SEARCH: Science Education Research Journal
Volume 5, Issue 2
E-ISSN: 3032-6435
https://doi.org/10.47945/search.v5i2.3449

Analyzing Student Needs for Teams Games Tournament (TGT)-Integrated Worksheets on the Periodic Table of Elements

Arista Widya*[a] , Dwi Finna Syolendra[a]

[a]Department of Chemistry, Universitas Negeri Padang, Indonesia;

Email: aristawidya281@gmail.com*, dwi.finna820@fmipa.unp.ac.id

Abstract

The periodic table of elements is hierarchical: students must translate electron configuration into group and period positions before they can interpret periodic-property trends, yet the teachers interviewed reported that the student worksheets (LKPD) in use do not scaffold this sequence or use tournament-based cooperative learning. This descriptive front-end analysis examined the need for a worksheet based on the Teams Games Tournament (TGT) cooperative learning model, using a questionnaire and a ten-item multiple-choice test (44 10th-grade students), interviews with two chemistry teachers, and score records from two schools in Padang. Concept mastery was uneven (29.5%–63.6% correct) and lowest for translating electron configuration into group/period position (29.5%). Distractor analysis showed that on the atomic-number item 54.5% of students chose the correct period but the wrong group, which points to difficulty in deriving the group from valence electrons rather than in locating the period, although an inter-item effect cannot be excluded. Only 16 of 50 students (32.0%) reached the completion criterion (KKTP 80). Students strongly favored group learning (84.1%) and game elements (86.4%), yet 63.6% said competition between groups reduced their involvement. The findings support a TGT-integrated worksheet that sequences activities from electron configuration to element position before periodic properties, and that uses ability-matched tournament tables instead of open competition between groups.

Article History:
Received 21/10/ 2026
Accepted 20/11/ 2026

Keywords:
Needs Analysis, Student Worksheet, Periodic Table Of Elements, Teams Games Tournament, Conceptual Understanding

License: © 2026 The Authors. This open access article is distributed under a (CC-BY License)

How to Cite: Widya, A., & Syolendra, D. F. (2026). Analyzing Student Needs for Teams Games Tournament (TGT)-Integrated Worksheets on the Periodic Table of Elements. SEARCH: Science Education Research Journal, 5(2), 300–313. https://doi.org/10.47945/search.v5i2.3449

INTRODUCTION

The periodic table of elements is a 10th-grade chemistry topic with a hierarchical reasoning structure. Students must master electron configuration before they can determine the group and period of an element, and only then can they interpret these positions as trends in periodic properties such as atomic radius, ionization energy, electron affinity, and metallic character. Cognitive load theory helps explain why this sequence is demanding. Learning isolated facts, such as the names of elements, is low in element interactivity because each fact can be learned on its own, whereas a task whose elements must be processed together imposes a high intrinsic load, particularly for novices (Chen et al., 2023). Translating an electron configuration into a position in the table is plausibly a task of the second kind, because the learner has to keep the filling order, the electron count, the outermost shell, and the block structure of the table in mind at the same time. The topic also requires movement between levels of representation, which (Johnstone, 1991) identified as a source of difficulty in chemistry: an electron configuration describes submicroscopic structure in symbolic form, and it must be read first as a position in a table and then as a trend in properties. Teaching that delivers this material linearly through lectures therefore risks overloading learners, and a student worksheet (Lembar Kerja Peserta Didik, LKPD) for this topic needs to guide each reasoning step explicitly. The data collected in this study (see Results) show uneven mastery across these sub-concepts, so the order

of presentation in the worksheet should rest on evidence and not on the order of textbook chapters alone.

Empirical reports are consistent with this theoretical expectation. (Susilawati et al., 2020) found that 64.52% of 31 students answered incorrectly in determining groups and periods, and 70.97% in determining the relationship between element location and periodic properties, with errors stemming, among other things, from an understanding of the outermost electron. (Kisdiono, 2023) reported that 10th-grade students' conceptual understanding of electron configuration indicators was only 33.70% and 32.10% in determining periods and groups, and interpreted weak mastery of electron configuration as the cause of difficulties in subsequent stages. (Yanti, 2024) found that the highest misconception in the periodic table of elements was in the indicator of the relationship between electron configuration and group location (53%). Recent international studies point in the same direction: 10th-grade students held misconceptions about the order in which sublevels are filled and about the sequence of electron removal when cations form (Karimi, 2026), and periodic trends such as ionization energy and atomic radius were also frequently misunderstood (Necor, 2018). Misconceptions are likewise widespread in other hierarchical topics; for the mole concept, (Virgiawan et al., 2020) found misconceptions across all target concepts tested and cited incomplete textbooks as a contributing factor. These findings indicate that difficulties in graded chemistry materials are related to mastery of prerequisite concepts and, in part, to the quality of the teaching materials. An analysis of the materials in use and of students' needs is therefore necessary before a worksheet is developed. Because the difficulty lies in coordinating several dependent steps, learning activities in which students work through these steps with peers, receive feedback, and practise them repeatedly are a plausible response, and this leads to cooperative learning.

Cooperative learning is a theoretically coherent response to this difficulty. From a social constructivist perspective, knowledge is built through interaction, and a more capable peer can help a learner work at the edge of what the learner can do alone (Vygotsky, 1978). The Teams Games Tournament (TGT) cooperative learning model puts this idea into practice by combining group work, academic games, and tournaments. Students are grouped heterogeneously and then compete on a tournament table that brings together representatives from different groups with equal abilities, which can be determined from pretest scores, and member scores are summed to form a group score (Slavin, 1995). In chemistry learning, the application of TGT is reported to increase motivation and learning outcomes (A'yuningsih et al., 2017). TGT has been applied to various materials. In the nomenclature of compounds, (Rusdiansyah et al., 2021) reported that the average learning outcome of the TGT class assisted with crossword puzzles (81.1) was higher than that of the direct learning class (70.6), and the effect of TGT assisted with crossword puzzles on learning outcomes was also studied by (Munawaroh et al., 2016). In the colloidal system, (Sukarsih et al., 2018) developed TGT-based chemistry playing cards and reported improved learning outcomes, while (Pardosi & Hutabarat, 2015) studied PBL integrated with TGT. In acids and bases, (Aslamiah et al., 2020) reported an average of 81.21 in the TGT class using the SOS game and 72.27 in the PBL class. TGT was also studied in redox reactions for learning achievement and creativity (Nopiyanita et al., 2013), in petroleum using domino cards (Susanna, 2017), and in 11th grade chemistry using cards, with an average of 78.19 in the TGT class and 69.88 in the control class (Widodo et al., 2016). In atomic structure and the periodic table of elements, (Anggraeni et al., 2018) reported a positive effect of the snakes and ladders game in TGT on the motivation and learning outcomes of 10th-grade students, (Meffa & Afrianis, 2026) reported a higher average post-test score in the Wordwall-assisted TGT class (68.84) than in the control class (55.17). However, the evidence is not uniform: (Mahmudah et al., 2019) obtained a higher average learning outcome in the Team-Assisted Individualization class

(79.62) than in the TGT class (72.45) on compound nomenclature, and (Ruhulessin et al., 2019) found no significant effect of destination media-assisted TGT on learning outcomes in buffer solutions. Thus, the effect of TGT on chemistry varies, depending on the material, comparator, and supporting media. The competitive element is also debated more broadly: a meta-analysis of 29 gamification studies reported better learning performance for competitive than for non-competitive designs in subgroup analyses (Ho et al., 2022), whereas a recent review of gamification in secondary and higher-education mathematics advised balancing competition with mastery and cooperation (Ratinho et al., 2026). The existing literature does not show how such design choices should be matched to a topic whose difficulty lies in a chain of dependent steps.

Despite this literature, the studies on the periodic table of elements known to the authors address three separate things, and none combines them. First, effect studies examine a treatment after it has been applied: TGT (Anggraeni et al., 2018), PBL (Devi et al., 2024), the Ludo game (Yanida & Iswendi, 2018), and a comparison of learning models on cognitive learning outcomes (Astuti et al., 2019). Second, product studies assess the feasibility of materials that have already been designed, for example a probing-prompting-based LKPD (Karsini & Ritonga, 2020) and an electron configuration e-module (Setiaji, 2022), as well as TGT-based LKPD for the neighboring topics of atomic structure (Putri & Alizar, 2025) and chemical bonding (Hsb & Alizar, 2025). (Karsini & Ritonga, 2020) also reported that in their research school, teaching materials only consisted of textbooks and monotonous commercial LKPD, but they did not examine the need for a tournament-based cooperative model. Third, a needs analysis of a problem-based e-LKPD on the periodic system of elements has been reported for a vocational school in Padang (Nurhayati & Aini, 2025). This gap matters because the periodic table differs structurally from the nomenclature of compounds and colloidal systems on which most TGT studies have focused: it requires a hierarchical translation from electron configuration to element position and then to periodic properties. To the best of the authors' knowledge, no study has therefore combined these elements, that is, a front-end needs analysis of a TGT-integrated worksheet on the periodic table of elements that links students' conceptual mastery profile, examined per answer option, with teachers' accounts of the materials in use and with students' perceptions of games and competition. A literature search in November 2026 with Indonesian and English keywords (for example, "analisis kebutuhan LKPD TGT sistem periodik unsur" and "needs analysis student worksheet Teams Games Tournament periodic table"), without a date limit, retrieved journal articles and university repositories. It found TGT-based LKPD only for atomic structure and chemical bonding, and needs analyses of LKPD on the periodic table only with problem-based learning.

The novelty of this study lies in combining four data sources (a student perception questionnaire, a multiple-choice concept mastery test analyzed at the level of answer options, teacher interviews, and a recapitulation of student scores on the periodic system of elements) to map the needs for a TGT-integrated student worksheet on this topic. The study also reports a contradictory finding explicitly, namely that some students feel less actively involved when groups compete, and treats it as a design consideration instead of omitting it to keep the narrative uniform. The purpose of this study is therefore to analyze the development needs of TGT-integrated Student Worksheets on the periodic system of elements based on students' perceptions and levels of understanding, as well as the perspectives of chemistry teachers in two high schools. The article is structured as follows: research methods, results of the questionnaire and comprehension test, results of the teacher interviews, a discussion of implications for worksheet design, and conclusions with recommendations for the next development stage.

RESEARCH METHODS

This study uses a descriptive approach positioned as the front-end analysis stage within the research and development (R&D) framework for teaching materials. This stage is typically the initial step before product design in development models such as ADDIE, which begins with the Analysis stage before moving on to Design, Development, Implementation, and Evaluation (a similar initial stage, namely curriculum, student, and concept analysis, is also used in the development of student worksheets (LKPD) on the periodic table of elements (Karsini & Ritonga, 2020). The descriptive approach was chosen because the purpose of the study was not to test the effectiveness of a treatment, but rather to map real-world conditions. Concept mastery profiles, availability of teaching materials, and teacher readiness form the basis for decision-making regarding the LKPD design in the next stage.

The research subjects were 44 10th-grade students (32 from SMAN 3 Padang and 12 from SMA Pertiwi 2 Padang) who had studied the periodic system of elements, and two chemistry teachers, one from each school. The two schools were selected purposively because the teachers described different levels of class activity (an estimated 60–70% at SMAN 3 Padang and 50–60% at SMA Pertiwi 2 Padang), which was expected to capture a wider range of conditions than a single school context. These estimates are teacher perceptions and not measured data, so the schools serve as a contrast and the sample is not intended to be representative. A separate recapitulation of student scores on the periodic system of elements was obtained from the same classes, covering 38 students at SMAN 3 Padang (32 of whom completed the questionnaire and test) and the same 12 students at SMA Pertiwi 2 Padang. The scores come from examination data supplied by the teachers. The completion criterion for the topic, the learning objective achievement criterion (Kriteria Ketercapaian Tujuan Pembelajaran, KKTP), was 80 at both schools. Because the records are aggregated, they could not be linked to individual test or questionnaire responses.

Data were collected through three instruments, in addition to the score records described above. First, a student questionnaire of 13 Yes/No statements was distributed online through an electronic form and completed by 44 students. It covered the use of worksheets (LKPD), challenges in understanding the material, preferences for group learning, motivation toward game elements, and responses to competition- and tournament-based learning. Second, a comprehension test of 10 multiple-choice items covered the history of the periodic table, determining the position of elements from atomic number and electron configuration, and periodic properties. Each item was analyzed by its percentage of correct answers to identify the sub-concepts with the weakest understanding, and the share of students choosing each answer option was also tabulated so that the distribution of incorrect answers could be examined. Third, a semi-structured interview with the two chemistry teachers used 14 guiding questions on the material taught, the teaching materials used, the integration of learning models and deep learning, student engagement, challenges in learning, strategies to increase engagement, experiences with group work and cooperative learning, the use of game elements, and responses to the planned tournament- and team-competition-based LKPD. The questionnaire, the test, and the interview guide were validated by five validators, three lecturers and two teachers, using Aiken's V; items with $V \geq 0.80$ were regarded as valid.

Questionnaire and test data were analyzed descriptively using the percentage of responses for each item. The interviews were recorded and transcribed, and the transcripts were analyzed qualitatively in three steps: (1) identifying tendencies and patterns in each teacher's answers for each interview topic; (2) comparing the answers of the two teachers to identify shared and divergent points; and (3) comparing these patterns with the questionnaire, test, and score findings to examine the consistency of the findings across data sources (data-source triangulation). The result of this

comparison is summarized in a triangulation matrix (Table 4). The score recapitulation was analyzed descriptively using the average score and the number and percentage of students who did and did not reach the completion criterion (KKTP 80). Completion percentages are reported per school and are not compared statistically.

RESULTS AND DISCUSSION

The results of the questionnaire show the conditions of use of teaching materials and students' needs for more varied learning of the periodic system of elements, as presented in Table 1.

Table 1Summary of Student Questionnaire Results

Statement	Yes	No
Teachers use LKPD when learning the material on the periodic system of elements.	72.7%	27.3%
The LKPD used only contains a summary of the material and practice questions.	56.8%	43.2%
The LKPD helps students understand the periodic table well	65.9%	34.1%
Difficulty understanding the periodic table due to numerous concepts	88.6%	11.4%
Feeling bored when learning the periodic table using only lectures	81.8%	18.2%
Feel able to understand the material well if it is explained in an interesting way	72.7%	27.3%
Always ask the teacher when there is a part of the material that you don't understand.	59.1%	40.9%
It is easier to understand the material when studying in a group.	84.1%	15.9%
More motivated to learn when there is an element of play in learning	86.4%	13.6%
Group competition makes students less actively involved	63.6%	36.4%
Fun learning makes it more active and easier to understand the material.	86.4%	13.6%
Interested in LKPD featuring discussions, games, and diverse exercises.	75.0%	25.0%
Learning that involves games makes participation in class more active.	81.8%	18.2%

Descriptively, the majority of students (72.7%) stated that their teachers had used Student Worksheets (LKPD) for the periodic table of elements, but 56.8% stated that the LKPD they used only contained a summary of the material and practice questions; only 65.9% considered the LKPD to be quite helpful. The relationship between these three data points shows a clear pattern: the availability of LKPD does not necessarily guarantee its usefulness, especially when 88.6% of students associate understanding of this material with the many interrelated concepts. The need for more engaging learning is consistent across three interrelated points: 81.8% of students feel bored if learning is only lectured, 72.7% stated that it would be easier to understand the material if it was explained in an interesting way, and 84.1% stated that it is easier to understand the material when studying in groups. The preference for group learning is consistent with the social constructivist rationale for cooperative learning (Vygotsky, 1978; Slavin, 1982), but a questionnaire records preference and cannot show the quality of interaction within groups, which this study did not observe.

The same pattern emerged for the three items related to game elements: 86.4% of students were more motivated when there was a game element, 86.4% stated that fun learning made them more active, and 81.8% stated that games made them more active participants. These findings align with reports that TGT improves motivation and chemistry learning outcomes (A'yuningsih et al., 2017; Zumaroh et al., 2017) and that game elements in TGT have a positive effect on atomic structure and the periodic table of elements (Anggraeni et al., 2018). Evidence remains mixed, with TGT showing lower results than TAI in nomenclature (Mahmudah et al., 2019) and no significant effect in buffer solutions (Amni et al., 2021). Consequently, favoring games does not guarantee better learning outcomes.

However, one finding warrants separate discussion because it appears to contradict the pattern above: in item 10, 63.6% of students stated that learning involving intergroup competition

made them less actively engaged. When read alongside items 9, 11, and 13, which all indicate high support for the game element, it can be seen that student support for games cannot be equated with support for intergroup competition as a form of play. The original design of TGT used a tournament table that matched students of equal ability, so that students of various ability levels had an equal opportunity to contribute points to their team (Slavin, 1995; Ardiansyah, 2014) this design is relevant to item 10, although this study did not test whether the tournament table actually reduces student withdrawal. The wider literature on competition in gamified learning is itself divided. A meta-analysis of 29 studies reported better learning performance under competitive than non-competitive game designs in subgroup analyses (Ho et al., 2022), while a recent review of gamification in secondary and higher-education mathematics concluded that designs should balance competition with mastery and cooperation and avoid excessive competition (Ratinho et al., 2026). These results do not contradict the present finding, because they concern learning performance and design principles, whereas item 10 records how students perceive their own involvement. They do suggest that the format of the competition matters more than its mere presence. The implication is that the successful implementation of TGT on this material cannot rely on the general appeal of games, but must specify how the tournament mechanism is built so that it does not create a competitive experience that excludes some students.

Results of Analysis of Understanding of the Periodic Table of Elements Material

The results of the understanding analysis were conducted using 10 multiple-choice questions. The percentage of students' correct answers is shown in Table 2.

Table 2. Results of Analysis of Understanding of the Periodic Table of Elements Material

Measured Material	Correct Answer
The figure who initiated the law of octaves	25/44 (56.8%)
Dobereiner's triad group of elements	24/44 (54.5%)
The basis for arranging periods in the modern periodic system	19/44 (43.2%)
Position of elements based on atomic number and mass number	28/44 (63.6%)
Position of elements (group/period) based on electron configuration	13/44 (29.5%)
Identification of noble gas groups	27/44 (61.4%)
Position of elements based on atomic number	13/44 (29.5%)
Properties that are not classified as periodic properties	27/44 (61.4%)
Trends in atomic radii	26/44 (59.1%)
Comparison of metallic properties between elements	21/44 (47.7%)

The data in Table 2 show a pattern consistent with the hierarchical structure of this topic. Students' mastery of the historical development of the periodic table (Newlands' law of octaves and Döbereiner's triads, items 1 and 2) was 56.8% and 54.5%, respectively. The lowest scores (29.5% each) were recorded for the two items requiring the application of electron configuration or atomic number to determine the position of an element (items 5 and 7). This decline from introductory concepts to applied hierarchical reasoning aligns with findings in atomic structure and the periodic table that poor mastery of electron configuration is followed by poor determination of periods and groups (Susilawati et al., 2020; Kisdiono, 2023; Yanti, 2024) and with recent evidence of misconceptions about sublevel filling among 10th-grade students (Karimi, 2026). Cognitive load theory offers a plausible explanation. Recalling the historical sequence of the table is largely a matter of remembering separate facts, which is low in element interactivity, whereas deriving a group and a period from an electron configuration requires several interacting steps (reading or writing the configuration, identifying the outermost shell, counting valence electrons, and mapping both onto the table) to be coordinated at once, which is high in element interactivity for novices (Chen, O., Paas, F., & Sweller, 2023). Two cautions apply. Items 1 and 2 were also answered correctly by only about half of the students, so low interactivity did not translate into high mastery, and the test was not designed to measure cognitive load; the explanation is therefore an interpretation that is consistent with the data, not a tested

mechanism. Mastery of periodic properties (items 8–10; 47.7%–61.4%) was also incomplete, in line with reports that trends such as atomic radius and ionization energy are difficult for students (Necor, 2018). The implication for the worksheet is that it should break the transition from electron configuration to element position into explicit, ordered steps with immediate feedback before students move on to periodic properties, an approach that has supported retention and transfer in another chemistry topic high in element interactivity (Kala & Ayas, 2023).

In item 3, on the basis of period arrangement in the modern periodic system, 19 of 44 students (43.2%) answered correctly. The most frequently chosen incorrect option was "number of valence electrons" (25.0%), a criterion that is conceptually close to the correct answer ("similarity of properties and atomic number"). This distribution suggests confusion between two seemingly similar criteria for period arrangement, which makes it a candidate misconception about the logic of the table. Because the test was single-tier, it cannot show whether these students held this confusion firmly or guessed between plausible options; two-tier diagnostic tests address this by asking for the reason behind an answer (Treagust, 1988). The LKPD should therefore distinguish the two criteria explicitly and not assume that both are understood. For the periodic-property items (atomic radius, periodic properties, and metallic properties), the percentage of correct answers ranged from 47.7% to 61.4%, which indicates uneven mastery that also needs to be taken into account when ordering the presentation of material in the LKPD.

The distribution of answer choices for items 5 and 7 provides information that the percentage of correct answers alone does not capture. Both items were answered correctly by 13 of 44 students (29.5%), but their error patterns differed and should be interpreted differently. In item 5, which presents an electron configuration directly, incorrect answers were spread almost evenly across the three distractors (27.3%, 25.0%, and 18.2%). A spread of this kind is more typical of guessing or missing knowledge than of a shared misconception, and suggests that some students cannot yet read an electron configuration as positional information. In item 7, which gives only the atomic number, 24 of 44 students (54.5%) chose the same distractor, period 5 group VA. This option has the correct period but the wrong group, so the error appears to lie in deriving the group from valence electrons, particularly for p-block elements whose configurations extend beyond the d subshell, and not in finding the period. A concentrated error of this kind is what a systematic misconception would be expected to produce, and it is the strongest candidate in this data set. Two alternative explanations cannot be excluded, however. First, the same distractor is identical to the answer key of item 5, so students may have carried an answer from one item to the other, which would make the concentration an inter-item effect and not a conceptual error. Second, a single-tier test cannot reveal the reasoning behind a choice. Both explanations lead to the same design implication: element-positioning exercises in the LKPD need to separate two skills that were previously treated as one step, namely determining the period from the outermost shell and determining the group from the number of valence electrons. Only student interviews or a two-tier follow-up test could show which explanation is correct.

Student Grade Recapitulation Results

A recapitulation of students' scores on the periodic system of elements material in both schools is presented in Table 3.

Table 3 Summary of Student Scores on the Periodic Table of Elements Material

School	Number of Students	Average Value	Completed	Not Completed
SMAN 3 Padang	38	67.74	15 (39.5%)	23 (60.5%)
SMA Pertiwi 2 Padang	12	62.67	1 (8.3%)	11 (91.7%)

Table 3 shows that the learning completion of the periodic table of elements material is relatively low in both schools. At SMAN 3 Padang, 15 out of 38 students (39.5%) completed the material with an average score of 67.74, while at SMA Pertiwi 2 Padang only 1 out of 12 students (8.3%) completed the material with an average score of 62.67. Overall, 16 out of 50 students (32.0%) completed the material and 34 students (68.0%) did not. This picture is generally in line with the results of the comprehension test in Table 2, which shows the percentage of correct answers per item only ranges from 29.5% to 63.6%, and with the statements of both teachers that determining groups and periods based on electron configuration is the part that requires the most attention.

The differences between the two schools need to be read with caution. The average scores of the two schools are close (62.67 and 67.74), but the completion percentages are markedly different (8.3% and 39.5%). Furthermore, the number of students at SMA Pertiwi 2 Padang is only 12, so one student is equivalent to 8.3 percentage points, so the completion percentages should be compared with caution even though both schools use the same completion criterion (KKTP 80). These data support the existence of learning achievement gaps that underlie the need to improve teaching materials and learning strategies, but cannot be used to infer the causes of these achievements, let alone to predict whether the TGT-integrated LKPD will improve completion; this can only be tested during the development and pilot phase.

Teacher Interview Results

The interview results showed that both teachers taught the periodic table of elements in grade 10 with similar coverage, namely the development of the periodic table, groups and periods, electron configurations, and determining the position of elements. The teaching materials used by the teacher at SMAN 3 Padang included textbooks, Google Books, worksheets, and occasional modules, while the teacher at SMA Pertiwi 2 Padang used modules, worksheets, and self-made media; both teachers stated that the existing teaching materials did not specifically integrate the deep learning approach or the TGT model. It should be noted that this information comes from teacher statements and not from document review, because during the interview both teachers were unable to show the teaching materials in question. In terms of learning models, the teacher at SMAN 3 Padang stated that student-centered learning was used more often, while the teacher at SMA Pertiwi 2 Padang had implemented Problem Based Learning in addition to discussions and group work. Thus, the identified gap is not the absence of active learning in general, but rather the absence of game- and tournament-based cooperative models that specifically structure the hierarchical reasoning flow in this material.

In terms of student engagement, the teacher at SMAN 3 Padang estimated student engagement at around 60–70%, while the teacher at SMA Pertiwi 2 Padang estimated it at around 50–60%. Both teachers cited group and period determination and their relationship to electron configuration as the most demanding aspects, while the teacher at SMA Pertiwi 2 Padang additionally mentioned determining periodic properties. This information aligns with the pattern in Table 2, which places the two items on determining the position of elements based on electron configuration at the lowest scores. Strategies implemented by teachers included a variety of discussions, questions and answers, and presentations (SMAN 3 Padang), as well as icebreakers, song lyrics, and project activities (SMA Pertiwi 2 Padang). Both teachers had implemented group-based learning, but both reported uneven participation: the teacher at SMAN 3 Padang mentioned that active students tended to be the same, while the teacher at SMA Pertiwi 2 Padang mentioned that some students lacked focus during group work. Specific cooperative models such as TGT had never been implemented by either teacher on this material.

Regarding the game element, the teacher at SMAN 3 Padang has implemented simple games and icebreakers, while the teacher at SMA Pertiwi 2 Padang more often uses icebreakers and creative activities such as song lyrics. Both teachers reported happier, more enthusiastic student responses, and a more lively classroom atmosphere when the game element was used, including students who were usually passive. This report should be read as the teachers' perception; in the material on the periodic system of elements, observation scores for learning activities were also reported to be higher in the TGT class (91%) than in the control class (80%) (Meffa & Afrianis, 2026).

Regarding the plan to develop student worksheets (LKPD) based on a cooperative model based on tournaments/team competitions, both teachers responded positively but with cautionary notes. A teacher at SMAN 3 Padang stated that this approach has the potential to attract students' interest because of the cooperation and competition, but cautioned that the implementation time needs to be regulated so that it is not too long. A teacher at SMA Pertiwi 2 Padang stated that this approach has the potential to support more active and meaningful learning, provided that the LKPD is designed interestingly and the activities do not only consist of questions. These two teachers' notes are consistent with the questionnaire findings in item 10 of Table 1, strengthening the conclusion that the design of the tournament mechanism, not just the existence of the competition itself, is a determining factor in the success of implementing TGT in this material.

Implications of Needs Analysis Results for LKPD Development

Overall, the triangulation of the questionnaire, comprehension test, teacher interviews, and score records (Table 4) supports three main points. First, the periodic table of elements requires a clear hierarchical reasoning flow, particularly in translating electron configurations into element positions, with varying levels of mastery across sub-concepts. Second, the teaching materials currently available have not been specifically designed to accommodate this hierarchical flow or to integrate tournament-based cooperative models, although this point rests on teachers' statements. Third, students showed a high preference for group learning and game elements, but this preference did not automatically extend to all forms of intergroup competition. Convergence across sources strengthens the credibility of these points compared with relying on a single source, but the sources differ in kind: the questionnaire and interviews capture perceptions, whereas the test and score records capture performance, and only the first point is supported by both. The score recapitulation (Table 3) shows that only 16 of 50 students (32.0%) completed this material, which is consistent with the first point and serves as supporting evidence.

Table 4 Triangulation of Findings Across Data Sources

Finding	Questionnaire	Concept test	Teacher interviews	Score records	Assessment
Weak translation from electron configuration to element position	88.6% find the many concepts hard to understand (item 4)	Lowest mastery on items 5 and 7 (29.5% each)	Both teachers cited determining group/period positions from electron configuration as hardest	32.0% met the completion criterion	Convergent
Current materials do not scaffold this sequence or use TGT	56.8% note the LKPD contains only summaries and exercises; 65.9% find it helpful (items 2–3)	Not applicable	Teachers report no integration of TGT or deep learning in the materials (statements only; documents not reviewed)	Not applicable	Partly supported
Preference for group learning and game elements	84.1% favor group study; 86.4% are motivated by games (items 8, 9)	Not applicable	Teachers report livelier, more enthusiastic responses to games (perception)	Not applicable	Convergent (perceptions only)
Concern about competition between groups	63.6% say it reduces their active involvement (item 10)	Not applicable	Teachers advise time limits and non-question activities and report uneven participation	Not applicable	Consistent but indirect

Compared to previous TGT studies on chemistry materials, namely compound nomenclature (Mahmudah et al., 2019; Rusdiansyah et al., 2021), colloidal systems (Sukarsih et al., 2018), 11th grade chemistry with card media (Widodo et al., 2016), and atomic structure and the periodic table of elements (Anggraeni et al., 2018; (Meffa & Afrianis, 2026), which focused on learning outcomes or motivation after the treatment was implemented, the contribution of this study lies in mapping needs before the Student Worksheet (LKPD) is developed, with TGT placement specifically on materials that require translation of hierarchical representations (symbolic → tabular → properties), not just linear memorization material. This characteristic requires that the TGT-integrated LKPD not only insert quizzes or tournaments at the end of the lesson, but also compile academic game stages that explicitly practice the transition from electron configuration to element location before entering the periodic properties tournament stage. In other words, the order of presentation of material in LKPD needs to follow the order of mastery of concepts identified in Table 2, not just follow the order of chapters in the textbook. In theoretical terms, the contribution is to treat the order of conceptual mastery as a design variable: if the transition from configuration to position is a step high in element interactivity, the worksheet has to manage that load before the game begins, since a game played on material that students cannot yet process may add extraneous load (Chen, O., Paas, F., & Sweller, 2023) instead of motivation.

The most important implication of the findings from questionnaire item 10 is the need to distinguish between "game elements" and "competition elements" in the design of student worksheets. The original TGT design (Slavin, 1995; Ardiansyah, 2014) addressed this issue through a tournament table system that grouped students based on ability equality, so that each student competed against other students of similar level, rather than against the entire group at once. This mechanism could plausibly address the concerns of the 63.6% of students in this study, a hypothesis that this study did not test, and it aligns with the two teachers' notes regarding the importance of time management and variety of non-question activities in student worksheets. Based on this synthesis, five design needs can be formulated: (1) Student worksheets need to include stepwise, scaffolded activities that explicitly practice the transition from electron configuration to elemental location, given that this section showed the lowest scores on the comprehension test (29.5%), with particular emphasis on calculating the valence electrons of p-block elements because this is where the distribution of distractors showed the most systematic errors; (2) LKPD should not be limited to summaries and practice questions, because 56.8% of students stated that the current LKPD is like that; (3) LKPD needs to facilitate group work with a clear division of roles to overcome the dominance of certain students reported by both teachers; (4) academic game elements need to be integrated considering the high level of student support (86.4%); and (5) the tournament mechanism must use a table system based on equal ability, not direct large group competition, to accommodate students who are less comfortable with open competition.

This study has limitations that need to be explicitly acknowledged. First, the score recapitulation used only contains the average score and the number of students who completed and did not complete the test at the two schools, without a breakdown of scores per student, so it cannot be linked to test results at the individual level. Second, the number of students is very imbalanced between schools (38 and 12 in the score recapitulation), so comparisons between schools and generalization of the findings to a broader context are limited. Third, the pattern of misconceptions in test items 3, 5, and 7, although traceable from the distribution of answer options, has not been confirmed through direct interviews with students, so the interpretation remains tentative. Specifically, in item 7, the similarity of the dominant distractor to the answer key for the previous item makes it impossible to separate the explanation of misconceptions from the explanation of the

influence between items. Fourth, the conclusion regarding the lack of integration of learning models into teaching materials rests entirely on teachers' verbal statements because teaching material documents could not be reviewed directly during data collection. Fifth, in the interview item regarding the feasibility of integrating game elements into the periodic table of elements material, one teacher's answer repeated the answer to the previous item so that this aspect was effectively represented by only one informant. Sixth, the schools were selected on the basis of teacher-reported engagement and the sample is small, so the findings describe these two settings and are not intended to be representative. These limitations also open up the direction for further research: the development and trial of TGT-integrated LKPD on this material should be accompanied by pre- and post-implementation academic achievement measurements, as well as a specific evaluation of the level of student engagement at each stage of the tournament to verify whether the ability-equal tournament table design truly addresses the concerns identified in questionnaire item number 10.

CONCLUSION

This needs analysis shows that a TGT-integrated student worksheet for the periodic table of elements is justified, and that its design should follow the hierarchical structure of the topic. Mastery was weakest where several dependent steps must be coordinated, namely translating electron configuration into group and period positions, and the error patterns suggest that determining the group, not the period, is the main source of error. Together with teachers' reports that current materials neither scaffold this sequence nor use tournament-based cooperative models, and with the low completion in both schools, these results shift the question from whether a TGT worksheet is needed to how its stages should be ordered. The contribution of this study is to treat the order of conceptual mastery as an evidence-based design variable for cooperative, game-based materials, an approach not found in the TGT studies reviewed here.

The central design principle is that enthusiasm for games should not be equated with comfort with competition. Although students strongly favored group learning and game elements, a majority reported that competition between groups reduced their involvement. The worksheet should therefore treat the game and the competition as separate design decisions: academic games can be introduced early to practise each reasoning step, while the tournament should use ability-matched tables so that every student competes with peers of a similar level and contributes to the team score. This principle is a hypothesis grounded in perceptions and not a tested effect, and it is the first thing the next development stage should examine.

For worksheet developers, three practical implications follow: sequence the activities from electron configuration to element position and then to periodic properties, separating the determination of the period from that of the group; place academic games before the tournament stage; and manage tournament time and group roles so that participation is not dominated by a few students. Because the data come from two schools, aggregate scores, and a single-tier test, the next stage should test the worksheet with pre- and post-implementation measures of achievement, a diagnostic follow-up on the group-determination error, and an evaluation of student engagement at each tournament stage.

ACKNOWLEDGMENTS

The author would like to thank Ms. Dwi Finna Syolendra, S.Pd, M.Pd, as the supervising lecturer who provided guidance and input in the preparation of this article. Thanks are also extended

to the chemistry teachers of SMAN 3 Padang and SMA Pertiwi 2 Padang, as well as all students who contributed to the data collection process.

REFERENCES

A'yuningsih, D. Q., Suardana, I. N., & Suwenten, I. M. (2017a). Penerapan Model Pembelajaran Kooperatif Tipe Tgt (Teams Games Tournament) Untuk Meningkatkan Motivasi Dan Hasil Belajar Peserta Didik. *Pendidikan Kimia Indonesia*, *1*.

A'yuningsih, D. Q., Suardana, I. N., & Suwenten, I. M. (2017b). Penerapan model pembelajaran kooperatif tipe TGT (Teams Games Tournament) untuk meningkatkan motivasi dan hasil belajar peserta didik. *Jurnal Pendidikan Kimia Indonesia*, *1*(2), 37–47. https://doi.org/10.23887/jpk.v1i2.12810

Amni, Z., Ningrat, H. K., & Raehanah. (2021). Pengaruh Model Pembelajaran Kooperatif Tipe Teams Games Tournament (Tgt) Berbantuan Media Destinasi Terhadap Motivasi Dan Hasil Belajar Pada Materi Larutan Penyangga. *Inovasi Pendidikan Kimia*, *15*(2), 2840–2848.

Anggraeni, V., Muharram, & Alimin. (2018). Pengaruh permainan ular tangga dalam model pembelajaran kooperatif tipe TGT terhadap motivasi dan hasil belajar kimia siswa kelas X SMA Negeri 1 Masamba (studi pada materi pokok struktur atom dan tabel periodik unsur). *CHEMICA: Jurnal Ilmiah Kimia Dan Pendidikan Kimia*, *19*(1), 96–106. https://doi.org/10.35580/chemica.v19i1.6654

Ardiansyah, B. (2014). Penggunaan media pembelajaran "Monosimpur" (Monopoli Sistem Periodik Unsur-Unsur) melalui strategi pembelajaran kooperatif tipe Team Game Tournament (suatu upaya peningkatan prestasi belajar kimia SMA di kelas X). *Hydrogen: Jurnal Kependidikan Kimia*, *2*(1), 166–170. https://doi.org/10.33394/hjkk.v2i1.645

Aslamiah, S., Pardede, A., & Wardhani, R. R. A. A. K. (2020). Perbandingan problem based learning (PBL) dengan kooperatif tipe TGT (Team Game Tournament) menggunakan media permainan SOS terhadap hasil belajar siswa pada materi asam basa. *Dalton: Jurnal Pendidikan Kimia Dan Ilmu Kimia*, *3*(2). https://doi.org/10.31602/dl.v3i2.3910

Astuti, A. D., Larasati, C. N., & Parubak, A. S. (2019). Perbandingan model pembelajaran dan aktivitas belajar terhadap hasil belajar kognitif peserta didik kelas X IPA SMA Negeri 2 Manokwari pada materi sistem periodik unsur. *Arfak Chem: Chemistry Education Journal*, *2*(2), 142–147. https://doi.org/10.30862/accej.v2i2.287

Chen, O., Paas, F., & Sweller, J. (2023). A cognitive load theory approach to defining and measuring task complexity through element interactivity. *Educational Psychology Review*, *35*, 63. https://doi.org/https://doi.org/10.1007/s10648-023-09782-w

Devi, S., Edi, R., & Sofia. (2024). Pengaruh penerapan model pembelajaran problem based learning terhadap hasil belajar siswa kelas X pada materi sistem periodik unsur. *Jurnal Penelitian Pendidikan Kimia: Kajian Hasil Penelitian Pendidikan Kimia*, *11*(2), 132–141. https://jppk.ejournal.unsri.ac.id/index.php/jurpenkim/article/view/23652

Ho, J. C.-S., Hung, Y.-S., & Kwan, L. Y.-Y. (2022). The impact of peer competition and collaboration on gamified learning performance in educational settings: A meta-analytical study. *Education and Information Technologies*, *27*(3), 3833–3866. https://doi.org/10.1007/s10639-021-10770-2

Hsb, P. S., & Alizar. (2025). *Pengembangan LKPD Berbasis Team Game Tournament (TGT) pada Materi Ikatan Kimia Fase F SMA / MA*. *6*, 1731–1739.

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning*, *7*(2), 75–83. https://doi.org/10.1111/j.1365-2729.1991.tb00230.x

Kala, N., & Ayas, A. (2023). Effect of instructional design based on cognitive load theory on students' performances and the indicators of element interactivity. *Journal of Turkish Science Education*, *20*(3), 468–489. https://doi.org/10.36681/tused.2023.027

Karimi, H. (2026). A study of common student misconceptions in the topic of electronic configuration. *Research in Chemistry Education*. https://doi.org/10.48310/chemedu.2026.21388.1386

Karsini, R., & Ritonga, P. S. (2020). Desain dan uji coba lembar kerja peserta didik (LKPD) berbasis probing-prompting pada materi sistem periodik unsur. *Jurnal Riset Pendidikan Kimia*, *10*(1), 53–63. https://doi.org/10.21009/JRPK.101.08

Kisdiono, T. F. (2023). Deskripsi pemahaman konseptual siswa pada konsep struktur atom dan sistem periodik unsur (SPU). *Arfak Chem: Chemistry Education Journal*, *6*(2), 535–540. https://doi.org/10.30862/accej.v6i2.548

Mahmudah, S., Yuridka, F., & Mashuri, M. T. (2019). Komparasi pembelajaran kimia menggunakan metode Teams-Games Tournament dan Team-Assisted Individualization terhadap hasil belajar pada materi ajar tata nama senyawa kelas X SMA Negeri 12 Banjarmasin. *Dalton: Jurnal Pendidikan Kimia Dan Ilmu Kimia*, *2*(1). https://doi.org/10.31602/dl.v2i1.1995

Meffa, D. K., & Afrianis, N. (2026). Pengaruh model TGT berbantuan aplikasi Wordwall terhadap hasil belajar siswa pada materi sistem periodik unsur. *Konfigurasi: Jurnal Pendidikan Kimia Dan Terapan*, *10*(2), 11–18. https://doi.org/10.24014/konfigurasi.v10i2.40064

Munawaroh, S., Nuswowati, M., & Susatyo, E. B. (2016). Pengaruh pembelajaran team games tournament berbantuan crossword puzzle terhadap hasil belajar. *Jurnal Inovasi Pendidikan Kimia*, *10*(1), 1672–1682. https://doi.org/10.15294/jipk.v10i1.6013

Necor, D. C. (2018). Exploring students' level of conceptual understanding on periodicity. *JPAIR Multidisciplinary Research*, *33*(1), 136–154. https://doi.org/10.7719/jpair.v33i1.609

Nopiyanita, T., Haryono, H., & Ashadi, A. (2013). Penerapan model pembelajaran kooperatif tipe Teams Games Tournament (TGT) untuk meningkatkan prestasi belajar kimia dan kreativitas siswa pada materi reaksi redoks kelas X semester genap SMA Negeri 3 Sukoharjo tahun pelajaran 2012/2013. *Jurnal Pendidikan Kimia (JPK)*, *2*(4), 135–141. https://jurnal.fkip.uns.ac.id/index.php/kimia/article/view/2863

Nurhayati, N., & Aini, S. (2025). Analisis kebutuhan media pembelajaran e-LKPD berbasis problem based learning (PBL) pada materi sistem periodik unsur berbantuan Liveworksheet. *Science: Jurnal Inovasi Pendidikan Matematika Dan IPA*, *5*(4). https://jurnalp4i.com/index.php/science/article/view/7547

Pardosi, A. C., & Hutabarat, W. (2015). Implementing problem based learning integrated with cooperative learning teams games tournament in improving students' achievement in teaching colloidal system. *Jurnal Penelitian Bidang Pendidikan*, *21*(1). https://doi.org/10.24114/jpbp.v21i1.2992

Putri, N. N., & Alizar. (2025). Validitas LKPD berbasis Team Games Tournament pada materi struktur atom untuk kelas X fase E SMA. *Journal of Global Research Education*, *2*(2), 111–117. https://doi.org/10.62194/wtww1849

Ratinho, E., Figueiredo, M., Estêvão, M. D. M. A. O., Faísca, L., & Martins, C. (2026). Gamification on mathematics engagement and motivation in secondary school and higher education: A systematic review and meta-analysis. *Educational Psychology Review*, *38*. https://doi.org/10.1007/s10648-025-10108-1

Ruhulessin, S., Ratumanan, T. G., & Tamalene, H. (2019). Perbedaan Hasil Belajar Siswa Kelas X Sma Menggunakan Model Pembelajaran Kooperatif Tipe Student Facilitator and Explaining (Sfe) Dan Model Pembelajaran Konvensional Pada Materi Trigonometri. *JUPITEK: Jurnal Pendidikan Matematika*, *2*(1), 1–6. https://doi.org/10.30598/jupitekvol2iss1pp1-6

Rusdiansyah, Nurlaili, & Muflihah. (2021). Perbedaan hasil belajar antara siswa yang diajar dengan model pembelajaran teams games tournament - media TTS dan siswa yang diajar dengan model pembelajaran langsung - media TTS pada pokok bahasan tata nama senyawa. *Bivalen: Chemical Studies Journal*, *4*(1), 9–12. https://jurnal.fkip.unmul.ac.id/index.php/bivalen/article/download/720/470

Setiaji, S. N. P. (2022). *Pengembangan e-module berbasis problem solving pada konsep konfigurasi elektron* [Universitas Islam Negeri Sunan Gunung Djati Bandung]. https://digilib.uinsgd.ac.id/53204/

Slavin, R. E. (1982). *Cooperative Learning: Student Teams. What Research Says to The Teacher*. Library of Congress Cataloging in Publication Date.

Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice* (2nd ed.). Allyn & Bacon.

Sukarsih, N. K. A., Wardhani, R. R. A. A. K., & Mashuri, M. T. (2018). Pengembangan kartu remi kimia menggunakan model pembelajaran TGT (Teams Games Tournament) terhadap hasil belajar siswa pada materi pokok sistem koloid kelas XI SMA Korpri Banjarmasin. *Dalton: Jurnal Pendidikan Kimia Dan Ilmu Kimia*, *1*(1), 16–22. https://doi.org/10.31602/dl.v1i1.1497

Susanna. (2017). Penerapan Teams Games Tournament (TGT) melalui kartu domino pada materi minyak bumi siswa kelas XI MAN 4 Aceh Besar. *Lantanida Journal*, *5*(2), 93–105. https://doi.org/10.22373/lj.v5i2.2832

Susilawati, L., Ramdhani, E. P., & Yulita, I. (2020). Analisis kesulitan belajar siswa kelas X MIPA pada materi sistem periodik unsur di SMAN 1 Teluk Bintan. *Student Online Journal (SOJ) UMRAH*, *1*(2), 500–506. https://soj.umrah.ac.id/index.php/SOJFKIP/article/view/599

Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education*, *10*(2), 159–169. https://doi.org/10.1080/0950069880100204

Virgiawan, W., Nahadi, & Kusrijadi, A. (2020). Profil miskonsepsi siswa SMA negeri di Kota Bandung pada materi konsep mol menggunakan tes diagnostik two-tier berbasis piktorial. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *8*(2), 55–63. https://ejournal.upi.edu/index.php/JRPPK/article/download/52297/26659

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Widodo, A. T., Sunarto, W., & Afiatun, H. (2016). Pengaruh penggunaan model pembelajaran kooperatif tipe Team Games Tournament berbantuan media kartu terhadap hasil belajar kimia kelas XI SMA N 1 Tengaran. *Jurnal Inovasi Pendidikan Kimia*, *5*(2). https://doaj.org/article/8d7e46d68fc84d7e8466a0db6cab96b9

Yanida, F., & Iswendi. (2018). Efektivitas media permainan ludo berbasis chemo-edutainment untuk meningkatkan hasil belajar siswa pada materi sistem periodik unsur kelas X SMAN 5 Padang tahun pelajaran 2018/2019. *Menara Ilmu: Jurnal Penelitian Dan Kajian Ilmiah*, *12*(12), 30–37. https://doi.org/10.33559/mi.v12i12.1085

Yanti, R. (2024). *Analisis miskonsepsi siswa menggunakan tes diagnostik four-tier pada materi sistem periodik unsur* [Universitas Islam Negeri Sultan Syarif Kasim Riau]. https://repository.uin-suska.ac.id/84809/

Zumaroh, E., Widana, I. D., & Muliani, L. H. (2017). Penerapan model pembelajaran kooperatif tipe teams games tournament (TGT) pada pembelajaran kimia untuk meningkatkan motivasi dan hasil belajar siswa. *Jurnal Pendidikan Kimia Indonesia*, *1*(1), 30–36. https://doi.org/10.23887/jpk.v1i1.12809