of the research instrument in the form of chemistry learning outcome questions must meet the requirements of validity, reliability, difficulty level, and discriminating power (Saputri & Larasati, 2023). Item validation was carried out by testing 20 items of chemistry learning outcome test questions in 1 class other than the experimental and control classes.

The validation of objective items was tested using the point-biserial correlation formula (rpbis) and the normality testing with Kolmogorov-Smirnov Z. Hypothesis testing was conducted to see the difference in students' test scores between the experimental group with deep learning based on local partnerships and chemoentrepreneurship on the Alkane Derivative Compounds material (Esterification) and the control group. This hypothesis testing includes the N-Gain test to show the increase in students' understanding/mastery of concepts after the learning conducted by the teacher, and the Independent Sample t-test to determine whether or not there is a difference in averages between two unrelated sample groups, namely the learning outcomes between the experimental class and the control class. The formulation of the hypothesis in this study is as follows. Ho: There is no difference in chemistry learning outcomes between students who learn using deep learning based on chemoentrepreneurship and MSME partnerships and students who learn using conventional learning. H1: There is a difference in chemistry learning outcomes between students who learn using deep learning based on chemoentrepreneurship and MSME partnerships and students who learn using conventional learning.

RESULT AND DISCUSSION

Chemistry Learning Outcomes Achievement

Before applying the learning approaches to both classes, students were given pretest questions aiming to determine the initial capability of students in both groups. After that, each class received a different treatment according to its learning approach. At the end of the learning series, students were given posttest questions with the goal of knowing the extent of the increase in students' chemistry learning outcomes in understanding the Alkane Derivative Compounds material (Esterification Reaction). The learning outcome test instruments (pretest and posttest) used were in the form of objective tests consisting of 20 multiple-choice questions with 5 answer choices had been tried out and analyzed. The data on chemistry learning outcomes in the form of scores from working on chemistry learning outcome questions about the Alkane Derivative Compounds material (Esterification Reaction) are as follows.

Table 1. Chemistry Learning Outcome Scores

Data	Pretest		Posttest	
	E	C	E	C
Sample size	29	30	29	30
Highest score	75	75	100	95
Lowest score	25	25	80	65
Average	46.48	45.36	89.44	81.96

Based on the data analysis of the pretest that was carried out, it can be seen that student understanding of the Alkane Derivative Compounds material (Esterification Reaction) both in the experimental class and the control class was still very low. This is considered normal because learning activities had not yet been carried out. The low pretest scores represent a common condition when students have not yet received prior learning experiences related to the assessed topic, whereas the improvement in posttest scores reflects the impact of the instructional process that has taken place (Hattie & Zierer, 2024). Different results were shown after both classes conducted the learning process. This is shown by the students' posttest results which show an increase in learning achievement when compared to before the learning activities. The increase in posttest scores following instruction indicates an improvement in students' conceptual mastery as a result of the learning experiences they acquired during the intervention (OECD, 2023). The implementation of innovative instructional models has also been shown to significantly improve posttest performance (Yulianti et al., 2022). Furthermore, Buchs et al. (2023) reported that active learning enhances conceptual understanding, as reflected by higher posttest scores.

Table 2. N-Gain Score Data

N-Gain	Critical Reasoning		Learning Outcomes	
	E	C	E	C
Highest score	0.90	0.77	1.00	0.90
Lowest score	0.54	0.21	0.56	0.20
Average	0.75	0.48	0.81	0.66
Category	High	Medium	High	Medium

The chemistry learning outcomes of students in both the experimental class and the control class experienced an increase. Nevertheless, the data analysis of N-Gain scores shows that the average N-Gain in the experimental class was higher with a value of 0.81, which falls into the high category, compared to the average N-Gain in the control class whose value was 0.66, included in the medium category. Based on these data, it can be concluded that the increase in chemistry learning outcomes of the experimental class students was higher than that of the control class. These results also indicate that the average critical reasoning ability of students before and after the implementation of learning using a deep learning approach based on local partnerships and chemoentrepreneurship was in the high category, while learning with the conventional approach used by the teacher was in the medium category. These findings are consistent with those reported by Bailey et al. (2023), who found that although all groups generally demonstrated improvement, the class receiving the instructional intervention achieved substantially greater gains. This is also consistent with Weng's research, which found that the implementation of deep learning can enhance students' higher order thinking skill, such as critical thinking and problem solving abilities (C. Weng et al., 2023). Hypothesis prerequisite tests include normality tests and homogeneity tests. The results of the data normality test can be seen in Table 3.

Table 3. Normality Test Results

Class	Asymp Sig.(2-tailed)	Distribution
Experimental	0.365	Normal
Control	0.994	Normal

Based on data analysis using the SPSS Kolmogorov-Smirnov normality test, it can be seen that the samples were normally distributed in both the experimental class and the control class. This can be seen from the significance value (Asymp. Sig) > 0.05, which is 0.365 for the experimental class and 0.994 for the control class. Next, the results of the data homogeneity test can be seen in Table 4.

Table 4. Homogeneity Test Results

Variable	Levene Statistic	df1	df2	Sig.
Critical Reasoning	3.497	1	57	0.068
Learning Outcomes	3.333	1	57	0.074

The results of the homogeneity test for the control class and experimental class for the variables of critical reasoning and learning outcomes showed Sig. values of 0.068 and 0.074 respectively, where the Sig. value > 0.05, so it can be concluded that the samples have the same variance. An Independent Sample T-test was conducted to determine the difference in chemistry learning outcomes between the two classes.

Table 5. Independent Sample T-Test Results

Data	Description	Equal Variances Assumed
t-test for Equality of Means	t	4.799
	df	57
	Sig. (2-tailed)	0.000

The result of the Independent Sample T-test indicate that H1 is accepted, which can be seen from the calculated t-value of 4.799 and the significance from the table is 0.000 < 0.05, meaning that there is a difference in students' chemistry learning outcomes in learning using a deep learning approach based on chemoentrepreneurship and MSME partnerships compared to the learning conducted in the control class.

Graduate Profile Dimension Achievement

The results of the achievement analysis for the graduate profile dimension of creativity in the experimental class, which consisted of 29 students, are as follows.

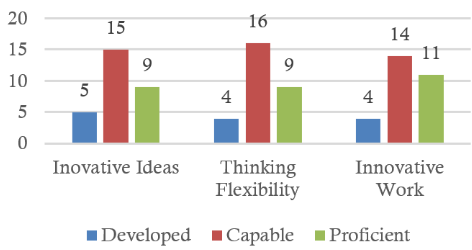

Figure 1. Achievement of the graduate profile dimension of creativity

In the new ideas sub-dimension, 9 students were proficient in producing several innovative ideas that were logical and effective while considering all the risks. As many as 9 students also had thinking flexibility in the proficient category in determining effective alternative solutions to problems in the environment and reflecting on the results of the solutions, and in the creation sub-dimension, as many as 11 students were in the proficient category of producing complex innovative works using various perspectives and evaluating their impacts and risks.

The increase in the creativity aspect in the experimental class can be explained through the implementation of deep learning based on local partnerships with perfume MSMEs combined with the Chemoentrepreneurship (CEP) approach. This learning provides an authentic learning experience because students do not only study the concept of esterification theoretically, but are also directly involved in the process of designing and making simple perfume products. These activities encourage students to generate new ideas related to scent combinations, determine alternative materials, and evaluate the quality of the products produced. In addition, the presence of perfume MSME partners provides a real stimulus regarding the production and product development processes in the business world. Direct interaction with practitioners allows students to gain new insights regarding product innovation and business opportunities, thereby triggering the emergence of creative ideas that are more contextual (Secundo et al., 2017).

The results of this study are supported by various previous studies showing that the CEP approach can increase creativity, higher-order thinking skills, and students' problem-solving abilities. Research by Sutarto et al., (2021) shows that chemoentrepreneurship-based chemistry learning is able to increase creativity and independent learning because students are involved in making products that are contextual and have economic value. Another study by Sumarni (2019) also states that CEP provides meaningful learning experiences so that students are more active in developing chemical-based product ideas and innovations. Creative ideas become more contextual when students work on real-world problems, engage in interdisciplinary dialoge, and experiment. Real-world problem-based programs foster creativity and entrepreneurship gradually throughout the learning cycle (X. Weng et al., 2022).

In the collaboration dimension, for the caring sub-dimension, as many as 15 students were in the proficient category of taking initiative to care about conditions in their environment; 17 students were in the proficient category of sharing, namely taking initiative to contribute to mutually empowering each other in practical activities and group discussions for perfume product making. As many as 17 students were proficient in the cooperation sub-dimension, namely taking initiative to cooperate with group peers and perfume entrepreneur speakers in learning activities.

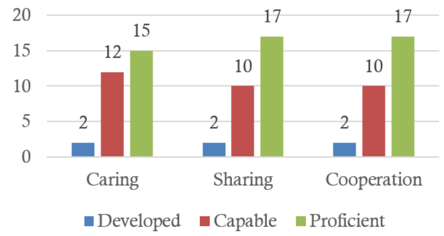

Figure 2. Achievement of the graduate profile dimension of collaboration

Deep learning with learning experiences that are conscious, meaningful, and joyful, along with learning partnerships with perfume MSMEs, is able to enhance collaboration by encouraging students and teachers to work together actively, think critically, and share perspectives to understand concepts meaningfully. The increase in the collaboration dimension occurred because the learning process was designed through group activities that required interaction, division of tasks, and collective decision-making (Leeuwen & Janssen, 2019). During the perfume-making practicum, students worked in groups to determine material composition, make observations, and compile product outcome analysis. These activities encouraged students to share ideas, respect the opinions of group members, and be responsible for their respective tasks.

Deep learning based on partnerships also strengthened collaboration because students did not only interact with peers but also with perfume MSME speakers. Through discussions with practitioners, students learned to build two-way communication, ask questions actively, and cooperate in understanding the actual perfume production process. Such learning situations create a social learning environment that supports the development of collaborative abilities (Cahill et al., 2015).

This communication dimension includes the sub-dimensions of listening, speaking, reading, and writing. In the listening sub-dimension, as many as 12 students were in the proficient category of listening actively to obtain explicit and implicit information, and providing relevant, critical, and structured responses. As many as 11 students were proficient in the speaking sub-dimension, namely delivering, exploring, and responding orally to various types of information in a way that is correct, precise, fluent, and highly effective. In the reading sub-dimension, 15 students were in the proficient category of reading actively to get explicit and implicit information, and providing relevant, critical, and structured responses. As many as 11 students were proficient in the writing sub-dimension, namely delivering, exploring, and responding in writing to various types of information in a correct, precise, fluent, and highly effective manner, as seen in the following diagram.

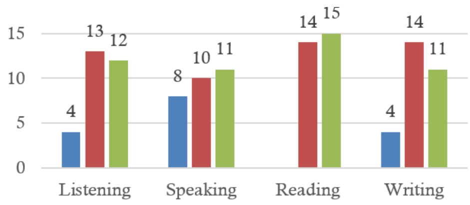

Figure 3. Achievement of the graduate profile dimension of communication

Deep learning applied using a discovery learning model based on partnerships and chemoentrepreneurship is able to improve mathematical/science communication through the presentation of complex scientific or mathematical ideas into a language that is understood. The increase in students' communication dimension was influenced by learning activities that provided broad opportunities for students to convey their ideas, communicate scientific concepts and thoughts both orally through discussions and in writing through the preparation of laboratory report (Vilela & Morais, 2025). In this learning, students conducted group discussions, presented practicum results, delivered analysis of perfume business opportunities, and responded to questions from other groups and MSME speakers.

These presentation and discussion activities trained students' ability to convey scientific information systematically and in an easily understood manner. In addition, direct interaction with perfume MSME actors created a more authentic communication situation compared to conventional learning. Students did not just talk to the teacher but also communicated with practitioners who had real experience in the business field. This condition increased students' confidence in asking questions, expressing opinions, and providing arguments. Communicative activities significantly improve oral skills, but they also boost students' confidence and willingness to participate in speaking tasks (Thi & Hue, 2024). The scientific method employed in the learning process effectively enhances writing and speaking skills, preparing students for their future careers (Montgomery et al., 2022).

Implementation of Deep Learning

The Deep Learning Framework enables the design of deep learning experiences steeped in creatingnew knowledge and solving real-life problems. Deep Learning is fostered when four learning designelements are intentionally integrated. These learning design elements are Learning Partnerships,Learning Environments, Leveraging Digital and Pedagogical Practices (Fullan & Quinn, 2020). The implementation of appropriate pedagogical designs, supported by technology, fosters participatory, contextual, and more meaningful learning (Haq & Prasetiyo, 2025). An adaptive and flexible curriculum provides space for project-based learning strategies, interdisciplinary approaches, and the contextual use of edtech tailored to students' need (Bal & Öztürk, 2025; Statti & Torres, 2020). In this way, deep learning can strengthen students' reflective, creative, and collaborative competencies-the key demans of the 21st century.

The process of deep learning based on local partnerships and chemo-entrepreneurship was implemented using the Discovery Learning syntax. The preparation of the teaching module was carried out by considering the characteristics of the students, namely that students had varied baseline knowledge regarding chemical reaction equations and functional groups, showed high interest in experimental activities, and had varied learning styles. The learning topic in this study was Esterification and Perfume Making Application. The learning topic was linked cross-disciplinarily (multi/inter-disciplinary) or related to the field of study or subjects studied by students, namely being linked to the Biology subject covering the human olfactory system, volatile compounds and aromatherapy, as well as the impact of chemicals on health and the environment. In addition, the learning was also linked to the Economics subject, namely directing students to think about business opportunities and perfume product innovations (production cost analysis, market analysis, value-added & product branding). This cross-disciplinary approach is able to combine various subjects to solve real problems, making the learning process more meaningful, contextual, and fun. In addition, this approach shifts the focus from memorizing facts toward conceptual understanding, critical thinking, creativity, and collaboration (Zhang et al., 2025). Interdisciplinary, theme-based learning activities rooted in real-world challenges foster students creative thinking, group communication, collaboration, and critical thinking skills through question-and-answer sessions and constructive criticism (Ye & Xu, 2023).

In implementing deep learningsg, it must contain four learning frameworks including graduate profile dimensions; learning principles, namely conscious, meaningful, joyful; learning experiences, namely understanding, applying, reflecting; and the learning framework as a systematic guide in compiling learning designs, namely pedagogical practices, learning partnerships, learning environments, and digital utilization (Kemendikdasmen, 2025). Learning partnerships form collaborative relationships to provide learning experiences, novel information, and feedback to students through contextual and real knowledge (Annor et al., 2023). Learning partnerships in this deep learning include partnership with laboratory assistants in preparing for learning, namely preparing practicum tools and materials; partnership with Perfume Entrepreneur MSMEs as speakers in the learning process in the classroom; and partnership with economics subject teachers in conducting learning assessments to evaluate perfume product innovation results in the form of production cost analysis, market analysis, value-added & product branding.

Local partnerships with MSMEs become an important factor in supporting authentic experience-based learning (experiential learning). Experience-based learning activities yield better learning outcomes than traditional learning environments (Burch et al., 2019).Collaboration between schools and local business actors allows students to gain direct insight into production processes, business management, marketing, to the actual challenges of the industrial world. The presence of practitioners or MSME actors in learning provides a more concrete and relevant learning experience compared to learning that only takes place inside the classroom. In addition, local partnerships help students understand the connection between chemistry concepts and community needs as well as economic potential in the surrounding environment. Through observation activities, joint practices, discussions, and collaborative projects with MSMEs, students obtain authentic learning experiences that can increase motivation, social skills, collaboration abilities, and readiness to face the world of work and entrepreneurship. Thus, learning becomes more meaningful because students learn from real and contextual situations.

The integration of chemoentrepreneurship (CEP) implementation in deep learning using discovery learning syntax is as seen in Tabel 6.

Table 6. Implementation of Deep Learning

Deep Learning Characteristics		Implementation in CEP-Discovery Learning
Learning Principles	Conscious	• Students understand the learning objectives, namely explaining the concept of esterification reaction and perfume making practicum • Students are active and motivated in learning
	Meaningful	• Contextual and/or relevant to real life • Connection with other fields of science (biology and economics) • Students analyze reactions and the quality of perfume products made
	Joyful	• Interactive learning environment, group collaboration • Interesting learning activities through practicum, interactive discussion with perfume MSME speakers • Achievement of the "AHA moment" (when students succeed in making perfume products)
Learning Experience	Understanding	Syntax 1: Stimulation • Exploration of alkane derivative concepts through videos and worksheets • Students actively construct knowledge to understand concepts or materials deeply from various sources and contexts Syntax 2: Problem Identification • Students are directed to identify problems related to esterification reactions in perfume making
	Applying	Syntax 3: Data Collection • Students seek information through observation of practicum materials and the perfume making process demonstrated by the speaker (perfume entrepreneur) – learning partnership • Group discussion, students respect each other's opinions

Deep Learning Characteristics	Implementation in CEP-Discovery Learning
	Syntax 4: Data Processing • Students conduct a simple perfume making practicum using the provided tools and materials • Perfume making procedures match the demonstration examples given by the speaker. • Students record changes in odor and characteristics. • Students compile a perfume business opportunity analysis
Reflecting	Syntax 5: Verification • Students match perfume results with ester characteristics. • Each group presents results and is responded to by other groups Syntax 6: Generalization • Students draw conclusions and reflect on the learning that has been done.

The results of this study indicate that there is a difference in the learning outcomes of students who followed learning using a deep learning approach based on chemoentrepreneurship and MSME partnerships compared to the control class. This is because deep learning facilitates students' active involvement, meaningful concept understanding through contextualization of chemistry materials with real life (based on MSME products), and development of graduate profile dimensions through learning activities that are conscious, meaningful, and joyful. As Jalil, (2026) pointed out, this approach also creates an enjoyable learning environment, reduces boredom, and strengthens positive relationships between teachers and students. Students get learning experiences starting from understanding, applying, and reflecting on their learning process in class. This is consistent with research (Haq & Prasetiyo, 2025) showing that the implementation of stategies such as, project-based learning, discovery learning, collaborative learning has been proven to enhance conceptual understanding, critical thinking skills, creativity, collaboration, and communication. In addition, these approaches contribute to strengthening empathy, social responsibility, and the development of reflective character.

The implementation of deep learning using this discovery learning syntax makes knowledge last longer (long-term memory) in memory because students find the concepts themselves, while simultaneously motivating students through direct learning experiences. Students are trained to reason critically, analyze, and solve problems through exploration via direct proof (Andelkovic & Maricic, 2023). Meanwhile, in the control class that applied conventional learning with discussion and lecture methods without chemoentrepreneurship and MSME partnerships, students were less able to explore themselves, received information more in a one-way manner, and thus were less actively involved in learning. This is consistent with the findings of Muizaddin & Santoso, (2016) and Alfian et al., (2020) who observed that students in the control group appeared more passive because they merely listened and took notes on what the teacher instructed. Students also sometimes lacked the confidence to ask questions or express their opinions, making it more difficult for teachers to identify their learning difficulties. Learning was less meaningful because students did not get direct experience in Esterification reaction lab and making perfume products. This had an impact on the learning outcomes and the graduate profile dimensions developed.

CONCLUSION

Based on the research results, it can be concluded that there is a significant effect between the implementation of deep learning based on chemoentrepreneurship and MSME partnerships on student learning outcomes. The integration of deep learning principles in chemoenterprenership learning has a stronger impact on developing students' critical thinking skills than without a deep learning approach. The difference in critical thinking skills is clearly seen in the post-test results, where the average critical thinking score of students in the class that applied Deep Learning was higher than that of the class that applied non-Deep Learning. This finding indicates that learning that emphasizes deep understanding, linking concepts to real contexts, and reflecting on the thinking process can encourage students to think more analytically, logically, and systematically in solving social studies problems. The learning experiences obtained also increased the achievement of students' graduate profile dimensions, namely creativity, collaboration, and communication.

The study contributes to science by extending the application of the Deep Learning framework through the integration of chemo-entrepreneurship and MSME partnerships, providing empirical evidence that contextual, industry-based learning can effectively enhance students' critical thinking and graduate competencies. Practically, these findings offer a replicable instructional model for chemistry educators seeking to implement meaningful and authentic learning experiences.

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