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The effectiveness of thermochemistry's ludo game media for improving students' learning outcomes and collaboration skills

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ABSTRAK

Penelitian ini dilakukan untuk mengukur efektivitas penggunaan media permainan ludo materi termokimia terhadap hasil belajar dan keterampilan kolaborasi peserta didik. Penelitian ini menggunakan one group pretest-posttest design dengan pengambilan sampel menggunakan teknik purposive sampling yang melibatkan siswa kelas XI-2 berjumlah 33 orang. Hasil pengolahan data penelitian menemukan rata-rata efektivitas pembelajaran pada pertemuan I sampai IV secara berturut-turut mencapai 69,62; 72,41; 84,24; dan 85,51; yang mencapai kategori semakin efektif pada pertemuan IV. Hasil belajar diukur melalui pretest dan posttest dengan nilai rata-rata berturut-turut sebesar 25 dan 82,12. Uji hipotesis dengan uji T berpasangan menyatakan nilai T_{hitung} = 33,60 dan diketahui nilai T_{tabel} = 2,037 maka nilai $T_{hitung} > T_{tabel}$, artinya hasil belajar meningkat signifikan setelah penggunaan media permainan ludo materi termokimia. Peningkatan hasil belajar berada pada kategori tinggi dengan skor N-Gain = 0,765. Hasil angket keterampilan kolaborasi memperoleh skor rata-rata sebesar 85,32, termasuk kategori sangat tinggi. Dari penelitian ini ditemukan bahwa media permainan ludo materi termokimia terbukti mampu meningkatkan hasil belajar dan keterampilan kolaborasi peserta didik.

ABSTRACT

This study measured the effectiveness of using Ludo game media on thermochemistry on students' learning outcomes and collaboration skills. This study used a group pretest-posttest design with a purposive sampling technique involving class XI-2 with 33 students. The results of the research data processing found that the average learning effectiveness from meetings 1 to 4 consecutively reached 69.62, 72.41, 84.24, and 85.51, which reached the increasingly effective category at meeting IV. Learning outcomes were measured through pretest and posttest with average values of 25 and 82.12, respectively. The paired T-test states that T_{count} = 33.60 and the T_{table} = 2.037, thus $T_{count} > T_{table}$, meaning that learning outcomes increased significantly after using the ludo game of thermochemistry. The improvement in learning outcomes in the high category with N-Gain score = 0.765. The results of the collaboration skills questionnaire obtained an average score of 85.32 (very high category). So, this study concluded that Ludo game media on thermochemistry proved to improve the students' learning outcomes and collaboration skills.

INTRODUCTION

Chemistry is a part of science with an essential role in human life. In general, it discusses a substance's composition, structure and properties, changes, and energy. This field involves the skills and reasoning of students, so it is urgent to learn as a provision for the student's knowledge, understanding, and ability to develop science and technology. Chemistry learning must pay attention to the attitude, process, and results of its application (BSNP, 2006). Thermochemistry applications are frequently found in daily life. In general, this material discusses the theory of enthalpy changes in chemical reactions, exotherm and endotherm reactions, thermochemistry equations, Hess' law, enthalpy changes in formation reactions, and bonding energy. In other words, thermochemistry materials discuss the relationship between energy and chemical reactions. This material is so complex that students often find difficulty understanding it (Zakiyah et al., 2018). Moreover, it is commonly proven that students tend to memorize the subtopics of thermochemistry without having a deep understanding of the concepts. Thus, students have difficulty illustrating the concrete application of the materials through phenomena in daily life (Sanjaya, 2020).

The discovery of facts in the school environment regarding learning difficulties experienced by students in learning chemistry comes from interconnected internal and external factors. Internal factors refer to students' low motivation and enthusiasm for learning, low initial and final understanding of the materials, and limited mathematical skills. Student's final understanding after receiving learning indicates the level of learning achievement of objects designed by teachers (Sariati et al., 2020). Moreover, external factors such as teachers' less ideal ability to find and apply the appropriate learning models, methods, and media can reduce students' interest in learning. This is because monotonous and not varied teaching methods make students more easily bored (Sudrajat, 2020). Similarly, when the learning model used is only teacher-centered, for example, the lecture method will limit the active participation of students. The current learning curriculum demands student-centred learning. This is to foster independence and encourage student activity during learning (Adriana et al., 2025). The role of teachers in addressing students' learning difficulties is vital, namely through the use of appropriate learning methods, models, and media. Therefore, teachers should be able to link the learning of thermochemistry with phenomena in the environment to attract the attention and motivation of students to explore further (Sintia & Jasmidi, 2022).

In designing learning activities, teachers apply specific learning methods based on the learning objectives and materials, students' characters, situations, learning facilities in the classroom, and teachers' abilities. For a learning method to be implemented effectively, it requires the support of a suitable learning model (Prahesti & Fauziah, 2021). The trend in the 21st century is that teachers implement learning that hones students' creativity, critical thinking, collaboration skills, and communication skills. In addition, education is not only demanded to make students proficient in knowledge but also to master the skills (Mardhiyah et al., 2021).

Observation activities by the authors for two weeks at State Senior High School 10 Medan unveiled that students' Chemistry scores tended to be below the limit of completeness, one of which is in class XI-2 where only 24.24% of students scored above the limit of completeness. This means that the learning was ineffective because the ones who did not achieve completeness reached 71% of the total students, as in the study of Rochman et al., (2018). In addition, Chemistry learning employed conventional methods such as lectures and teacher presentations, so it did not involve students actively. It also focused on textbooks without being accompanied by practicums or attracting learning media, which reduced students' enthusiasm for learning. They tend to experience learning difficulties triggered by limited information and not finding peers to discuss. This was because the learning was usually individually and rarely in groups. This certainly affects the enthusiasm and understanding of students in thermochemistry (Barutu & Simatupang, 2023).

Several previous studies have shown efforts to address students' learning difficulties in thermochemistry through the development and application of creative and innovative learning media in the form of assessment instruments, various media applications, and innovative learning models (Azizah & Kamaludin, 2023). Learning media in the form of Ludo games is one of the learning media developments that adopts the ludo game system, which can create a sense of fun

when played. In learning, this game can create an enjoyable learning atmosphere through the interaction of students in groups (Lestari & Iswendi, 2021and Stanley, 2022). In addition, the ludo game can increase the enthusiasm and excitement of students because of the uniqueness of its game system and media design (Fadillah & Iswendi, 2019). The ludo game as learning media is expected to address learning difficulties for students so that learning becomes effective and capable of developing 21st-century skills in students (Mardiana & Djazari, 2015).

Another study by Alia & Iswendi (2021) on "Development of Chemical Ludo Games as Learning Media of Thermochemistry Material" states that the ludo developed based on thermochemistry has a fairly high validity and practicality. In addition, in a study by Indriliza & Iswendi (2019) and Khairani & Iswendi (2023), the application of chemistry ludo games as learning media has high effectiveness for increasing students' activeness and learning outcomes.

Based on the description above, this study aimed to measure the effectiveness of using the ludo game of thermochemistry on students' learning outcomes and collaboration skills. Existing studies show that researchers exclusively conducted studies on the development and application of Ludo games on students' learning outcomes. So, the added variable of this study is the students' collaboration skills, which are one of the skills students must master today. Finally, this study was vital to help teachers find suitable learning media and models to improve learning outcomes and students' collaboration skills in thermochemistry. Hopefully, this study can provide scientific contributions for future researchers.

METHOD

This study is a descriptive quantitative research. A study with this approach is carried out to test the hypothesis in a particular sample. Data collection was conducted using test and non-test research instruments in the form of statistical data (Sundari et al., 2024). The research employed a one-group pretest-posttest design. Research with this design focuses on one experimental class without involving other classes as control classes. This research is a pre-experimental design because the subjects in the study were not randomly assigned (Creswell & Creswell, 2018). The population was class XI at State Senior High School 10 Medan. With the purposive sampling technique, 33 students of class XI-2 were the experimental sample.

The experimental class took a pretest at the beginning and a posttest at the end of learning. The learning meeting applied the Teams Games Tournament (TGT) type of cooperative model and ludo game of thermochemistry material. The study attempted to determine the effectiveness of the learning on the student's cognitive learning outcomes and collaboration skills. The research design is summarized in Table 1.

Table 1. Research design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2

Information:
O_1 = Pretest for the experimental class
O_2 = Posttest for the experimental class
X = Learning using Ludo games of thermochemistry material and Teams Games Tournament (TGT) type of cooperative learning model

The instrument used in this study is a test instrument of 20 multiple-choice questions with five options (A, B, C, D, and E). This instrument measured the students' cognitive learning outcomes before and after the learning. Before being used, the instrument passed the validity, reliability, difficulty level, and differentiation tests. The instrument test contains the entire thermochemistry materials, ranging from systems and environments, exotherm-endotherm reactions, thermochemistry equations, enthalpy of reaction, calorimetry, Hess' law, and bonding energy. From learning activities with the TGT learning model, learning effectiveness was measured using student worksheets so the learning effectiveness level could be analysed descriptively. The ludo game was used after the learning. This game was performed by groups of 4-5 students. Students answered some thermochemistry questions studied previously. Cooperation in groups can be developed through this game.

At the end of the lesson, a collaboration skills questionnaire was distributed, with 22 statements to find out how students' collaboration skills developed after the learning. This supports Saenab et al. (2019) who stated four aspects of collaboration skills: working productively, respecting and appreciating others, agreeing with each other, and sharing responsibilities and contributions. The questionnaire uses a Likert scale with a score of 5 stating strongly agree to a score of 1 stating strongly disagree that applies to positive statements, and vice versa on negative statements. After all data were collected, several tests took place, including the prerequisite validity test -the normality test, and the hypothesis test -the paired T-test and the N-Gain test.

RESULT

In this study, as many as 33 students participated in the learning as an experimental class. The learning began with a pretest. The instrument test had been validated; out of 40 questions, 21 were valid and 20 were then selected for use. The learning with the TGT model was conducted for 4 meetings. It was carried out by grouping students into 8 groups of 4-5 students. The effectiveness of each meeting was measured using students' worksheets, which were given values according to the designed answer key. The results of valuing for each meeting are described in Figure 1. In Figure 1, the effectiveness of the learning is presented through the average of students' scoring for each meeting. The level of achievement of learning effectiveness can be categorised according to Table 2.

At Meeting I, the average value of the students' worksheets was 69.62. Based on Table 2, the learning belongs to the less effective category. At Meetings II and III, the students' worksheets reached an average value of 72.41 and 84.24, respectively. The effectiveness of learning at these two meetings increased and was categorised as effective. Meanwhile, in Meeting IV, the average value of the students' worksheets reached 85.51. The graph unveils an increase in the average value of the students' worksheets, with the highest being at the fourth meeting, which is categorised as highly effective.

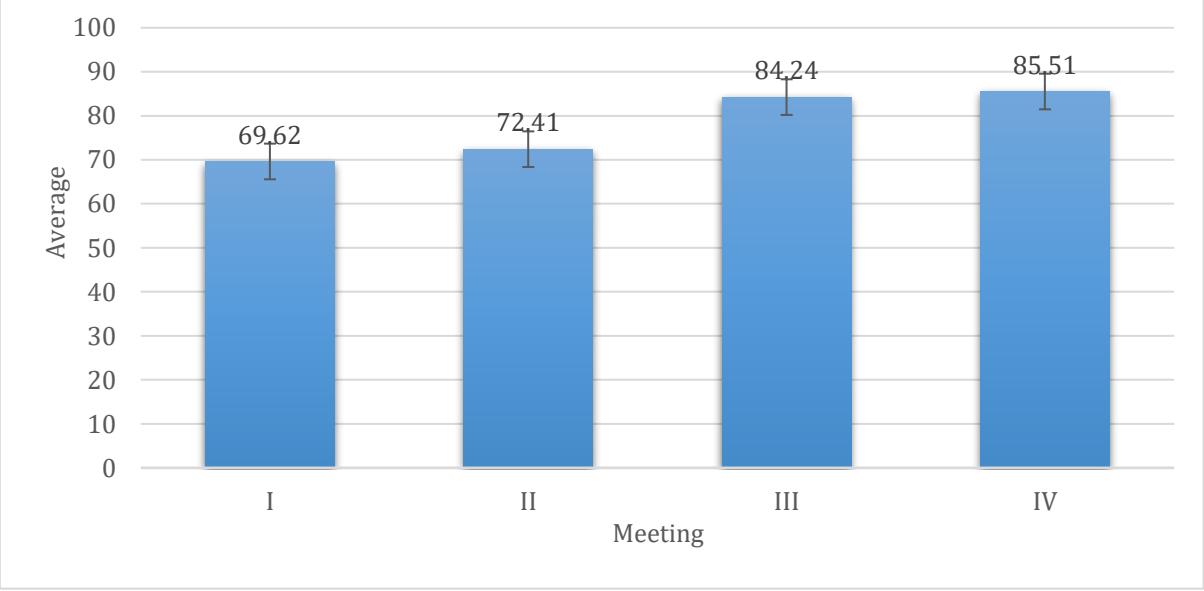

Figure 1. Average of students' worksheets score for each meeting

Table 2. Achievement level of learning effectiveness

Achievement level	Category
< 55	Not effective
55 - 70	Less effective
71 - 85	Effective
> 85	Highly effective

Developed from: Rochman et al., (2018)

Normality test

In this study, the learning outcomes data were analysed with the Chi-Square test at the significance level α = 0.05. The data are declared to come from a normally distributed population if $X^2_{count} < X^2_{table}$ (Silitonga, 2014). The normality test results of the pretest and posttest data are presented in Table 3. At the significance level α = 0.05 with the number of students N = 33, it is known that the value of X^2_{tabel} = 11.07.

Table 3. Normality test results of pretest and posttest data

Class	Data	X^2_{count}	X^2_{table}	Information
Experiment	Pretest	6.72	11.07	Normal
	Posttest	9.81		Normal

Based on the calculations, the pretest data with a significance level of α = 0.05 results in X^2_{count} = 6.72, so the data is declared normally distributed because the $X^2_{count} < X^2_{table}$. Likewise, the posttest data with a significance level of α = 0.05 obtained a value of X^2_{count} = 9.81, so the data is declared normally distributed because the value of $X^2_{count} < X^2_{table}$.

Hypothesis test (paired T-test)

In this study, two groups of data were obtained, namely pretest and posttest. Both groups were declared to have a significant difference when $T_{count} < -T_{table}$ or $T_{count} > T_{table}$, or stated as reject Ho and accept Ha. At the significance level α = 0.05 with degrees of freedom dk = n-1 = 32, the value of T_{table} obtained is 2.037. The paired T-test results of the pretest and posttest data are presented in Table 4.

Table 4. Paired T-test results of pretest and posttest data

Class	T_{count}	T_{table}	Remark
Experiment	33.60	2.037	Ho rejected or Ha accepted

Based on the calculations, at the significance level α = 0.05, the value of T_{count} = 33.60 was obtained. This data indicated that $T_{count} > T_{table}$. Then, it concluded that the Ho is rejected or the Ha is accepted. This means the students' learning outcomes increased significantly after using the ludo game of thermochemistry.

N-gain test

From the learning outcomes data in pretest and posttest values, the improvement of students' learning outcomes can be measured using the N-Gain score criteria. The N-Gain test results of the pretest and posttest data are presented in Table 5.

Table 5. N-Gain test results of pretest and posttest data

Class	N-gain score		Criteria
	Average	g (%)	
Experiment	0.765	76.5	High (effective)

Table 6. Students' collaboration skills data

Statistics	Experiment class
Minimum Score	70
Maximum Score	100
Average Score	85.32
Standard Deviation	7.84
Variances	61.42

Table 7. Achievement level of students' collaboration skills

No.	Aspects of collaboration skills	Average	Category
1.	Working productively	4.05	Very high
2.	Showing respect and appreciation for others	4.70	Very high
3.	Agree or compromise with each other	4.10	Very high
4.	Responsibility & contribution	4.05	Very high

Based on the calculations in Table 5, at the significance level α = 0.05 with the number of students N = 33, the average N-Gain score is 0.765. This means the score of g > 0.70 indicates the average in student learning outcomes reached high criteria. Similarly, the g (%) data shows an N-Gain score of 76.5%. This means the students' learning outcomes increased effectively after the learning.

Description of collaboration skills questionnaire results

The students' collaboration skills were measured through questionnaires at the end of the learning. The data of collaboration skills are presented in Table 6. Based on each aspect, the level of achievement in students' collaboration skills can be measured through score calculations according to the Weighted Means Score table (Dewi, 2022). The level of achievement of collaboration skills is presented in Table 7. Based on the calculations in the Table 7, the four aspects of collaboration skills show development in the very good category. Thus, the students' collaboration skills can be stated to have increased after group learning using the ludo game of thermochemistry.

DISCUSSION

The observation activities at State Senior High School 10 Medan showed that the midterm test values in chemistry subjects were quite low, such as class XI-2 with only 24.24% of the students' total number scored in the 71-100 range. If the learning outcomes tend to be below the limit of completeness criteria, the learning can be said to be less effective. This is in line with studies by Rochman et al., (2018) and Amiruddin et al., (2024) that state that learning is effective when learning outcomes reach completeness ≥ 71% of the number of students. That fact shows the students' difficulty in learning chemistry, especially thermochemistry. The learning process using only the lecture method and limited to printed books can cause these difficulties (Solikhin & Wijanarko, 2021). Based on the studies by Lutfi et al., (2019) and Nurjaya & Wulandari (2023), the availability of facilities and the application of media and learning models significantly affect students' learning outcomes. In addition, the studies by Uyun & Lutfi (2022) and Aldwinarta et al., (2024) remarked that innovative learning can create active student interactions. The studies by Syafitri et al., (2019) and Azeez et al., (2022) also highlighted the importance of peer tutors to fostering confidence while learning.

In this study, attempts to create innovative learning were carried out by applying the ludo game of thermochemistry. The application of game-based learning as a learning media is a form of technology utilization in the education field (Lagdan et al., 2024). In addition, this media has the advantage of honing memory and creativity, creating a pleasant learning atmosphere, and attracting the students' attention to be more active during learning (Nisa & Susanto, 2022). Moreover, attractive learning media can help the delivery of materials more effectively according to the characteristics of diverse students (Nugraha, 2020). This is supported by studies by Iswendi & Husni (2023) and Farisi & Iswendi (2024), where students' cognitive learning outcomes increased when using chemistry Ludo games compared to conventional learning media.

This study applied the ludo game assisted by the TGT cooperative model in four meetings. According to Matondang (2024) and Sitinjak & Pulungan (2024), this learning model is suitable to support the use of game-based learning media. The syntax of learning that begins with the presentation by teachers can encourage students' curiosity about thermochemistry, which tends to be memorized and calculated. They also learn in heterogeneous groups so that each learner can be actively involved and hold responsibility in the group (Agustina et al., 2020). Research by Rahayu et al., (2022) stated that the TGT learning model is very appropriate to be applied with learning media based on games because it can provide new learning experiences for students. In addition, the learning effectiveness was observed from the average value of the student worksheets. The result of the first meeting was 69.62 (less effective category), relatively low due to the adaptation process to the newly applied learning model (Marlita et al., 2023). Meanwhile, those of the second and third meetings were 72.41 and 84.24 (effective category), and the fourth was 85.51 (very effective category).

The pleasant learning experience through the TGT model fosters a sense of responsibility and active interaction among group members (Jura et al., 2018). Therefore, this study was conducted

to observe not only the learning outcomes but also students' collaboration skills. Collaboration skills are one of the skills that are required to be mastered by students at this time. Puspitasari (2018) stated that grasping this skill enables students to share tasks fairly, be responsible for their tasks, and so forth. In this study, students' collaboration skills were measured through statements in a questionnaire. Meanwhile, students' learning outcomes were measured through the pretest and posttest. Through the pretest and posttest data, it was known that the sample class was normally distributed with an average pretest value of X^2_{count} = 6.72 and posttest X^2_{count} = 9.81, while the X^2_{table} value = 11.07, then the data is declared normally distributed because the $X^2_{count} < X^2_{table}$.

According to the hypothesis test results, the ludo game of thermochemistry increased students' cognitive learning outcomes. This is known through the value of T_{count} = 33.60 and T_{table} = 2.037 at the significance level α = 0.05 which states the value of $T_{count} > T_{table}$. More specifically, the N-Gain test was to state the criteria for improvement in learning outcomes. From the N-Gain test, the average score of 0.765 was obtained, which indicated that the improvement in student learning outcomes reached high criteria, according to the table of Wahab et al. (2021). This is supported in research by Rasyid & Iswendi (2024) that shows the effectiveness of the chemistry ludo game helped student learning outcomes to reach high criteria. However, the research was devoted to petroleum material, while this study was conducted specifically on thermochemistry. Other research by Alia & Iswendi (2021) and Barutu & Simatupang (2023) developed a ludo game of thermochemistry, which showed that the media was valid and feasible to use.

Furthermore, at the end of the learning, a questionnaire to analyse collaboration skills was given to the students. The average score was 85.32, which shows the achievement of students' collaboration skills is in a very high category. Similarly, in each aspect of collaboration skills, it is proven that the achievement is in a very high category with an average score of 4.05, 4.70, 4.10, and 4.05, respectively. This means that the ludo game of thermochemistry applied with the TGT model improved students' collaboration skills. This argument is supported by Ulhusna et al., (2020), who stated that ludo games have the potential to generate student involvement and interest in learning and collaboration skills.

Through this study, the researchers contributed in learning activities on thermochemistry using the ludo game applied with the TGT learning model. This research proved that the use of innovative media and learning models can overcome learning difficulties in thermochemistry, which is with the ludo game. Therefore, teachers and prospective teachers are expected to develop their ability to master technology so they can apply some innovations in chemistry learning. Hopefully, these innovations will help to improve learning outcomes and other student skills.

CONCLUSION

The results of this study indicate the effect of using the ludo game of thermochemistry on students' learning outcomes and collaboration skills. This is indicated by the significant difference between learning outcomes, before and after learning using the ludo game and TGT cooperative learning models on thermochemistry. The students' learning outcomes have increased with a high category after learning to use the ludo game developed by the researchers. This was shown by the average of the N-Gain scores of the pretest and posttest. In addition, through this learning, students are able to improve their collaboration skills. Collaboration skills are one of the skills that every learner needs to possess nowadays. However, the use of media and this learning model has limitations on the duration of the lesson. Therefore, future teachers and researchers are expected to innovate this game system to be more concise and be able to be used during chemistry lessons in general schools.

Authors contributions

The authors made significant contributions to the study's conception and design. The authors were in charge of data analysis, interpretation, and discussion of results. The final manuscript was read and approved by the authors.

Conflict of interest

The authors declare that there is no potential conflict of interest.

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Data availability statement

All data are available from the authors.

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