ARFAK CHEM
Chemistry Education journal
Vol 9 No 1, pp.826-840, 2026
p-ISSN: 2615-627X, e-ISSN: 2615-6255
Available online at: https://journalfkipunipa.org/index.php/accej

A Literature review on cooperative learning effects on student achievement in chemistry education

Edward Ifan Rumbewas[1], Achmad Rante Suparman[2], Faisal[2]*

[1]Education Office of Teluk Bintuni Regency, West Papua, Indonesia
[2]Department of Chemistry Education, University of Papua, Jl. Gunung Salju Amban, Manowkari
Corresponding Author E-mail: f.faisal@unipa.ac.id*

ARTICLE INFO:

Revised: 2026-04-19
Accepted: 2026-06-14
Published: 2026-06-17

Keywords:

Cooperative learning, chemistry, literature review, TPACK

ABSTRACT

This study aims to evaluate the impact of implementing cooperative learning models on students' academic achievement in chemistry. The main focus of this research is to examine the effectiveness of various cooperative learning approaches such as Jigsaw, Student Teams Achievement Division (STAD), Think-Pair-Share (TPS), and Group Investigation in enhancing students' understanding of chemical concepts at the secondary school level. The method employed in this study is a literature review, drawing on previous research findings published in both national and international scientific journals. The analysis reveals that, in general, cooperative learning models positively contribute to improving students' performance in chemistry, particularly in terms of cognitive achievement, active participation, and conceptual understanding. However, some research gaps were also identified, including the limited number of studies using mixed-methods approaches, the lack of exploration at the 11th and 12th grade levels, minimal integration with TPACK-based digital technology, and the suboptimal analysis of individual student factors such as gender and learning styles. These findings highlight the need for more comprehensive, context-specific follow-up research on the implementation of cooperative models in chemistry education.

How to cite: Rumbewas, E. I., Suparman, A. R., & Faisal. (2026). A Literature review on cooperative learning effects on student achievement in chemistry education. *Arfak Chem: Chemistry Education Journal, 9*(1), 826-840. https://doi.org/10.30862/accej.v9i1.1260

1. INTRODUCTION

Education is a process of interaction between teachers as facilitators and students as the centre of learning activities. In its implementation, teachers systematically design learning activities based on a set of guidelines and educational plans formulated as a curriculum. The previously implemented curriculum, namely the 2013 Curriculum, has been replaced by the Merdeka Curriculum, which began implementation in the 2022/2023 academic year. The Merdeka Curriculum provides educators with flexibility to adjust learning strategies based on each student's achievement levels and developmental stages. This curriculum also provides opportunities to modify the context and content of learning to meet needs. Furthermore, the Merdeka Curriculum is designed to develop students' creativity, critical thinking skills, collaboration, and communication skills. One learning model aligned with the spirit of the Merdeka Curriculum is cooperative learning (Farman et al., 2024).

Cooperative learning is an instructional approach that emphasizes collaboration within a learning community through the formation of study groups (Simamora et al., 2024; Suparman, 2018). This model encourages students to optimize their understanding through interaction and group discussion. By dividing students into several groups, active communication is fostered when discussing problems or materials provided by the teacher. Indirectly, students become more responsible for their groups and are encouraged to share information (Wahdini & Ilyas, 2024). The cooperative learning model has several main characteristics, namely cooperative tasks, shared goals, and rewards for group success. In this approach, success is achieved through mutual interdependence among group members, where each individual plays an important role in supporting the achievement of common goals, and individual achievement reflects the group's overall success. Therefore, to achieve the learning objectives, each member is required to support one another and actively contribute to their group's success (Mawati et al., 2021). Various techniques in cooperative learning include: 1) Student Teams Achievement Division (STAD); 2) Group Investigation (GI); 3) Jigsaw; 4) Teams Games Tournament (TGT); 5) Two Stay–Two Stray; 6) Make a Match Type; 7) Think Pair Share (TPS); 8) Numbered Heads Together (NHT); 9) Rotating Trio Exchange (Nurjayanti et al., 2018; Ngalimun, 2017; Sulistio & Haryanti, 2022).

Learning outcomes can be defined as behavioral changes that occur in students after participating in the learning process, encompassing cognitive, affective, and psychomotor aspects (Suma, 2021). Chemistry, as part of the Natural Sciences discipline, is often perceived by students as a subject that is difficult to understand and master (Suparman, 2017). The low achievement of learning outcomes in chemistry is partly caused by students' low interest in learning chemistry, as well as a sense of compulsion in participating in chemistry classes (Sanjiwani, Muderawan, I, & Sudiana, I, 2018).

In addition, students tend to assume that chemistry material is not relevant to their needs, abilities, interests, or areas of expertise (Priliyanti, Muderawan, & Maryam, 2021). As a result, chemistry is less favoured because students find it difficult and many feel bored (Muderawan, Wiratma, & Nabila, 2019). Active and collaborative learning has been shown to improve learning outcomes. One alternative approach is cooperative learning (Farman et al., 2024).

Several research findings support the effectiveness of cooperative learning in improving students' learning outcomes. Amanah (2023) found that the Jigsaw learning model enhanced students' achievement in hydrocarbon materials. Another study by Ibrahim (2021) also found that implementing the Jigsaw model had a positive impact on students' understanding of chemistry concepts. Furthermore, the use of the Group Investigation type of cooperative learning model has been proven to improve students' learning outcomes (Ledoh & Panjaitan, 2024). Similarly, implementing the Teams Games Tournament (TGT) cooperative learning model in classroom instruction resulted in a significant increase in students' learning outcomes.

Cognitive learning outcomes are divided into several categories of cognitive processes that serve as indicators of successful retention and transfer of knowledge. These cognitive processes are classified into six levels according to Bloom's revised taxonomy, as outlined by Anderson and Krathwohl. The cognitive processes in learning include six levels: remembering, understanding, applying, analysing, evaluating, and creating (Krathwohl & Anderson, 2019).

Fundamentally, chemistry encompasses two main aspects: chemistry as a product and chemistry as a process (Emda, 2017; Ningsih & Hidayah, 2020). These two aspects are closely interconnected and form an integrative unity; therefore, in the chemistry learning process, they cannot be separated (Sasmono, 2018). The concept of chemistry as both product and process is also taught at the senior high school (SMA) level (Laksmiwati, Hadisaputra, & Siahaan, 2018). At this level, chemistry subjects include the study of matter, covering composition, structure, properties, changes, dynamics, and energy involved at the molecular level, as well as scientific skills and reasoning (Astuti, 2020). Furthermore, chemistry learning at the senior high school level is delivered through three levels of representation: macroscopic, submicroscopic, and symbolic (Sagita, Azra, & Azhar, 2017; Sukmawati, 2019).

Macroscopic representation includes real phenomena that students can directly observe, either through laboratory experiments or in everyday life (Ibnu & Sutrisno, 2020; Wilandari, Ridwan, & Rahmawati, 2018). Submicroscopic representation refers to the abstract aspects of chemistry that explain macroscopic phenomena by visualising the particles that make up matter, such as atoms, molecules, and ions (Imaduddin, 2018). Because it is not visible to the naked eye, this representation cannot be directly observed; however, it is essential in helping students understand the mechanisms underlying a phenomenon (Hatimah & Khery, 2023). Meanwhile, symbolic representation is used to describe macroscopic phenomena through scientific symbols such as element symbols, chemical formulas, reaction equations, mathematical notations, graphs, and various forms of analogy and reaction mechanisms (Jariati & Yenti, 2020).

Based on the description above, a literature review examining the effects of cooperative learning models on students' learning outcomes in chemistry should consider the diversity of cooperative learning models implemented, the variation in instructional media or learning aids used, and differences in the chemistry topics taught. These variations necessitate identifying the most effective conditions for implementing cooperative learning. This type of study has not previously been conducted using 60 relevant articles. Therefore, it is highly necessary to investigate students' achievement further when cooperative learning models are applied..

This literature review aims to: (1) Analyse and synthesise findings from previous studies that have examined the effect of implementing cooperative learning models on students' learning

outcomes in chemistry. (2) Identify the various types of cooperative learning models used in previous research and evaluate the level of effectiveness of each model in improving students' chemistry learning outcomes. (3) Describe research trends regarding the influence of cooperative learning models in chemistry instruction. (4) Reveal research gaps in studies on cooperative learning and chemistry learning outcomes, which can serve as a foundation for the development of further research in the field of chemistry education.

2. METHODS

A. Research Design

This study employed a literature review design to examine the implementation of cooperative learning models in chemistry education. The review was conducted systematically through four stages: identification, screening, eligibility assessment, and inclusion of relevant articles. The objective was to identify research trends, research gaps, and the effectiveness of cooperative learning models in improving chemistry learning outcomes.

B. Research Target

The population of this study consisted of articles retrieved from Google Scholar (https://scholar.google.com). The search was conducted using combinations of keywords such as "cooperative learning", "chemistry learning", "chemistry education", "student achievement", "STAD", "Jigsaw", "TPS", and other variations of cooperative learning models.

The articles were selected based on predetermined inclusion and exclusion criteria.

Inclusion Criteria:

1. Articles published between 2020 and 2025.
2. Articles published in national peer-reviewed journals.
3. Articles indexed in SINTA or other reputable academic databases.
4. Articles focusing on the implementation of cooperative learning models in chemistry education.
5. Articles reporting empirical research findings related to learning outcomes, conceptual understanding, learning motivation, or student engagement.
6. Full-text articles are accessible to researchers.

Exclusion Criteria:

1. Conference proceedings, editorials, book reviews, and literature reviews.
2. Articles unrelated to chemistry education.
3. Articles that did not provide empirical data.
4. Duplicate articles were identified during the screening process.
5. Articles with incomplete methodological descriptions.

C. Research Data

The initial search identified 60 articles related to cooperative learning in chemistry education. After screening titles and abstracts, articles that did not meet the inclusion criteria were excluded. The remaining articles underwent full-text assessment to determine their eligibility. Finally, 60 articles that met all inclusion criteria were selected and analysed in this review.

The articles were classified based on publication year, authors, cooperative learning model type, chemistry topic, educational level, learning outcome indicators, and major findings.

D. Data Analysis

Data analysis was conducted using descriptive qualitative techniques. Each article was reviewed and coded according to the predetermined categories. The findings were synthesised to identify patterns in the effectiveness of cooperative learning models, dominant research themes, research trends, and existing research gaps. The synthesis process enabled the formulation of comprehensive conclusions concerning the development of cooperative learning research in chemistry education over the last five years.

3. RESULTS AND DISCUSSIONS

The scientific articles reviewed in this literature study examine the effects of cooperative learning models on students' learning outcomes in chemistry subjects.

A. Analysis and Synthesis of Previous Research Results

Based on the analysis of 60 research articles, several findings were obtained by the researchers, namely: a) The majority of research findings indicate that the implementation of the cooperative learning model has a positive effect on improving students' learning outcomes in chemistry. b) The cooperative learning model has been proven effective in increasing students' active participation, strengthening understanding of conceptual material, and producing higher cognitive learning achievements compared to conventional learning approaches. c) In general, the cooperative learning model can be widely applied to almost all topics or materials in chemistry learning.

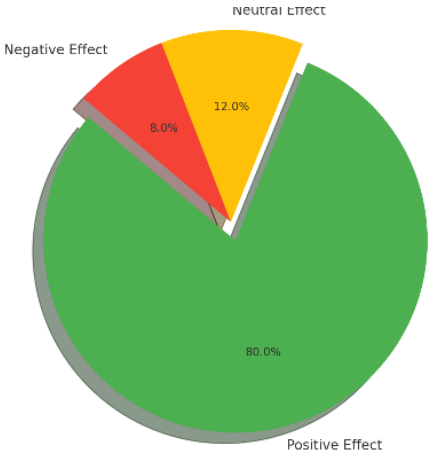

Figure 1. Graph of the Distribution of the Positive Effects of the Cooperative Learning Model on Learning Outcomes

Based on data from 60 analysed articles, 80% reported a significant improvement in learning outcomes, 12% reported neutral results, and 8% reported no significant effect.

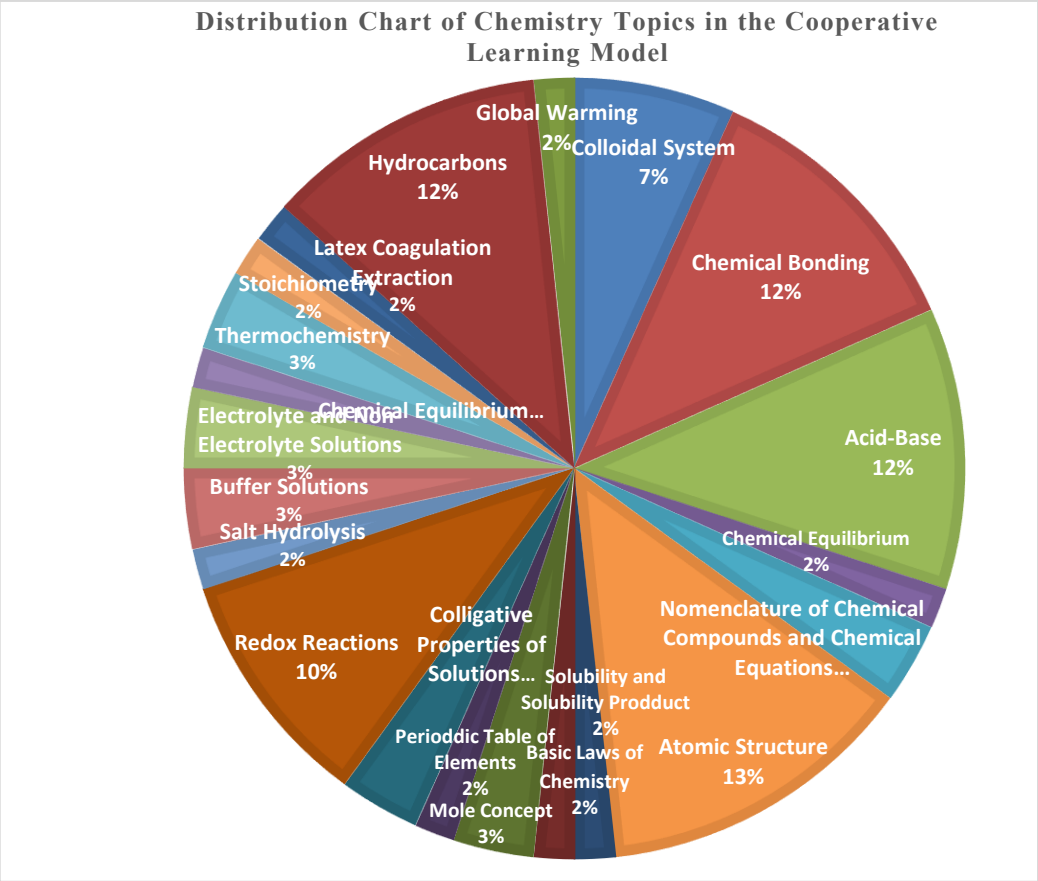

Figure 2. Distribution Chart of Chemistry Topics in the Cooperative Learning Model

Based on the analysis of 60 reviewed articles, it was found that the cooperative learning model can be widely applied to almost all topics in chemistry education.

B. Identification of Types of Cooperative Learning Models and Their Effectiveness

Based on an analysis of 60 reviewed research articles, the most frequently used cooperative learning models in chemistry education are shown in the following table.

Table 1. Effectiveness of Cooperative Learning Models

Cooperative Model	Number of Articles	Dominant Effectiveness
STAD	14	High
TGT	10	High
TPS	8	Medium- High
NHT	8	Medium- High
Jigsaw	6	Medium
GI	6	Medium
Make a Match	4	Medium
TAI	4	Medium

The STAD and TGT types have been proven to improve chemistry learning outcomes most consistently. TPS and NHT are effective in classes with strong verbal interaction. Jigsaw, GI, Make a Match, and TAI are better suited to students with strong group-work skills.

C. Trend of Recent Research Quantity

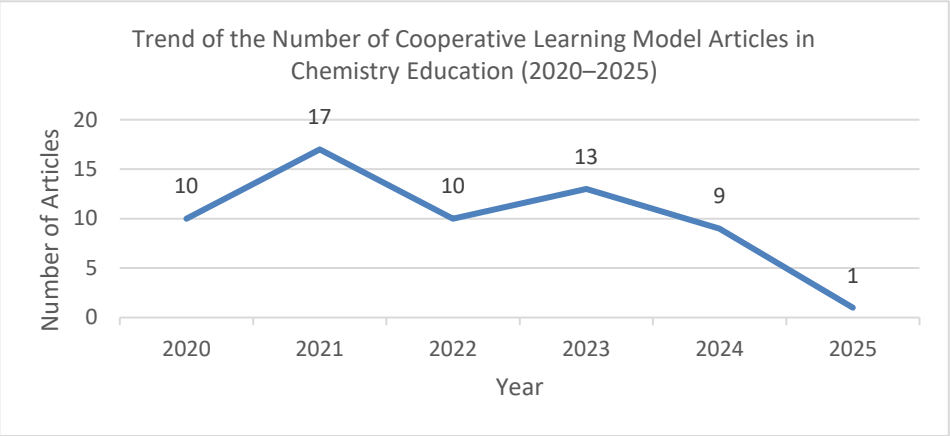

Figure 3. Trend of the Number of Cooperative Learning Model Articles in Chemistry Education

The trend in the number of articles researching cooperative learning models in chemistry education from 2020 to 2025 is as follows: a) The peak of research occurred in 2021 with 17 articles. b) There was a significant increase from 2020 to 2021 (from 10 articles to 17 articles), indicating a growing interest in this research topic. c) After that, there was a sharp decline in 2022 (back to 10 articles). d) In 2023, there was a slight increase to 13 articles. e) However, the trend then declined again to 9 articles in 2024.

D. Thematic Trend:

The graph above illustrates the trend in scientific publications on cooperative learning models in chemistry education from 2020 to 2025. The data shows that the number of publications fluctuated quite significantly throughout this period. In 2020, the number of published articles was recorded at 10. This number sharply increased in 2021, reaching the highest point during this period with 17 articles. This increase indicates a high level of interest among researchers in applying cooperative learning models in chemistry education at that time, which may have influenced the need for active learning methods during the transition to online learning prompted by the pandemic.

However, in 2022, the number of publications decreased back to 10 articles, the same as in 2020. This decline likely reflects a temporary saturation of the topic or a shift in research focus to other areas. In 2023, there was a slight increase to 13 articles, indicating that the topic still received attention, although not as high as before.

In 2024, the number of articles decreased again to 9. This decline warrants attention, as it could signal reduced interest in research on cooperative learning models in chemistry education or a shift toward other learning models considered more relevant to current needs.

Overall, this trend shows that although cooperative learning models were once a primary focus of research in chemistry education, their continuity as a research topic appears to have significantly decreased in recent years. This can serve as a point of reflection for educators and researchers to re-evaluate the effectiveness and relevance of cooperative approaches in the context of current and future science education.

E. Identification of Research Gaps

1. Limited Research Using Mixed Methods

Although the effect of cooperative learning models on chemistry learning outcomes has been widely studied, most studies remain dominated by quantitative approaches, particularly quasi-experimental designs. This approach tends to focus solely on cognitive scores, limiting its ability to provide in-depth insights into the ongoing learning process, student interactions, and the subjective experiences of teachers and learners. Research combining quantitative and qualitative approaches (mixed methods) remains very limited, even though this approach can provide a more comprehensive understanding of the effectiveness and dynamics of implementing cooperative learning models in chemistry classrooms.

2. Lack of Exploration at Senior High School Grades XI and XII

Research in grades XI and XII is still relatively limited, even though at this level, students encounter more complex chemistry topics such as thermochemistry, chemical equilibrium, and organic chemistry, which have significant potential for development through cooperative learning approaches. This gap needs attention, considering the characteristics and challenges of upper-level learning that require appropriate strategies to enhance conceptual understanding.

3. Limited Integrative Research and Technological Pedagogical Content Knowledge (TPACK) or Digital Technology Integration

In the digital era and 21st-century learning, integrating information technology into learning has become essential. However, research on cooperative learning in chemistry that explicitly integrates the TPACK (Technological Pedagogical Content Knowledge) framework is still very limited. The use of interactive digital media such as chemistry simulations (PhET), collaborative learning applications (Padlet, Google Jamboard), or Learning Management Systems (LMS) can enhance the effectiveness of cooperative learning models. This limitation indicates an opportunity for research to develop TPACK-based cooperative learning models suitable for the current digital context.

4. Limited Exploration of Differential Effects Based on Gender or Learning Styles

Research on the effects of cooperative learning models on chemistry learning outcomes remains largely general, failing to deeply examine contextual variables and individual student characteristics, such as gender and learning styles (visual, auditory, kinesthetic), within the studied population. Comparative analyses that reveal whether certain models are more effective for specific student groups are almost nonexistent. Understanding these differences is crucial to developing inclusive and responsive teaching approaches, ensuring that learning interventions are more targeted and have an optimal impact.

4. CONCLUSIONS

Based on the results of the research, analysis, and discussion, it can be concluded that:

a. Positive impact of cooperative learning models

Based on various studies, cooperative learning models consistently improve students' learning outcomes in chemistry. Implementing these models enhances student engagement, social interaction, and conceptual understanding of chemistry.

b. Common Types of Cooperative Learning Models Used in Chemistry Learning:
(1) Student Teams Achievement Division (STAD). This model has been proven effective in increasing student engagement and academic achievement, particularly in topics such as acids and bases, chemical bonding, colloid systems, atomic structure, redox reactions, and electrolyte and non-electrolyte solutions; (2) Teams Games Tournament (TGT). The use of the TGT model has improved student learning outcomes, especially in topics such as chemical bonding, atomic structure, buffer solutions, and colloid systems; (3) Think Pair Share (TPS). The TPS model contributes positively to increasing student motivation and conceptual understanding, particularly in learning topics such as salt hydrolysis, buffer solutions, and acids and bases; (4) Numbered Heads Together (NHT). The NHT model is effective in enhancing student learning outcomes across various chemistry topics, including acids and bases, basic chemical laws, colligative properties of solutions, and chemical equilibrium.

c. Research Trends
The findings indicate a growing interest in the application of cooperative learning models in chemistry education. Recent studies have increasingly explored integrating cooperative learning with various instructional media, including chemistry comics, student worksheets (LKPD), and other learning resources designed to enhance conceptual understanding, student engagement, and collaborative skills. However, most of these innovations remain focused on conventional or print-based media rather than on technology-enhanced learning environments. Furthermore, recent research has highlighted the growing attention to the implementation of cooperative learning within the context of the Kurikulum Merdeka, which emphasises student-centred learning, collaboration, critical thinking, and the development of 21st-century competencies.

d. Research Gaps
Despite the growing body of research, several gaps remain. First, studies employing mixed-methods approaches remain limited, resulting in a lack of a comprehensive understanding of both learning outcomes and learning processes. Second, research has predominantly focused on lower secondary and early senior high school levels, while studies involving Grade XI and XII students remain relatively scarce. Third, although some studies have integrated cooperative learning with innovative instructional media, research explicitly incorporating digital technology through frameworks such as Technological Pedagogical Content Knowledge (TPACK) remains limited. Most existing studies emphasise conventional learning media, leaving substantial opportunities for investigating technology-supported cooperative learning in chemistry education. Finally, limited attention has been given to examining the differential effects of cooperative learning across student characteristics, such as gender, learning styles, and other individual differences.

REFERENCES

Amanah, S. (2023). Penerapan Model Pembelajaran Jigsaw Untuk Meningkatkan Hasil Belajar Siswa Pada Materi Hidrokarbon Sekolah Menengah Atas. *Jurnal Hasil Penelitian Dan Pengembangan (JHPP)*, *1*(1), 35–40. https://doi.org/10.61116/jhpp.v1i1.25

Astuti, R. T. (2020). Relevansi Kegiatan Praktikum Dengan Teori Dan Pemahaman Mahasiswa Pada Mata Kuliah Kimia Dasar Lanjut. *Orbital: Jurnal Pendidikan Kimia*, *4*(1), 16–30. Retrieved from https://doi.org/10.19109/ojpk.v4i1.4336

Emda, A. (2017). Laboratorium Sebagai Sarana Pembelajaran Kimia Dalam Meningkatkan Pengetahuan Dan Ketrampilan Kerja Ilmiah. *Lantanida Journal*, *5*(1), 83. https://doi.org/10.22373/lj.v5i1.2061

Farman, Hamzah, R. A., Winarto, Setyaningrum, P. M. P., Reissyaf, M., Misesani, D., … Rahmah, S. (2024). *Cooperative Learning dalam Kurikulum Merdeka* (Cetakan Pe). Sumatera Utara: Sumatera Utara : PT. Mifandi Mandiri Digital.

Hatimah, H., & Khery, Y. (2023). Pemahaman konsep dan literasi sains dalam penerapan media pembelajaran kimia berbasis android. *Jurnal Ilmiah IKIP Mataram*, *8*(1), 111–120.

Ibnu, S., & Sutrisno, S. (2020). Pengembangan bahan ajar kimia materi hidrolisis garam dengan pendekatan scientific inquiry berbasis problem based learning. State University of Malang. https://doi.org/10.17977/jptpp.v5i7.13778

Ibrahim, R. A. (2021). Penerapan Model Pembelajaran Kooperatif Tipe Group Investigation untuk Meningkatkan Hasil Belajar Peserta Didik. *Syntax Idea*, *3*(17), 916–925. https://doi.org/10.46799/syntax-idea.v3i4.1172

Imaduddin, M. (2018). Analisis miskonsepsi submikroskopik konsep larutan pada calon guru kimia. *Edu Sains: Jurnal Pendidikan Sains & Matematika*, *6*(2), 1. https://doi.org/10.23971/eds.v6i2.983

Jariati, E., & Yenti, E. (2020). Pengembangan E-magazine berbasis multipel representasi untuk pembelajaran kimia di SMA pada materi larutan elektrolit dan non elektrolit. *Journal of Natural Science and Integration*, *3*(2), 138–150. https://doi.org/10.24014/jnsi.v3i2.10131

Krathwohl, D. R., & Anderson, L. W. (2019). *Kerangka landasan untuk pembelajaran pengajaran dan asesmen*. Yogyakarta: Yogyakarta : Pustaka Pelajar.

Laksmiwati, D., Hadisaputra, S., & Siahaan, J. (2018). Pengembangan modul praktikum kimia berbasis problem based learning untuk Kelas XI SMA. *Chemistry Education Practice*, *1*(2), 36–41. https://doi.org/10.29303/cep.v1i2.981

Ledoh, C. C., & Panjaitan, A. T. (2024). Implementasi Model Pembelajaran Kooperatif Tipe TGT untuk Meningkatkan Prestasi Belajar Kimia Siswa SMA. *Jurnal Ilmiah Pendidikan Dasar*, *09*(04), 718–732. https://doi.org/10.23969/jp.v9i4.18926

Mawati, A. T., Siregar, R. S., Fauzi, A., Purba, F. J., Sinaga, K., Ili, L., Bermuli, J. E. (2021). *Strategi pembelajaran*. Medan : Yayasan Kita Menulis.

Muderawan, I. W., Wiratma, I., & Nabila, M. (2019). Aanalisis Faktor-Faktor Penyebab Kesulitan Belajar Siswa pada Materi Kelarutan dan Hasil Kali Kelarutan. *Jurnal Pendidikan Kimia Indonesia*, *3*, 17. https://doi.org/10.23887/jpk.v3i1.20944

Ngalimun, S. M. (2017). *Strategi pembelajaran*. Yogyakarta: Parama Ilmu.

Ningsih, R. K., & Hidayah, R. (2020). Validitas KIT Praktikum Kimia Sebagai Media Pembelajaran Untuk Melatihkan keterampilan Proses Sains Siswa SMA Kelas X pada Materi Metode Ilmiah, Senyawa Kovalen Polar dan Non Polar Serta Larutan Elektrolit dan Non Elektrolit, *09*(February), 1–9. https://doi.org/10.26740/ujced.v9n1.p1-8

Nurjayanti, N., Morin, J. V., & Suparman, A. R. (2018). Meningkatkan Hasil Belajar Peserta Didik Menggunakan Model Kooperatif Tipe Group Investigation (GI) Untuk Materi Kelarutan Dan Hasil Kali Kelarutan Kelas XI IPA Di SMA Yapis Manokwari Semester Genap Tahun Ajaran 2015/2016. *Arfak Chem: Chemistry Education Journal*, *1*(1), 15-20. https://doi.org/10.30862/accej.v1i1.44

Priliyanti, A., Muderawan, I. W., & Maryam, S. (2021). Analisis Kesulitan Belajar Siswa Dalam Mempelajari Kimia Kelas Xi. *Jurnal Pendidikan Kimia Undiksha*, *5*(1), 11–18. https://doi.org/10.23887/jjpk.v5i1.32402

Sagita, R., Azra, F., & Azhar, M. (2017). Pengembangan Modul Konsep Mol Berbasis Inkuiri Terstruktur Dengan Penekanan Pada Interkoneksi Tiga Level Representasi Kimia Untuk Kelas X Sma. *Jurnal Eksakta Pendidikan (Jep)*, *1*(2), 25. https://doi.org/10.24036/jep.v1i2.48

Sanjiwani, Muderawan, I, W., & Sudiana, I, K. (2018). Jurnal Pendidikan Kimia Undiksha | 75 Jurnal Pendidikan Kimia Undiksha. *Jurnal Pendidikan Kimia Undiksha*, *2*(2), 75–84.

Sasmono, S. (2018). Project based learning untuk meningkatkan hasil belajar kimia siswa pokok bahasan hakikat ilmu kimia. *JIPVA (Jurnal Pendidikan IPA Veteran)*, *2*(2), 189–200. https://doi.org/10.31331/jipva.v2i2.727

Simamora, A. B., Panjaitan, M. B., Manalu, A., Siagian, A. F., Simanjuntak, T. A., Silitonga, I. D. B., … Sibarani, I. (2024). *Model Pembelajaran Kooperatif* (Cetakan Pe). Jawa Barat: Jawa Barat : Perkumpulan Rumah Cemerlang Indonesia.

Sukmawati, W. (2019). Analisis level makroskopis, mikroskopis dan simbolik mahasiswa dalam memahami elektrokimia. *Jurnal Inovasi Pendidikan IPA*, *5*(2), 195–204. https://doi.org/10.21831/jipi.v5i2.27517

Sulistio, A., & Haryanti, N. (2022). *Model Pembelajaran Kooperatif (Cooperative Learning Model)*. *Visipena Journal*. Jawa Tengah : Eureka Media Aksara.

Suma, A. (2021). Meningkatkan Aktivitas Dan Hasil Belajar Kimia Melalui E-Learning Berbasis Google Classroom. *Jurnal Lingkar Mutu Pendidikan*, *18*(1), 1–12. https://doi.org/10.54124/jlmp.v18i1.22

Suparman, A. R. (2017). Pengembangan Media Pembelajaran Kimia Berbasis Masalah Dipadukan Budaya Lokal Papua. *Jurnal Nalar Pendidikan*, *5*(1). https://doi.org/10.26858/jnp.v5i1.3280

Suparman, A. R. (2018). Penggunaan Model Kooperatif Tipe Group Investigation (GI) untuk Meningkatkan Aktivitas dan Hasil Belajar Mahasiswa pada Materi Struktur dan Sifat-Sifat Atom. *Quantum: Jurnal Inovasi Pendidikan Sains*, *9*(1), 17-22.

Wahdini, W., & Ilyas, M. (2024). Model Pembelajaran Kooperatif Tipe Scramble Terhadap Kemampuan Pemahaman Konsep Matematis. *Venn: Journal of Sustainable Innovation on Education, Mathematics and Natural Sciences*, *3*(1), 45–51. https://doi.org/10.53696/2964-867x.143

Wilandari, D. N., Ridwan, A., & Rahmawati, Y. (2018). Analisis Model Mental Siswa pada Materi Larutan Elektrolit dan Nonelektrolit: Studi Kasus di Pandeglang. *JRPK: Jurnal Riset Pendidikan Kimia*, *8*(2), 25–35. https://doi.org/10.21009/JRPK.082.03

Appendix
An Article on the Cooperative Learning Model

No	Author(s) and Year	Author Affiliation	Conclusion	Chemistry Topic	Link Articles
1.	Hamela Sari Sitompul, Intan Maulina. 2021	Universitas Efarina, Indonesia	Hypothesis testing at a significance level of α = 0.05 using a one-tailed (right-sided) t-test shows that t calculated > t table (3.05 > 1.667). Therefore, H_o is rejected and H_a is accepted. The results of the study indicate that the make-a-match learning model produces higher chemistry learning outcomes (68%) compared to conventional teaching (60%).	Colloid	https://jurnal.itscience.org/index.php/educendikia/article/view/1008
2.	Ramlan Silaban, Debora Pakpahan, Nurfajriani, Bajoka Nainggolan, Lisnawaty Simatupang. 2024	Universitas Medan (UNIMED), Indonesia	Hypothesis tests I and II using a right-tailed t-test show that $t_{calculated} > t_{table}$ (5.36 > 1.666 and 11.57 > 1.666), while Hypothesis Test III shows that $r_{calculated} > r_{table}$ (0.547 > 0.339). These results indicate that the use of Android-based SAC media with the STAD-type cooperative learning model has an effect on students' learning outcomes and interest in learning on the topic of bonding.	Chemical Bonding	https://www.ejournal.uncen.ac.id/index.php/JIPI/article/view/3697
3.	Brian Pontoh, Ignatius R.S. Santoso, Hardin F. Rares. 2021	Universitas Negeri Manado, Indonesia	The results of the study show that the average learning outcome of the experimental class (81.6) is higher than that of the control class (73.9), indicating that the cooperative learning model Think-Pair-Share (TPS) has an effect on learning outcomes in the acid–base topic.	Acid-base	https://indochembull.com/index.php/oxygenius/article/view/225
4.	Jeivana Laluas, Djefry Tani, Abdon Saiya. 2021	Univeritas Negeri Manado, Indonesia	The average learning outcome of the experimental class is higher than that of the control class. The t-test shows that t calculated > t table (1.778 > 1.67), indicating that the TAI-type cooperative learning model accompanied by laboratory practice has an effect on learning outcomes in the topic of chemical bonding.	Chemical Bonding	https://www.indochembull.com/index.php/oxygenius/article/view/240
5.	Kristiani Teke, Anderson Aloanis. 2021	Univertas Negeri Manado, Indonesia	The value of $t_{calculated} > t_{table}$ (4.399 > 1.717) indicates that the Group Investigation learning model has an effect on students' learning outcomes in the topic of chemical bonding.	Chemical Bonding	https://indochembull.com/index.php/oxygenius/article/view/265
6.	Maria Enny Retno Sari, Jeanne M. Tuerah. 2023	Universitas Negeri Manado, Indonesia	There is a difference in learning outcomes between students who use the STAD model supported by podcasts and those who receive conventional instruction on the acid–base topic. The t-test shows that the significance value (2-tailed) is 0.000 < 0.05, therefore H_o is rejected and H_1 is accepted.	Acid–Base Theory	https://indochembull.com/index.php/oxygenius/article/view/574
7.	Fransiskus Gultom, Marioga Pardede, Elisabeth Sitepu, Yona Gulo. 2024	Universitas Darma Agung, Medan, Indonesia	A one-tailed t-test shows that $t_{calculated} > t_{table}$ (3.898 > 1.671), indicating that the STAD-type cooperative learning model has a significant effect on chemistry learning outcomes in the topic of chemical equilibrium.	Chemical Equilibrium	https://j-las.lemkomindo.org/index.php/AFoSJ-LAS/article/view/836
8.	Yeni Anggraeni. 2022	Universitas Indraprasta PGRI, Indonesia	The average score of the experimental class (82.33) is higher than that of the control class (74.80). The Mann–Whitney test shows a significance value of 0.000 < 0.05, indicating a significant difference, which means that the Jigsaw II method improves students' learning outcomes.	Colloid	https://www.jurnalp4i.com/index.php/teaching/article/view/1299
9.	Ayu Rahayu, Alimuddin, Musdalifatul Adewia. 2023	Universitas Sembilanbelas November, Indonesia	The PLTL model has an effect on conceptual understanding in the topic of compound nomenclature (Sig. 0.000 < 0.05), with students' responses categorized as good (74%).	Nomenclature of Compounds	https://e-journal.uniflor.ac.id/index.php/JPM/article/view/2824
10.	Fransiskus Gultom, Selamat Karo-karo, Hernawaty, Marioga Pardede, Yona Gulo. 2023	Universitas Darma Agung, Indonesia	A one-tailed t-test shows that $t_{calculated} > t_{table}$ (3.898 > 1.671), indicating that the Group Investigation–type cooperative learning model has a significant effect on chemistry learning outcomes in the topics of compound nomenclature and chemical equations.	Compound Nomenclature and Chemical Equations	https://jurnal.darmaagung.ac.id/index.php/jurnaluda/article/view/3001
11.	Anisa Kurnia Dewi, Hisar Marulitua Manurung, Eva Pratiwi Pane. 2024	Universitas HKBP Nommensen Pematang Siantar, Indonesia	The average learning outcome of the experimental class (82.08) with an N-gain of 70.38% is higher than that of the control class (71.94) with an N-gain of 53.82%. The t-test shows a significance value of 0.000 < 0.05, indicating that the TGT cooperative learning model with creative animation media has an effect on students' learning outcomes.	Atomic Structure	https://jurnal.darmaagung.ac.id/index.php/jurnalrectum/article/view/5258
12.	Merlin, Nur Asbirayani Limatahu, Indra Cipta, Fadlan Muin. 2023	Universitas Khairun, Maluku Utara, Indonesia	The peer tutoring–type cooperative learning model with a scientific approach increases students' learning motivation (86–92%) and learning outcomes in the topic of solubility. The ANCOVA test shows that $t_{calculated} > t_{table}$ (5.75 > 1.68), with an N-gain of 0.65 (moderate category), and the affective and psychomotor outcomes of the experimental class are better than those of the control class.	Solubility and Solubility Product (Ksp)	https://ejournal.unkhair.ac.id/index.php/jpku/article/view/6403
13.	Fitri Amrin, Zulkifli Zam-Zam, Fitriana Ibrahim, Elsa Sri Wahyuni, Dira Ayu Annisa, Ilham S. W. Mauraji. 2023	Universitas Khairun, Maluku Utara, Indonesia	The NHT type cooperative learning model has an effect on students' learning outcomes in the acid–base topic ($t_{calculated}$ = 13.719); however, the magnitude of the effect is relatively low, with a gain value of 0.1.	Acid-base	https://ejournal.unkhair.ac.id/index.php/jpku/article/view/6406
14.	Candra, A. Ifriani Harun, Rini Muharini. 2022	Untan Pontianak, Indonesia	There is a difference in learning outcomes between the use of LKPD with the NHT model and conventional methods. NHT learning supported by LKPD has a strong effect (42.51%; Effect Size = 1.44) on students' learning outcomes.	Basic Laws of Chemistry	https://ojs.uniska-bjm.ac.id/index.php/daltonjurnal/article/view/6655
15.	Nur Asbirayani Limatahu, Khadijah. 2023	Universitas Khairun, Indonesia	The Group Investigation–type cooperative learning model improves learning outcomes in the topic of the mole concept ($t_{calculated} > t_{table}$: 5.48 > 1.63), with an increase of 91%.	Mole Concept	https://ejournal.unkhair.ac.id/index.php/Saintifik/article/view/7377

16.	Ismaun. 2023	IAIN Kendari, Indonesia	The TPS model has an effect on chemistry learning outcomes in the topic of chemical bonding ($t_{calculated}$ 7.75 > t_{table} 1.67). The average score of the experimental class (87.05) is higher than that of the control class (75.29), indicating that TPS is more effective than conventional instruction.	Chemical Bonding	https://ejournal.iainkendari.ac.id/index.php/kulidawa/article/view/7402
17.	Yuli Tamar Filindity. 2022	Universitas Pattimura, Maluku, Indonesia	The chemo-edutainment–based make-a-match model in the topic of atomic structure achieves a learning mastery of 96% with an N-gain of 0.75 (high category).	Atomic Structure	https://ojs3.unpatti.ac.id/index.php/sciencemap/article/view/7551
18.	Nurhasana Batubara, Febri Yanti, Eva Pratiwi Pane. 2023	Universitas HKBP Nommensen Pematang Siantar, Indonesia	Hypothesis testing shows sig < 0.05 (0.003 and 0.002), indicating that the Talking Stick model supported by Question Cards has an effect on students' interest and learning outcomes. The N-gain of the experimental class (58.8%) is higher than that of the control class (53%), showing a significant difference in the topic of the periodic table of elements.	Periodic Table of Elements	https://j-innovative.org/index.php/Innovative/article/view/7634
19.	Meissy Manik Ambarita, Hendra Simanjuntak, Febri Yanti. 2023	Universitas HKBP Nommensen Pematang Siantar, Indonesia	The TGT model has an effect on students' motivation and learning outcomes, with the average motivation score of the experimental class (97.33) higher than that of the control class (93.36). Learning outcomes are also higher, as shown by the pre-test scores (46.39 for the control class and 39.58 for the experimental class), post-test scores (82.08 for the experimental class and 71.94 for the control class), and N-gain (67.34 in the experimental class and 52.65 in the control class).	Atomic Structure and Nanotechnology	https://j-innovative.org/index.php/Innovative/article/view/7720
20.	Fitri Handayani Siregar. 2024	Politeknik Kesehatan YRSU Dr. Rusdi, Indonesia	The NHT-type cooperative learning model has an effect on chemistry learning outcomes, with a higher N-gain (0.64) compared to without NHT (0.48). There is a significant interaction between motivation and the learning model (sig. 0.017 < 0.05).	Colligative Properties of Solutions	https://jurnal.uisu.ac.id/index.php/CHEDS/article/view/10292
21.	Sani Ulan Sari, Nurbayani, Hidayati Oktarani, Qadis Pratiwi. 2022	UIN Ar-Raniry Aceh, Indonesia	Learning outcomes increased from 31.84% to 80.78% (sig. 0.000; effect size 3.26), indicating that the GI model has a significant effect. Students' responses were also high (86.9%), showing strong interest in the learning process.	Oxidation–Reduction Reactions	https://syekhnurjati.ac.id/jurnal/index.php/respec/article/view/12201
22.	Sofi Ira Fanti, Murtihapsari, Yunita Pare Rombe. 2022	Universitas Papua, Papua Barat, Indonesia	The TPS model supported by animated videos has a 60% effect on cognitive learning outcomes, with a significance value (2-tailed) of 0.000 < 0.05; therefore, H_o is rejected and H_a is accepted.	Salt Hydrolysis	https://ppjp.ulm.ac.id/journal/index.php/quantum/article/view/13977
23.	Nurlaili Dwi Ulfah, Jusniar, Surati Eka Putri. 2021	Universitas Negeri Makassar, Indonesia	The use of crossword puzzles (TTS) in the STAD-type cooperative learning model has a positive effect on students' interest and chemistry learning outcomes.	Oxidation–Reduction Reactions	https://ojs.unm.ac.id/ChemEdu/article/view/20436
24.	Zaki Amni, Hadi Kusuma Ningrat, Raehanah. 2021	Universitas Islam Negeri Mataram, Indonesia	The TGT model supported by destination media has an effect on learning motivation (sig. 0.017 < 0.05), but does not have a significant effect on learning outcomes (sig. 0.223 > 0.05), although the average score of the experimental class is higher than that of the control class.	Buffer Solution	https://journal.unnes.ac.id/nju/JIPK/article/view/25716
25.	Nursyam, Sumiati Side, Muhammad Jasri Djangi. 2022	Universitas Negeri Makassar, Indonesia	The N-gain of the experimental class (0.73) is higher than that of the control class (0.62). The t-test shows that $t_{calculated} > t_{table}$ (4.038 > 1.670), indicating that the Jigsaw model has a positive effect on learning outcomes in the topic of redox reactions.	Oxidation–Reduction Reactions	https://ojs.unm.ac.id/ChemEdu/article/view/32498
26.	Handayani, Muhammad Danial, Hardin. 2022	Universitas Negeri Makassar, Indonesia	The Think-Pair-Share method within the discovery learning model has a positive effect on students' learning outcomes.	Acid-base	https://ojs.unm.ac.id/ChemEdu/article/view/32949
27.	Mulianti Saharun, Murtihapsai, Yunita Pare Rombe. 2023	Universitas Papua, Papua Barat, Indonesia	The average score increased from a pre-test of 48.55 to a post-test of 75.03. The STAD model supported by video has a significant effect on learning outcomes (54%) with a moderate N-gain (60%, fairly effective), and shows a significant difference compared to conventional instruction.	Colloidal System	https://jurnal.uns.ac.id/jdc/article/view/72841
28.	Caroline Monica, Tritiyatma Hadinugrahaningsih, Darsef Darwis. 2021	Universitas Negeri Jakarta, Indonesia	The value of $t_{calculated} > t_{table}$ (1.995 > 1.668) indicates that the TAI-type cooperative learning model has a positive effect on learning outcomes in the topic of electrolyte and non-electrolyte solutions.	Electrolyte and Non-Electrolyte Solutions	https://journal.unj.ac.id/unj/index.php/jrpk/article/view/11866
29.	Nasral, Kurnia Nengsi. 2023	Universitas Muhammadiyah Bengkulu, SMA Negeri 9 Kota Bengkulu, Indonesia	The NHT and Jigsaw cooperative learning models have an effect on learning outcomes (sig. 0.001 < 0.05). The Jigsaw model is more effective than NHT and conventional instruction, with average learning outcomes of 75.76 > 72.63 > 65.21.	Equilibrium	https://jurnal.umb.ac.id/index.php/kependidikan/article/view/5399
30.	Jamilah, Rody Putra Sartika, Maria Ulfah. 2021	UNTAN Pontianak, Indonesia	There is a significant difference in learning outcomes between the STAD model and conventional instruction (31.77%), with the STAD model having an effect of 37.06% on students' learning outcomes.	Atoms and Their Constituent Particles	https://journal.upgripnk.ac.id/index.php/saintek/article/view/2465
31.	Organes Moses Kapisa. 2021	Universitas Papua, Papua Barat, Indonesia	The STAD model has a positive effect on cognitive learning outcomes in the topic of redox reactions, with a contribution of 27.9%.	Oxidation–Reduction Reactions	https://journalfkipunipa.org/index.php/accej/article/view/319
32.	Manuella Tandi Toding, Dian Oktavia Pandi. 2021	Universitas Papua, Papua Barat, Indonesia	The online TPS model has a significant effect on cognitive learning outcomes (sig. 0.000 < 0.025), with a contribution of 57%.	Buffer Solution	https://journalfkipunipa.org/index.php/accej/article/view/316
33.	Novi Dian Sari, Nur Arifah Adila Fahzal, Faisal. 2024	Universitas Papua, Papua Barat, Indonesia	The NHT-type cooperative learning model has a 78% effect on cognitive learning outcomes, with a significance value of 0.00 < 0.05, indicating a significant difference before and after instruction in the acid–base topic.	Acid-base	https://journalfkipunipa.org/index.php/accej/

					article/view/602
34.	Ernika Novianda, Sri Lestari, Yuli Hartati. 2025	Universitas Mulawarman, Kalimantan Timur, Indonesia	The average learning outcome of the experimental class (82.65) is higher than that of the control class (72.62), indicating that the Talking Chips model has a better effect on learning outcomes in the topic of thermochemistry.	Thermochemistry	https://journal.lpkd.or.id/index.php/Edukasi/article/view/1273/1771
35.	Jami' Lamhatil Ma'rifah, Mawadatur Rohmah, Firmansyah. 2020	Universitas Wahidiyah Kediri, Jawa Timur, Indonesia	The make-a-match cooperative learning model has a significant effect on learning outcomes (sig. 0.000 < 0.05), with the average score of the experimental class being higher than that of the control class.	Atomic Structure	https://ojs.uniska-bjm.ac.id/index.php/daltonjurnal/article/view/3108
36.	Karima Damai Ati, Hartatiana, Wiwid P Ningrum, Moh. Ismail Sholeh. 2021	Universitas Islam Negeri Raden Fatah Palembang, Indonesia	The TGT model has a significant effect on cognitive learning outcomes in the topic of colloidal systems, as shown by an increase in scores from 51.25 to 70.06. The paired samples t-test results show a significance value of 0.000 < 0.05; therefore, H_o is rejected and H_a is accepted.	Colloidal System	https://jurnal.radenfatah.ac.id/index.php/alilmi/article/view/16174
37.	Fena Prayunisa, Muhsinun. 2021	Institut Nusantara Global, Lombok Tengah, Indonesia	Learning outcomes increased in both classes, but were higher in the Jigsaw model (from 36 to 88) compared to conventional instruction (from 36.5 to 75), indicating that the Jigsaw model is more effective in the stoichiometry topic.	Stoichiometry	https://ejournal.nusantaraglobal.ac.id/index.php/jige/article/view/126
38.	Eva Pratiwi Pane, Fine Eirene Siahaan. 2020	Universitas HKBP Nommensen Pematang Siantar, Indonesia	The STAD model combined with concept maps improves learning outcomes by 40.89% and is higher than conventional instruction, as evidenced by $t_{calculated} > t_{table}$ (6.995 > 1.994).	Electrolyte and Non-Electrolyte Solutions	https://jurnal.uisu.ac.id/index.php/CHEDS/article/view/4621/0
39.	Nenni Faridah Lubis, Mutiara, Emmi Juwita Siregar. 2024	Institut Teknologi Sains Padang Lawas Utara, Indonesia	The value of $t_{calculated} > t_{table}$ (12.29 > 1.66) indicates that the Jigsaw-type cooperative learning model has a significant effect on chemistry learning outcomes.	Latex Coagulation Extraction	https://journal.ipts.ac.id/index.php/ED/article/view/5080
40.	Diana Londong Salu, Army Auliah, Pince Salempa. 2021	Universitas Negeri Makassar, Indonesia	The N-gain of the experimental class (0.609) is higher than that of the control class (0.509). The t-test shows that $t_{calculated} > t_{table}$, indicating that the student worksheet (LKS) with the Pair Checks model has a positive effect on learning outcomes in the redox topic.	Oxidation–Reduction Reactions	https://ojs.unm.ac.id/ChemEdu/article/view/20426
41.	Nurul Fahmi, Mohammad Wijaya, Mohammad Danial. 2021	Universitas Negeri Makassar, Indonesia	The t-test shows the effect of pre-quiz in the NHT model on students' motivation and learning achievement, with $t_{calculated} > t_{table}$ (1.48 > 1.828 and 2.625 > 1.674) in the topic of chemical bonding.	Chemical Bonding	https://ojs.unm.ac.id/ChemEdu/article/view/22399
42.	Musawwir Usman, Iwan Dini, Ramlawati. 2021	Universitas Negeri Makassar, Indonesia	The WSP media in the Talking Stick model has a significant effect on learning outcomes, but does not have a significant effect on students' attitudes toward chemistry.	Hydrocarbon	https://ojs.unm.ac.id/ChemEdu/article/view/26618
43.	Ayu Amalia Andi Mandasini, Alimin, Hardin. 2021	Universitas Negeri Makassar, Indonesia	The t-test shows that $t_{calculated} > t_{table}$ (3.36 > 2.07), indicating that Quizlet media in the TGT model has an effect on learning outcomes in the topics of atomic structure, the periodic table, and chemical bonding.	Atomic Structure, Periodic Table, and Chemical Bonding	https://ojs.unm.ac.id/ChemEdu/article/view/26625
44.	Novriza, Liza Utami. 2024	Universitas Islam Negeri Sultan Syarif Kasim	The Think-Talk-Write model has a significant effect on learning outcomes (sig. 0.000 < 0.05), with an improvement of 3% compared to the control class.	Global Warming	https://ejournal.uin-suska.ac.id/index.php/JCEI/article/view/29006
45.	Husnul Saptiani, Taty Sulastry, Ramdani. 2022	Universitas Negeri Makassar, Indonesia	The average score and N-gain of the experimental class (0.860) are higher than those of the control class (0.774). The Mann–Whitney test shows that $Z_{calculated} > Z_{table}$ (2.059 > 1.64), indicating that Uno card media in the STAD model has an effect on learning achievement in the hydrocarbon topic.	Hydrocarbon	https://ojs.unm.ac.id/ChemEdu/article/view/32494
46.	Nurfajrianti Akhmad, Taty Sulastry, Muh Yunus. 2022	Universitas Negeri Makassar, Indonesia	The data are normally distributed and homogeneous, and the t-test shows that $t_{calculated} > t_{table}$ (2.04 > 1.67). This indicates that the word search puzzle game in the TGT model has a positive effect on learning outcomes in the hydrocarbon topic.	Hydrocarbon	https://ojs.unm.ac.id/ChemEdu/article/view/39338
47.	Mega Febriyanti, Muhammad Danial, Muhammad Anwar. 2024	Universitas Negeri Makassar, Indonesia	The t-test shows that $t_{calculated} > t_{table}$ (2.79 > 1.99), with the average score of the experimental class (77.28) higher than that of the control class (68.63), indicating that the use of Macromedia in the TGT model has a positive effect on students' learning outcomes.	Hydrocarbon	https://ojs.unm.ac.id/ChemEdu/article/view/50730
48.	Dandi Suriyanto, Lukman Taufik, Syarifatul Mubarak. 2020	UIN Mataram, Indonesia	The Mann–Whitney test shows Asymp. Sig. 0.029 < 0.05 and Z_calculated -2.527 < 1.96, indicating that the STAD model has an effect on students' chemistry learning outcomes.	Acid-base	https://journal.uinmataram.ac.id/index.php/spin/article/view/2696
49.	Yohana Tandi, Sanusi Gugule, I Dewe Ketut Anom. 2020	Universitas Negeri Manado, Indonesia	The t-test shows that $t_{calculated} > t_{table}$ (4.087 > 2.018), indicating that the Jigsaw-type cooperative learning model accompanied by laboratory practice has an effect on learning outcomes in the topic of colligative properties of solutions.	Colligative Properties of Solutions	https://indochembull.com/index.php/oxygenius/article/view/168
50.	Doni Setiawan, Hadi Kusuma Ningrat, Raehanah. 2020	UIN Mataram, Indonesia	Students' learning outcomes using the TPS model are better than those using the conventional model. The test shows Asymp. Sig. 0.011 < 0.05, so H_a is accepted, meaning that TPS has an effect on students' chemistry learning outcomes.	Oxidation–Reduction Reactions	https://journal.uinmataram.ac.id/index.php/spin/article/view/2616

51.	Yonni Sepriani Tampubulon, Ajat Sudrajat. 2024	Universitas Negeri Medan, Indonesia	The TGT cooperative learning model has a positive and significant effect on learning outcomes, and learning motivation acts as a variable that strengthens this effect.	Chemical Bonding	https://edunity.publikasikupublisher.com/index.php/Edunity/article/view/313
52.	Ammi Latifatunnisak. 2020	MA NW Boro' Tumbuh, Lombok, Indonesia	The average score of the experimental class (76.7) is higher than that of the control class (66.8). The t-test shows that $t_{calculated} > t_{table}$ (2.86 > 1.998), indicating that the NHT model has an effect on chemistry learning mastery; however, it does not have an effect on student activity.	Hydrocarbon	https://jurnal.bimaberilmu.com/index.php/diksi/article/view/95/62
53.	Ramdanil Putri Yanti, Asregi Asril, Dwi Putri Musdansi. 2020	Universitas Islam Kuantan Singingi, Riau, Indonesia	The t-test shows a significance value (2-tailed) of 0.000 < 0.05 (one-tailed also remains significant), so H_o is rejected. Students' learning outcomes using the Jigsaw model are better than those using conventional instruction.	Hydrocarbon	https://ejournal.uniks.ac.id/index.php/JOM/article/view/1043/701
54.	Siti Nur Aisyah, Ratna Kusumawardani, Maasje Cathrine Watulingas. 2020	Universitas Mulawarman, Samarinda, Indonesia	The t-test shows that $t_{calculated} > t_{table}$ (12.70 > 2.01), indicating that the GQGA model has an effect on learning outcomes in the hydrocarbon topic.	Hydrocarbon	https://jurnal.fkip.unmul.ac.id/index.php/kpk/article/view/788/496
55.	Desy Rahmayanti Hasibuan, Rabiah Afifah Daulay, Anisa Hasibuan. 2022	IAIN Padangsidimpuan, Sumatera Utara, Indonesia	The t-test shows that $t_{calculated} > t_{table}$ (4.885 > 2.021), indicating that there is a difference in the improvement of learning outcomes between STAD with mind mapping and STAD with question cards, with a difference of 12.63%.	Chemical Bonding	https://jurnal.uinsyahada.ac.id/index.php/Lavoisier/article/view/5452
56.	Artika, Asregi Asril, Nofri Yuhelman. 2020	Universitas Islam Kuantan Singingi	The average learning outcome of the SAVI class is higher than that of the conventional class, with mastery levels of 97% versus 76.5%. The test shows a significance value of 0.000 < 0.05, indicating that the SAVI model has an effect on chemistry learning outcomes.	Thermochemistry	https://ejournal.uniks.ac.id/index.php/JOM/article/view/670
57.	Arif Munandar, Haerani. 2020	STKIP Bima, Indonesia	The TGT model has a significant effect on learning outcomes in the topic of electron configuration, with the average score of the experimental class (82.52) higher than that of the control class (69.67). The Mann–Whitney test shows a significance value of 0.000 < 0.05; therefore, H_o is rejected and H_a is accepted.	lectron Configuration	https://jurnal.stkipbima.ac.id/index.php/RE/article/view/402
58.	Ayu Rahmi, Henni Fitriani, Nurul Muna. 2021	Universitas Malikussaleh, Indonesia	The average learning outcome increased from 35.63 (pre-test) to 78.33 (post-test). The Wilcoxon test shows a significance value of < 0.05, so H_a is accepted. Students' learning interest is also categorized as good (73.33%). Thus, the Cooperative Script model assisted by picture cards has an effect on students' interest and learning outcomes in the topic of atomic model development.	Development of Atomic Models	https://ejurnalunsam.id/index.php/katalis/article/view/3738
59.	Susnenti. 2023	MAN 2 Pesisir Selatan, Indonesia	The STAD-type cooperative learning model has a significant effect on chemistry concept understanding, as do learning styles and their interaction. This indicates that STAD can improve students' understanding of chemistry concepts, and learning styles influence how students absorb the material.	Chemistry Concepts	https://lpppipublishing.com/index.php/alacrity/article/view/162
60.	Anita Septiani, Yuniati Tewa, Rahmanpiu. 2023	Universitas Halu Oleo, Kendari, Indonesia	The TPS model produced an average post-test score of 76.97 with very good learning activity (80.5%). An N-gain of 0.65 indicates that the TPS model is fairly effective in improving students' learning outcomes.	Acid-base	https://sains.uho.ac.id/index.php/journal/article/view/38