



## Improving high school students understanding through cooperative learning on atomic structure material

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### ABSTRACT

The learning of high school chemistry is divided into two phases, E and F. One of the materials in phase E that is difficult for students to understand is atomic structure. The objective of this study is to ascertain the impact of cooperative learning on students' comprehension. The comprehension of learners can be gauged by the outcomes of their learning during cooperative learning. The research was conducted at SMA Negeri 15, Semarang City, Central Java on 10 February 2024. The subject of the research was the entire X2 class of SMAN 15 Semarang in the academic year 2023-2024, comprising 36 students: 18 male and 18 female. The study employed a one-group pretest-posttest design. The objective of this study was to assess the impact of cooperative learning on students' learning outcomes. The study comprised three stages: a pre-test, a treatment period, and a post-test. The students' scores on the pretest ranged from 40.00 to 75.00, while their scores on the posttest ranged from 60.00 to 90.00. The values obtained from the pre-test and post-test were added to the data set and analysed using the normalised gain (N-Gain) test. The N-Gain test results indicated a value of 0.48, which signifies that the students' perception of their understanding of chemical concepts increased when they were taught using a cooperative learning model. Consequently, the endeavour to enhance students' comprehension of chemical concepts pertaining to atomic structure through the utilisation of a cooperative learning model was a resounding success.

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## INTRODUCTION

The development of a country is contingent upon the advancement of education. The Indonesian government is committed to the realisation of national education, as evidenced by the enactment of Law No. 20 of 2003. This legislation elucidates that education is an endeavour to cultivate an ambience conducive to learning, whereby students may become active and develop in the improvement of their personalities, intellects, moralities, and the skills necessary for themselves, society, the nation, and the state (Apriakanti et al., 2020). The existence of curriculum changes set by the government is one of the policies in achieving national education goals (Prasetyawati, 2021). The curriculum currently in place is the independent curriculum.

The implementation of an independent curriculum in Indonesia through the Merdeka Curriculum demonstrates both differences and similarities with other countries. Indonesia places a strong emphasis on flexibility for schools and teachers, although the implementation of this approach is still in its early stages. Finland has long been characterised by a highly autonomous system, which places a high degree of trust in the professionalism of teachers. The Australian approach utilises a national curriculum as a framework, with the autonomy of schools in its implementation.

This is supported by an established teacher development system. Singapore combines a robust national curriculum with initiatives designed to enhance flexibility, such as "Teach Less, Learn More". The primary distinction lies in the degree of implementation maturity, with Finland and Australia having a longer history of experience, while Indonesia is still in the process of adapting. Factors such as cultural context, educational resources, and teacher support systems also influence variations in implementation across countries (O.E.C.D., 2020; Sahlberg, 2021).

Pedagogically, the independent curriculum requires a student-centred learning environment, with teachers and students as subjects in the learning system (Sartini & Mulyono, 2022). This requires collaboration between students and teachers in the learning process to seek truth or knowledge so that learning is more meaningful (Wahyuni et al., 2024). The demands of the independent curriculum can be carried out well with the help of an appropriate learning model design (Soim Daimah, 2023). A review of international case studies on collaborative-based curriculum models reveals a range of outcomes. The Japanese "Lesson Study" initiative led to improvements in teaching quality, although it encountered time constraints. The Netherlands' "Design-Based Education" was observed to enhance student engagement while maintaining a balance between autonomy and the maintenance of standards.

The competency-based approach developed in New Zealand facilitated the acquisition of 21st-century skills, although it encountered challenges in relation to the complexity of assessment procedures. The "Teach Less, Learn More" approach adopted in Singapore has been successful in increasing flexibility while maintaining high standards. Despite achieving high student performance, Finland's collaborative model encountered consistency challenges across autonomous schools. These examples demonstrate that the successful implementation of such approaches depends on the provision of systemic support, professional development, and cultural adaptation.

The most common challenges encountered include those related to time management, maintaining standards, and developing appropriate assessments. These experiences offer valuable insights for countries implementing similar models (Darling & Dannels, 2003; O.E.C.D., 2020; Sahlberg, 2021). Cooperative learning is a model that is in line with the demands of the independent curriculum, this model involves students in learning activities, students can find knowledge (Herianto et al., 2021).

The field of cooperative learning has become an important and fruitful area of educational philosophy, application, and practice. In this teaching method, teachers divide students into small groups who work together and support each other in learning academic material and achieving common goals. From a theoretical perspective, it is clear that cooperative efforts are necessary to achieve optimal academic outcomes, including academic achievement, academic retention, and many other important educational outcomes (Simesso et al., 2024).

The cooperative learning model is appropriate when applied to chemistry learning. Cooperative learning can improve students' academic achievement compared to conventional teaching methods (Sibomana et al., 2021). chemistry is included in the science family that studies the interaction, structure and properties of a material (Herianto et al., 2021). Chemistry learning requires students to learn to find problems, make hypotheses, design simple experiments, analyse

data, draw conclusions, and convey the results of experiments in writing or orally (Sibomana et al., 2021).

Theories of motivation in cooperative learning place significant emphasis on the role of goals and rewards, as well as the systems through which they are distributed. One of the fundamental principles of cooperative learning is that of positive interdependence. This concept postulates that learners believe their success or failure is contingent upon their ability to work collectively as a group. Consequently, from a motivational perspective, cooperative goal agreements facilitate the achievement of individual goals by team members.

The achievement of individual goals by team members is contingent upon the success of the team as a whole. It is the responsibility of learners to motivate others to undertake any necessary tasks to ensure the success of the team and to provide support to their colleagues when conducting group activities. This is the only means by which they can achieve their own goals. Two theories that are particularly pertinent to the context of cooperative learning are the developmental model of cognition and the elaboration model.

In the independent curriculum, chemistry learning in high school is divided into stage E (grade X) and stage F (grade XI and XII) (Sumiarti, 2021). Phase E contains basic material that students need to acquire to study chemistry in more detail in Phase F (Yulianti & Haris, 2015). One of the chemistry learning materials in Phase E that is difficult for students to understand is Atomic Structure. The use of appropriate teaching materials or learning activities is a solution to overcome this problem (Santoso et al., 2009).

A grasp of the fundamental concepts of chemistry, in particular atomic structure, is of paramount importance in an independent curriculum, as it provides the basis for more advanced topics and cultivates critical thinking skills (Chang & Goldsby, 2016). This knowledge enhances scientific literacy, which is of great importance in our technology-driven world, and enables interdisciplinary connections with physics and biology (Tro, 2020). Mastering atomic structure develops problem-solving abilities and supports self-directed learning, which are valuable in many fields beyond chemistry (Zumdahl & Zumdahl, 2018). By focusing on these fundamental concepts, students develop a robust foundation for independent study and gain the capacity to comprehend more intricate chemical processes, ultimately equipping them for advanced coursework or real-world applications.

Understanding is a process of creating meaning from what is previously known, then connecting the new information with students' existing thoughts (Wahyuni et al., 2024). Indicators of student understanding include cognitive objectives such as interpreting, illustrating or giving an example, classifying, summarising, drawing conclusions, comparing, and explaining (Redhana, 2019). In other words, understanding is the ability to construct meaning, connect new information and integrate new knowledge based on the knowledge that students have in their own way.

Concept understanding is something very important because with good mastery of concepts will make it easier for students to learn chemistry. If students have difficulty and do not understand basic concepts, then students will have difficulty understanding the concept of the next concept. This is in accordance with the opinion of Sastrawijaya (1988) which suggests that concepts in chemistry are concepts that are tiered from simple concepts to higher level. To understand the concept higher level concepts need correct understanding of the basic concepts that make up that concept

The above problems form the basis of the importance of this research. This study aims to evaluate the impact of cooperative learning on students' understanding of atomic structure, with a focus on improving learning outcomes as an indicator of success. Through a pre-test and post-test approach, this study seeks to provide insight into the potential of cooperative learning in improving the understanding of challenging chemistry concepts for high school students.

## RESEARCH METHODOLOGY

The location of this research was at SMA Negeri 15 Semarang City, Central Java. The research was conducted on 10 February 2024. The research subjects were all X2 class of SMAN 15 Semarang in the academic year 2023-2024 as many as 36 students, consisting of 18 male students and 18 female students.

The research design used in this study was One-group pretest-posttest design. This design is used to determine the effect of independent variable (independent variable) cooperative learning on dependent variable (dependent variable) learning outcomes without looking at the control group (Knapp, 2016). The stages in this study are the research subject group measured the level of understanding before and after treatment. Measurement before treatment ( $O_1$ ) is called pretest, while measurement after treatment ( $O_2$ ) is called posttest (Meltzer, 2002).

$O_1 \rightarrow X \rightarrow O_2$

Description:

$O_1$  = pretest

X = cooperative learning

$O_2$  = posttest

The stages carried out in this study can be seen in the figure below:

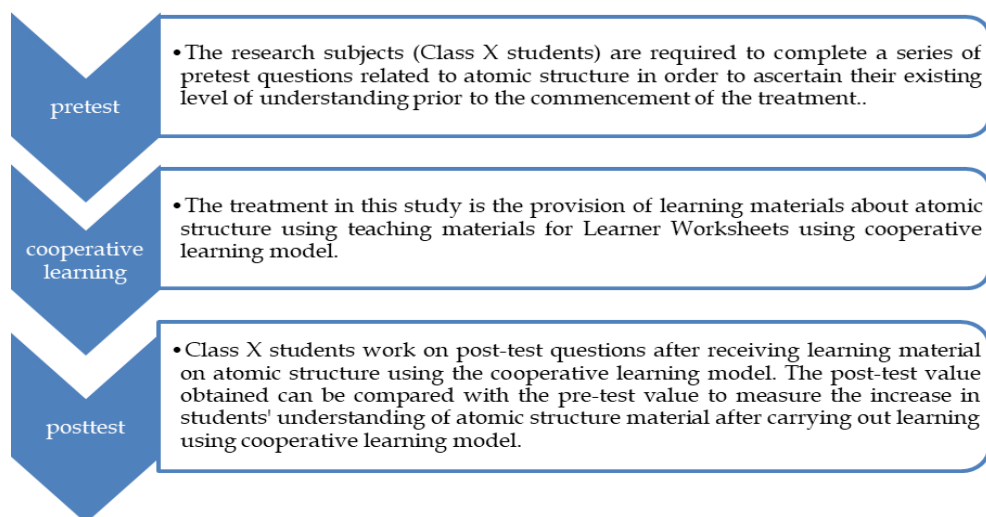


Figure 1. slow chart of the study

The data in this study were analysed using quantitative descriptive data analysis techniques. To analyse the completeness of the learning process, it is done by calculating the scores obtained by students on the answers to the questions given (Suyati & Ani Sutiani, 2018). To see the effect of giving treatment in the form of a cooperative learning model, N-Gain testing was carried out on the pretest-posttest test results using multiple choice questions. Students are said to have met the criteria for completion if they achieve sufficient learning completeness (score  $\geq 70$ ) (Falentina et al., 2022).

**Table 1.** Table of results completeness criteria

Score	Criteria
$90 \leq X < 100$	Very Good
$80 \leq X < 90$	Good
$70 \leq X < 80$	Fair
$45 \leq X < 70$	Less
$0 \leq X < 45$	Very Poor

Description:

X = Students score

The effect of providing treatment on student learning outcomes was analysed through the normalised gain (N-Gain) test of the pretest-posttest average value. Determination of the N-Gain value using the formula according to (Meltzer, 2002; Wahyuni, 2021), namely:

$$Y = \frac{S_{post} - S_{pret}}{S_{max} - S_{pret}}$$

Description:

Y = N-Gain value

$S_{post}$  = Average of posttest score

$S_{pret}$  = Average of pretest score

$S_{max}$  = Maximum score

The criteria for increasing the N-Gain value are shown in the following table

**Table 2.** N-gain criteria

N-Gain value	Criteria
$0,70 \leq y < 1,00$	High
$0,30 \leq y < 0,70$	Medium
$0,00 \leq y < 0,30$	Low

## RESULTS AND DISCUSSIONS

Cooperative learning is group learning that requires cooperation between group members to complete individual and group tasks given by the teacher. It is necessary to improve students' performance in participating in learning activities and foster an attitude of mutual cooperation in students' social behaviour. Cooperative learning is incomplete if one of the group members does not master the proposed learning material (Prasetyawati, 2021).

The results of group discussions are presented to other groups to be read and responded to. In understanding the material provided by the teacher, each group member must help each other by explaining to each other, because this greatly affects the mastery of the material. In addition, it also affects the improvement of student academic achievement.

Student learning outcomes in the study were obtained from test scores conducted to all students through pretest and posttest. This study analysed the results of the pretest and posttest to determine the improvement of students' understanding. The pretest questions were given before the implementation of cooperative learning and posttest questions after the application of cooperative learning models for learning chemical atomic structure. To find out the effect of cooperative learning, the results of the pretest and posttest scores were tabulated before the N-Gain test (Delina & Refelita, 2021). Tabulation of research data as follows

**Table 3.** Recapitulation of pretest and posttest scores

Data distribution	Pretest score	Posttest score
Lowest value	40,00	50,00
Highest value	75,00	90,00
Mean Average	55,16	69,67

Table 3. above shows that the lowest pretest score is 40.00 and the highest score is 75.00, then the lowest posttest score is 60.00 and the highest score is 90.00. This value shows that the learning treatment using the cooperative learning model can improve students' concept understanding. According to (Rostika, 2020), the cause of low student learning outcomes is ineffective classroom learning methods, one of which is a teacher-centred learning model. This is the cause of low student learning outcomes because students become passive in class.

This learning will facilitate the creation of a more extensive interaction between teachers and students, as well as between students and students and students and teachers (multi-way traffic communication). In co-operative learning, the teacher acts as a facilitator who serves as a bridge to higher understanding, with the students' own notes. The teacher does not just give knowledge to the student, but must build it in their mind as well. Students have the chance to gain practical experience in putting their ideas into practice. This presents an opportunity for students to apply their own ideas and engage in a more active learning process.

Student learning outcomes have increased after being given treatment in learning activities. The increase in student understanding can be seen in the average posttest score obtained. The criteria for the magnitude of the effect of the treatment of cooperative learning learning models on student understanding can be done through the acquisition of N-Gain values from the analysis of student pretest and posttest scores. The results of the N-Gain test are as follows:

**Table 4.** N-Gain test results

Average pretest score	Average posttest score	N-Gain Value	category
55,16	69,67	0,48	medium

The N-Gain test results showed a value of 0.48 with moderate gain criteria. According to (Surip, 2023), with the implementation of collaborative learning, students not only listen, but participate in the exchange of ideas and thoughts. With the increase in student achievement, students' attitudes and characters improve in every learning experience.

Another factor that causes increased learning outcomes is adequate resources to support learning activities in the classroom. In line with what was conveyed by (Martha, 2022) that inadequate classroom conditions, irregular arrangements, and the availability of inadequate facilities hinder learning. On the other hand, a good classroom allows learning to succeed. This opinion shows that good classroom conditions will create a good classroom atmosphere because it produces learning outcomes for students.

(Slavin, 2011)revealed that constructivism learning can be carried out by using a cooperative learning model, meaning that in learning techniques with this method students actively construct their own knowledge by using existing knowledge.

The interaction between students who apply this cooperative learning method can make students quickly understand and analyse the material discussed. With the help of explanations from smarter friends, students who experience delays in assimilating information will more quickly understand the material provided. In addition, students are taught to listen and respect other people's opinions. The application of this method allows intelligent students to develop characters such as tolerance, caring, responsibility and train their communication skills.

The cooperative learning model in science and chemistry learning has a great impact on students influence on students. The purpose of co-operative learning is different from conventional learning which applies competition system. Creating individuals with personalities and a sense of responsibility as well as building positive interactions is the essence of cooperative learning. and sense of responsibility as well as building positive interactions are the essence of the goal of cooperative learning (Triani et al., 2023). Cooperative learning provides many opportunities for learners to communicate and interact with other learners who come from diverse backgrounds, so

that learners become backgrounds, so that learners become active and produce reciprocity, which in turn leads to more positive interactions, positive on learning outcomes and learner responses. Whereas conventional learning is mostly conducted in one direction, namely the teacher as the centre of learning, so that students only receive material without playing an active role in the learning process. receive material without playing an active role in the learning process.

Through cooperative learning, students will build a sense of positive dependence, caring and acceptance of their friends' backgrounds in the learning process. and acceptance of their friends' backgrounds in the learning process, so that the learning objectives will be easier to achieve. will be easier to achieve. The results of this analysis research show that the treatment of co-operative learning models is more effective. the use of co-operative learning model is more effective than the use of conventional learning model. conventional learning model. This finding is in line with the results of meta-analysis research conducted by (Zorlu & Sezek, 2020), the overall average effect of the application of constructivism-based learning on based learning on constructivism in science-physics materials can improve learning outcomes and student responses.

Overall, the use of the cooperative learning model has achieved a high mean value of influence. These results indicate that the use of the cooperative learning model has an impact on improving students' understanding. This is in line with Johnson et al's 1981 meta-analysis research on cooperative learning models. The result is that the cooperative learning model provides higher achievement and productivity than competitive and individualistic learning. Cooperative learning is one of the best means of positively the classroom climate and motivate learning, thereby increasing positive attitudes and deeper self-esteem, encouraging higher achievement and developing collaborative skills.

## CONCLUSION

The increase in student understanding through cooperative learning model learning has an N-Gain test value of 0.48 with the criteria for a moderate level of improvement by Meltzer about N-Gain test value. The study's findings indicate that the utilization of a cooperative learning model had a positive impact on high school students' comprehension of atomic structure in chemistry, as evidenced by the significant increase in their perception of understanding chemical concepts. This suggests that cooperative learning can be an effective method for addressing the challenges students face in comprehending complex topics.

## References

- Apriakanti, D., Kusuma, M., & Nurhayati, M. (2020). The Effectiveness of Two Stay Two Stray (TSTS) Cooperative Learning Model in Improving Students' Critical Thinking Skills. *Journal of Science Education Research Journal*, 1, 40–43.
- Chang, R., & Goldsby, K. A. (2016). *Chemistry* (12th ed.). McGraw-Hill Education.
- Darling, A. L., & Dannels, D. P. (2003). Practicing engineers talk about the importance of talk: A report on the role of oral communication in the workplace. *Communication Education*, 52(1), 1–16.
- Delina, E., & Refelita, F. (2021). The Application Of Round Robin Techniques Cooperative Learning Model To Improve The Students Learning Outcome. *Educhemia*, 6(2). <https://doi.org/10.30870/educhemia.v6i1.11764>
- Falentina, V. F., Muchyidin, A., & Nasehudin, T. S. (2022). Van Hiele's Theory and Think Pair Share Cooperative Learning Model and Their Effect on Madrasah Tsanawiyah Student's Level of Mathematical Thinking. *Journal of General Education and Humanities*, 1(1), 1–11. <https://doi.org/10.58421/gehu.v1i1.2>
- Herianto, A., Nurjannah, N., Mahsup, M., Muhardini, S., Ibrahim, I., & Fitriani, E. (2021). Efforts to Improve Activeness and Learning Outcomes of Integrated Social Sciences Through Time Token Type Cooperative Learning Model. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di*

- Bidang Pendidikan, Pengajaran Dan Pembelajaran*, 7(3), 719. <https://doi.org/10.33394/jk.v7i3.2626>
- Knapp, T. R. (2016). Why Is the One-Group Pretest-Posttest Design Still Used? *Clinical Nursing Research*, 25(5), 467–472. <https://doi.org/10.1177/1054773816666280>
- Martha, A. D. (2022). Penerapan Model Pembelajaran Kooperatif Tipe Numbered Heads Together Untuk Meningkatkan Hasil Belajar dan Aktivitas Belajar Kimia. *Indonesian Journal of Educational Development*, 3(1). <https://doi.org/10.5281/zenodo.6563799>
- Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gain in physics: A possible “hidden variable” in diagnostic pre-test scores. *American Association of Physics Teachers*, 70(12), 1259–1268.
- O.E.C.D. (2020). *Education at a Glance 2020: OECD Indicators*. OECD Publishing. <https://doi.org/10.1787/69096873-en>
- Prasetyawati, V. (2021). Metode Cooperative Learning dalam Meningkatkan Kualitas Hasil Belajar Siswa pada Masa Pandemi Covid-19. *Epistema*, 2(2), 90–99. <https://doi.org/10.21831/ep.v2i2.41275>
- Redhana, I. W. (2019). Mengembangkan Keterampilan Abad Ke-21 Dalam Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, 13(1).
- Rostika, D. (2020). Penerapan Model Pembelajaran Kooperatif Tipe STAD Untuk Meningkatkan Hasil Belajar Kimia. *Indonesian Journal of Educational Development*, 1(2). <https://doi.org/10.5281/zenodo.4004041>
- Sahlberg, P. (2021). *Finnish Lessons 3.0: What Can the World Learn from Educational Change in Finland?* Teachers College Press.
- Santoso, A., Nurkhotimah, A. N., & Harintosasi, R. (2009). Meningkatkan keaktifan dan hasil belajar pada materi struktur atom dan nanoteknologi dengan menerapkan model pembelajaran project-based learning (PjBL). *Jurnal Kajian Pendidikan Indonesia (JKPI)*, 1(1).
- Sartini, & Mulyono, R. (2022). Analisis Implementasi Kurikulum Merdeka Belajar Untuk Mempersiapkan Pembelajaran Abad 21. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, 8(2), 1348–1363. <https://doi.org/10.36989/didaktik.v8i2.392>
- Sibomana, A., Karegeya, C., & Sentongo, J. (2021). Effect of cooperative learning on chemistry students' achievement in Rwandan day-upper secondary schools. *European Journal of Educational Research*, 10(4), 2079–2088. <https://doi.org/10.12973/EU-JER.10.4.2079>
- Simesso, M. D., Gutu, T. S., & Tarekegn, W. M. (2024). *The Contribution of Using Cooperative Learning Methods on Students' Achievement and Retention in Secondary Schools during Chemistry Lesson*. Education Research International.
- Slavin, R. (2011). *Cooperative Learning: Theory, Research and Practice* (N. Yusron (ed.)). Nusa Media.
- Soim Daimah, U. (2023). Pembelajaran Matematika pada Kurikulum Merdeka dalam Mempersiapkan Peserta Didik di Era Society 5.0. *SEPREN: Journal of Mathematics Education and Applied*, 04(02), 131–139. <https://doi.org/10.36655/sepren.v4i1>
- Sumiarti. (2021). *Modul ajar kimia fase e kelas x struktur atom dan aplikasinya dalam nanoteknologi*. 4(1), 1–23.
- Suyati, & Ani Sutiani, dan. (2018). Upaya Meningkatkan Hasil Belajar Kimia Siswa Melalui Model Pembelajaran Discovery Learning Pada Materi Termokimia Di Man 2 Model Medan. *Jurnal Penelitian Bidang Pendidikan*, 24(1), 22–27.
- Triani, F., Praminta, R., Tusa'diah, H., & Yolanda, S. A. (2023). Effects of Cooperative Learning Model in Science Learning on Students' Cognitive and Critical Thinking Ability: A Meta Analysis. *Journal of Innovative Physics Teaching*, 1(1), 76–84. <https://doi.org/10.24036/jipt/vol1-iss1/10>
- Tro, N. J. (2020). *Chemistry: Structure and properties* (3rd ed.). Pearson.
- Wahyuni, S. (2021). Penerapan Model Pembelajaran Kooperatif Tipe STAD dapat Meningkatkan Hasil Belajar Kimia di Kelas XI IPA 1 SMA Negeri 2 Kampar. *Jurnal Pendidikan Tambusai*, 5(3), 6947–6954.
- Wahyuni, S., Muyassaroh, A., Ria Budiarty, E., Puji Rahayu, E., Karolina, A., & Dzabillah Zahira, A. (2024). Pemahaman Konsep Peserta didik Menggunakan Pembelajaran Discovery Learning pada Materi Nanomaterial. *Jurnal Riset Dan Praktik Pendidikan Kimia*, 12(1), 34–41.
- Yulianti, R., & Haris, M. (2015). Pengaruh Model Pembelajaran Kooperatif Tipe Two Stay Two Strat (STS) Dengan Pendekatan Brain-Based Learning Terhadap Hasil Belajar Kimia Materi Pokok Struktur Atom dan Sistem Periodik Unsur Pada Siswa Kelas X SMAN 1 Kediri. *J Pijar MIPA*, 1, 57–60. <https://doi.org/10.29303/jpm.v18i1.3186>
- Zorlu, Y., & Sezek, F. (2020). An Investigation of the Effect of Students' Academic Achievement and Science Process Skills Application Together With Cooperative Learning Model and the Modeling Based



Teaching Method in Teaching Science Courses. *International Journal of Progressive Education*, 16(4), 135-157. <https://doi.org/10.29329/ijpe.2020.268.9>  
Zumdahl, S. S., & Zumdahl, S. A. (2018). *Chemistry* (10th ed.). Cengage Learning.