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Needs Analysis for Developing Student Worksheets Integrated with the Teams Games Tournament Model on the Hydrocarbon Topic

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Abstract

Hydrocarbons are conceptually dense: students must connect structures, names, and isomers, and many struggle to do so. Teaching materials that address this difficulty while keeping students engaged need to be grounded in the actual needs of students and teachers. This descriptive study analyzed the needs for developing student worksheets (LKPD) integrated with the Teams Games Tournament (TGT) cooperative learning model for hydrocarbons. Participants were 49 twelfth-grade students, one class each from SMAN 3 Padang and SMA Pertiwi 2 Padang (convenience sampling), and the chemistry teachers of both classes. Data were collected with a 13-item yes/no questionnaire, a 10-item multiple-choice comprehension test, teachers' grade records, and semi-structured interviews, and were analyzed descriptively. Fewer than half of the students at SMAN 3 Padang and one-third at SMA Pertiwi 2 Padang had reached the mastery criterion. Nomenclature items were the hardest in the comprehension test, followed by the number of isomers. Most students found hydrocarbons difficult and reported that group discussion and games helped them, although nearly half said that competition between groups reduced their involvement. Both teachers used group work and quizzes, but neither used tournament-based materials. The worksheet should therefore scaffold nomenclature and isomers, give every team member an accountable role, and keep competition low-stakes. These findings describe two classes and cannot be generalized.

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INTRODUCTION

The Merdeka Curriculum requires learning that is oriented toward deep competence rather than mere rote memorization. In this context, abstract and conceptual chemistry topics, hydrocarbons among them, pose particular challenges for both students and teachers. Hydrocarbons are compounds composed of carbon and hydrogen atoms (Chang, 2008), and the topic covers the distinctive characteristics of the carbon atom, classification, nomenclature, isomers, properties, reactions, and uses (Anggini et al., 2025). The hydrocarbon topic is conceptually quite complex because students must understand the interrelationships among the structure, nomenclature, classification, isomers, properties, and reactions of these compounds. Difficulties with this topic are shown by students' poor mastery of interrelated basic concepts, such as the distinctive characteristics of the carbon atom, nomenclature, and isomerism of hydrocarbon compounds (Ariani et al., 2024; Eka et al., 2025; Oktania et al., 2022). These difficulties can lead to misconceptions about various hydrocarbon concepts (Karini et al., 2022; Qodriyah et al., 2020). Moreover, mastery of hydrocarbons is a prerequisite for understanding later organic chemistry topics, from petroleum and alkane derivatives to polymers and benzene (Huddin & Lutfi, 2020). In other words, difficulty with this topic is not merely a partial obstacle; it can potentially hinder students' understanding throughout the

entire sequence of organic chemistry that follows. Based on interviews with the chemistry teachers at SMAN 3 Padang and SMA Pertiwi 2 Padang, students' difficulties lie mainly in nomenclature, structure, and isomers. The SMAN 3 Padang teacher stated that students need to grasp the basic concepts first, because if the concepts are not understood, students will struggle to determine the names of compounds. The SMA Pertiwi 2 Padang teacher also noted that students struggle because the hydrocarbon topic contains many things that must be both remembered and understood.

This condition is supported by the recapitulation of students' scores. The average hydrocarbon score was 76.16 at SMAN 3 Padang and 66.83 at SMA Pertiwi 2 Padang. With a mastery criterion of 80, 15 of 31 students at SMAN 3 Padang reached mastery, while at SMA Pertiwi 2 Padang 6 of 18 students did. These data show that more than half of the students at SMAN 3 Padang (51.6%) and two-thirds of the students at SMA Pertiwi 2 Padang (66.7%) had not met the mastery criterion, an outcome that reflects the need for a more effective and innovative approach to learning. Beyond academic ability, students' engagement and learning experience also deserve attention. The teaching materials used in class can be one means of helping students understand the content. LKPD (student worksheets) can be designed as teaching materials that guide students through learning activities systematically, rather than only reading the content and working on exercises. Research on LKPD for the hydrocarbon topic has been conducted by integrating particular learning models to support students' learning activities (Gabriella & Mitarlis, 2021; Nurmala & Yuni, 2024)

One alternative learning model that can be integrated into LKPD is *Teams Games Tournament* (TGT). TGT is a cooperative learning model that combines group work, academic games, tournaments, and group rewards, and it gives students the opportunity to work together while taking part in enjoyable academic competition (Nuriana, 2020; Slavin, 1982). Cooperative learning in chemistry can support interaction among students and the construction of understanding through collaboration (Warfa, 2016), and studies of TGT in chemistry learning suggest that the model has the potential to support learning outcomes (Dita & Armianti, 2025) and motivation (Heryati et al., 2024; Zumaroh et al., 2017). TGT has been applied to the hydrocarbon topic through various games and learning media: Pertiwi and Masykuri (2017) applied TGT-Chempuzzle, Akhmad and Sulastry (2022) applied a word search puzzle in TGT-type cooperative learning, and Dewi (2015) (2013) compared TGT combined with mind-mapping and Molymood media.

The rationale for combining these elements rests on constructivist and cooperative learning theory. From a constructivist, Vygotskian perspective, understanding develops as learners build meaning through interaction with peers and more capable others (Vygotsky, 1978), so structured group work gives students a setting in which to put their ideas into words, test them, and correct them. Hydrocarbon nomenclature and isomerism make this need acute: students must coordinate symbolic representations (names and structural formulas) with the molecular structures that they stand for (Johnstone, 1991) , and this can place a heavy demand on working memory while the rules are still unfamiliar (Sweller, 1988) . Cooperative structures such as TGT add positive interdependence and individual accountability, because team members prepare one another for the tournament and the team reward depends on each member's performance (Slavin, 1982) . In this view, the academic game is not decoration: it is an occasion for repeated, low-stakes retrieval and application of the naming rules. Whether students and teachers actually want, and can use, such a design is an empirical question, and it is the question that a needs analysis addresses.

Previous studies show that game-based learning has been used to increase students' interest in the hydrocarbon topic. Sari et al (2018) used a card game, Permata and Lutfi (2022) developed an Android-based game, and Hanim et al. (2025) developed an Android-based educational game on hydrocarbon nomenclature. These studies treat the game as a self-contained learning product that is

played apart from the worksheet in which students work through the content. The TGT studies on hydrocarbons (Akhmad et al., 2022; Dewi, 2015; Pertiwi & Masykuri, 2017) focused on the effect of a particular game or medium on learning outcomes, not on the needs that should shape a worksheet design. Studies that did develop hydrocarbon LKPD integrated other models, namely problem-based learning (Anggini et al., 2025; Gabriella & Mitarlis, 2021) and Search, Solve, Create, and Share (Nurmala & Yuni, 2024) not TGT. To the authors' knowledge, within the literature reviewed here, no study has analyzed the needs for a hydrocarbon LKPD that integrates games and the syntax of TGT (team work, academic game, tournament, and team reward). Without such an analysis, a TGT worksheet risks being designed around the method rather than around the difficulties that students and teachers actually face.

This study therefore analyzes the needs for developing hydrocarbon LKPD integrated with the TGT cooperative learning model. Specifically, it aims to: (1) describe students' hydrocarbon learning outcomes and identify the sub-topics that students understand least; (2) describe students' experiences with worksheets and their preferences regarding group work, games, and competition between groups; (3) describe the teaching materials, learning models, and views on tournament-based worksheets of the chemistry teachers; and (4) derive design requirements for the TGT-integrated LKPD from these findings.

RESEARCH METHOD

This study used a descriptive design and constitutes the needs analysis stage of a project to develop LKPD integrated with the *Teams Games Tournament* (TGT) cooperative learning model for the hydrocarbon topic. It combined quantitative data (a questionnaire, a comprehension test, and grade records) with qualitative data (teacher interviews) to describe the conditions and needs in the two schools.

Participants were twelfth-grade students who had studied the hydrocarbon topic in the odd semester of the 2025/2026 academic year at SMAN 3 Padang and SMA Pertiwi 2 Padang, together with the chemistry teachers who taught them. One class was taken from each school (31 and 18 students; N = 49) using convenience sampling: the classes were chosen because they were accessible and their teachers gave permission. The chemistry teacher of each class (two teachers in total) was interviewed. Because only one class per school was sampled, the findings describe these classes and cannot be generalized to other schools. Data were collected in July 2026.

Four instruments were used. (1) A questionnaire of 13 yes/no items asked about the use of LKPD, students' ability to understand hydrocarbons, learning difficulties, boredom, group learning, games, and competition between groups (Table 3). (2) A comprehension test of 10 multiple-choice items covered the definition and combustion of hydrocarbons, homologous series, identification and nomenclature of alkanes and alkenes, isomers, and tertiary carbon atoms. Each item was scored 1 if correct and 0 otherwise, and the percentage of correct answers per item was calculated to show which parts of the topic students had and had not understood. (3) Grade records for the hydrocarbon topic were provided by the chemistry teacher of each class. They come from each teacher's own assessment, and whether the two assessments were equivalent could not be verified, so averages are reported per school and are not compared statistically. (4) A semi-structured interview guide of 13 questions was used with the two teachers; it covered the content taught, teaching materials, learning models, student activeness, content difficulty, group learning, the use of games, and the teachers' views on tournament-based LKPD.

The questionnaire, the comprehension test, and the interview guide were validated for content by the supervising lecturer through expert judgment before data collection.

Questionnaire and test data were analyzed descriptively as percentages. The interviews were transcribed; the transcripts were read repeatedly, the answers were grouped by interview topic, and recurring statements were compared between the two teachers. Because only two teachers were interviewed, the interview data are treated as supporting evidence and not as generalizable findings. Data from the four sources were then compared to identify needs for the LKPD.

RESULTS AND DISCUSSION

Table 1 summarizes the hydrocarbon scores provided by the chemistry teachers of the two classes. The average score was 76.16 at SMAN 3 Padang (31 students) and 66.83 at SMA Pertiwi 2 Padang (18 students), against a mastery criterion of 80. At SMAN 3 Padang, 15 students (48.4%) reached mastery and 16 (51.6%) did not. At SMA Pertiwi 2 Padang, 6 students (33.3%) reached mastery and 12 (66.7%) did not.

Table 1. Recapitulation of Student Scores

School	Number of Students	Average	Mastered	Not Mastered
SMAN 3 Padang	31	76.16	15 (48.4%)	16 (51.6%)
SMA Pertiwi 2 Padang	18	66.83	6 (33.3%)	12 (66.7%)

The comprehension test consisted of 10 items, and Table 2 shows the percentage of the 49 students who answered each item correctly. The highest percentages were on the definition of hydrocarbon compounds (87.8%) and the products of complete combustion (85.7%), followed by the identification of alkenes (75.5%), the homologous series of alkanes (71.4%), the isomers of butane (63.3%), the identification of alkanes (61.2%), and the position of the tertiary carbon atom (57.1%). The lowest percentages were on the number of butyne (C_4H_6) isomers (42.9%), alkane nomenclature (34.7%), and alkene nomenclature (24.5%).

Table 2. Results of the Hydrocarbon Comprehension Analysis

Material Measured	Correct Answers
Definition of hydrocarbon compounds	43/49 (87.8%)
Products of complete combustion of hydrocarbons	42/49 (85.7%)
Homologous series of alkanes	35/49 (71.4%)
Identification of alkanes	30/49 (61.2%)
Identification of alkenes	37/49 (75.5%)
Alkane nomenclature	17/49 (34.7%)
Alkene nomenclature	12/49 (24.5%)
Isomers of butane	31/49 (63.3%)
Position of the tertiary C atom	28/49 (57.1%)
Number of butyne (C_4H_6) isomers	21/49 (42.9%)

Table 3 shows the questionnaire responses of the 49 students. On understanding of the topic, 38.8% said they could understand the hydrocarbon concepts well and 61.2% said they could not (item 4), and 77.6% said they found the material difficult because of the many concepts to be understood (item 5). On worksheets, 59.2% said the teacher had used LKPD when teaching hydrocarbons (item 1), 71.4% said the LKPD used contained only a summary of the material and practice questions (item 2), and 57.1% said the LKPD help them understand the material while 42.9% said it did not (item 3).

Table 3. Recapitulation of Student Questionnaire Results

No	Item	Yes	No
1.	The teacher used LKPD when teaching the hydrocarbon topic	59.2%	40.8%
2.	The LKPD only contains a material summary and practice questions	71.4%	28.6%
3.	The LKPD used helps me understand the hydrocarbon material well	57.1%	42.9%
4.	I am able to understand the concepts in the hydrocarbon topic well	38.8%	61.2%
5.	I find hydrocarbons hard to understand due to the many concepts involved	77.6%	22.4%
6.	I get bored when hydrocarbon lessons are just the teacher talking	63.3%	36.7%

No	Item	Yes	No
7.	I understand hydrocarbons well when explained interestingly	73.5%	26.5%
8.	Whenever a hydrocarbon concept is unclear, I always ask the teacher	57.1%	42.9%
9.	I find it easier to understand the material during group discussions	75.5%	24.5%
10.	I am more motivated to learn when there are game elements in the lesson	77.6%	22.4%
11.	Group competition makes me less active in learning	46.9%	53.1%
12.	Learning that involves games makes me participate more actively in class	65.3%	34.7%
13.	Enjoyable learning makes me more active and helps me understand faster	67.3%	32.7%

On learning activities, 63.3% said they felt bored when hydrocarbon lessons consisted only of listening to the teacher's explanation (item 6), and 73.5% said they could understand the material well if it was explained in an interesting way (item 7). A total of 57.1% said they always asked the teacher when a part of the material was unclear, and 42.9% said they did not (item 8). In addition, 67.3% said that enjoyable learning made them more active and helped them understand the material (item 13).

On group work, games, and competition, 75.5% said they found it easier to understand the material during group discussions (item 9). A total of 77.6% said they were more motivated to learn when game elements were present (item 10), and 65.3% said that learning with games made them participate more actively in class (item 12). Nearly half of the students, 46.9%, said that learning with competition between groups made them less active, while 53.1% said it did not (item 11).

Both teachers had taught the hydrocarbon topic in Grade XII, odd semester, covering the distinctive characteristics of the carbon atom, the classification of hydrocarbons, nomenclature, isomers, properties, reactions, and uses. The teaching materials they reported included LKPD, teaching modules, LKS (student worksheets), and digital modules, and the SMAN 3 Padang teacher also sometimes made her own materials to fit the content. Both teachers reported using problem-based learning and group activities. Neither teacher reported materials that specifically integrate a deep learning approach or the TGT model, although the SMA Pertiwi 2 Padang teacher said she considered her use of contextual problems consistent with deep learning. For nomenclature, the SMAN 3 Padang teacher said she prefers to explain the concepts first, because students must grasp them before they can name compounds. The SMA Pertiwi 2 Padang teacher said she had asked students to write song lyrics containing the hydrocarbon content to help them remember it.

The SMAN 3 Padang teacher estimated student activeness at about 67% and the SMA Pertiwi 2 Padang teacher at about 52%. The SMA Pertiwi 2 Padang teacher said that students tend to be active at the beginning of the lesson but become bored when the content requires a lot of memorization, especially hydrocarbon nomenclature. Asked which parts of the topic students find most difficult, the SMAN 3 Padang teacher named nomenclature and isomers, because students must understand the concepts and be careful in determining structures. The SMA Pertiwi 2 Padang teacher named nomenclature, structure, and isomers, because the content requires both understanding and the ability to remember.

Both teachers reported using group learning. The SMAN 3 Padang teacher said that group discussion works fairly well because students can help one another. The SMA Pertiwi 2 Padang teacher said that group learning produces good results but that students still need to be monitored so that they do not merely follow their friends. She said she puts diligent students with diligent ones and less diligent students with less diligent ones, because in mixed groups the less diligent students tend to rely on the diligent ones. For game elements, the SMAN 3 Padang teacher had used ordinary quizzes and the SMA Pertiwi 2 Padang teacher had used multiple-choice quizzes in Quizizz; neither had implemented tournament-style learning. Both teachers said that students tend to be more enthusiastic when quizzes or games are included.

Both teachers responded positively to the plan to develop LKPD using a cooperative model

based on tournaments or team competition. The SMAN 3 Padang teacher said that the approach has potential and that games might be possible for this topic. The SMA Pertiwi 2 Padang teacher said that the model has the potential to get students to cooperate, discuss, move around, and take part in games, making learning more active and varied, provided that the content remains at the center and the game serves to keep students interested.

Learning Outcomes and the Difficulty of Nomenclature

The results show that more than half of the students in both classes had not reached the mastery criterion, and that the weakness was concentrated in particular parts of the topic. Items that asked for recall, such as the definition of a hydrocarbon or the products of complete combustion, were answered correctly by more than 85% of students, whereas items that required turning a structural formula into a name or counting isomers were answered correctly by 24.5% to 42.9%. Students therefore appear to know what hydrocarbons are but to have difficulty using that knowledge to operate on structures. Nomenclature, structure, and isomerism are also the parts of the topic that students struggle with in other settings (Ariani et al., 2024; Eka et al., 2025; Oktania & Syarkawi, 2022), and they are the parts that both teachers named in the interviews. Because the teachers know their classes independently of the test, the test results and the teachers' accounts point in the same direction.

The response pattern on item 6 suggests where the difficulty lies. The two most frequently chosen wrong options (C and D, 20.4% and 26.5%) both name the molecule on a seven-carbon chain, although the longest continuous chain contains eight carbons. Together they attracted 46.9% of students, more than the scored answer (34.7%). A plausible reading is that many students did not identify the longest chain, which is the first step of naming, and not that they were unable to name substituents. This reading cannot be confirmed, because the test was not diagnostic and students were not asked to explain their choices. The response patterns are consistent with, but do not demonstrate, the misconceptions that have been reported for hydrocarbons (Karini et al., 2022; Qodriyah et al., 2020).

Why naming is harder than recall can be considered from a cognitive-load perspective, which should be read as an interpretation. Naming a compound requires students to hold several rules in mind at once (find the longest chain, number it from the end that gives the lowest locants, then name and order the substituents) while translating a structural formula into a name, that is, moving between a symbolic representation and the molecular structure it stands for (Johnstone, 1991; Sweller, 1988). When these rules are not yet automatic, the combined demand can exceed what novices can handle, and additional practice questions alone may not help. Worked steps, graded tasks, and repeated retrieval with feedback are more consistent with this explanation. The teachers' accounts add a motivational side: the SMA Pertiwi 2 Padang teacher said that students become bored when the content turns to memorization, especially nomenclature, and the SMAN 3 Padang teacher explains the concepts before nomenclature because students cannot name compounds without them. Games have been used to provide this kind of repeated nomenclature practice (Hanim et al., 2025).

Worksheets, Group Work, Games, and Competition from the Students' Perspective

The responses about worksheets need to be read with caution. A total of 71.4% of students said that the LKPD they used contained only a summary and exercises, but only 59.2% said that the teacher had used LKPD. Because the first figure is higher than the second, some students probably answered about worksheets in general, for example the LKS that the SMA Pertiwi 2 Padang teacher said students own, and not only about LKPD used by the teacher. Items 2 and 3 are therefore treated as students' general impression of the worksheets they know and not as the views of confirmed LKPD

users. Even so, 42.9% said that the worksheets did not help them understand the material, which leaves room for LKPD with more varied activities. Hydrocarbon LKPD built on other learning models have also been developed (Gabriella & Mitarlis, 2021; Nurmala & Fatisa, 2024), but the studies reviewed here did not build them around tournament-based group work.

Students were receptive to group work and games: 75.5% found it easier to understand the material in group discussions, and 77.6% said they were more motivated when game elements were present. The first result is consistent with evidence that cooperative learning supports chemistry learning (Warfa, 2016), and the second with syntheses showing that game-based learning can support motivation to learn chemistry (Byusa et al., 2022; Hu et al., 2022). Those studies, however, examine what happens after an intervention, whereas the present data are self-reported preferences before one. They show readiness for games, not that games will improve outcomes. The proportion of students who found the topic difficult (77.6%) is identical to the proportion who said games motivate them (77.6%), but the responses were not cross-tabulated, so it cannot be said that the students who find the topic difficult are the same students who are motivated by games.

Competition was the point on which students were least united: 46.9% said that competition between groups made them less active, and 53.1% said it did not. Because team competition is a defining feature of TGT (Slavin, 1995), this split matters for design more than any other result. In TGT, however, students compete at tournament tables against students of similar past performance, and the points they win count toward their team's score (Slavin, 1995). A well-structured tournament may therefore reduce the discouragement that open competition causes some students, although the present data cannot show whether it would. The LKPD should in any case keep competition low-stakes, reward team progress and not only winning, and give every student a role.

Teachers' Practices and Readiness for a TGT-Integrated LKPD

Both teachers already use group work and quizzes, so cooperative learning is not new in these classrooms. What is missing is a structure that connects the two: neither teacher had implemented tournament-style learning, and neither had materials organized around the TGT stages. Earlier TGT studies on hydrocarbons focused on adding a particular game or medium (Akhmad & Sulastry, 2022; Dewi, 2013; Pertiwi & Masykuri, 2017) and not on the worksheet that organizes the activity. Evidence that TGT can support motivation (Heryati et al., 2024) and learning outcomes (Dita & Armianti, 2025) in chemistry, and similar effects reported outside chemistry (Sefitri et al., 2026; Sokawati et al., 2025), are consistent with the teachers' view that the approach has potential. They do not show that it will work in these classes, and the teachers were commenting on a design they have not yet seen.

The grouping practice of the SMA Pertiwi 2 Padang teacher is in tension with TGT, which relies on heterogeneous teams so that students can help one another (Slavin, 1995). Her reason is that in mixed groups the less diligent students rely on the diligent ones, which is a free-rider problem. TGT addresses this through individual accountability, because each student's tournament score contributes to the team score. The LKPD should therefore state how heterogeneous teams are formed and how each member's contribution is made visible, which answers the teacher's concern and does not ignore it. The same teacher considered her contextual problems consistent with deep learning, which is the orientation of the curriculum described in the Introduction. Whether a TGT-integrated LKPD supports deep learning is a question for later stages, the present data do not address it.

Implications for the Design of the TGT-Integrated LKPD

Taken together, the four data sources point in a broadly consistent direction, and five design requirements for the TGT-integrated LKPD follow from them. First, the LKPD should include

graduated activities on nomenclature and isomers, the sub-topics with the lowest scores, beginning with identifying and numbering the longest chain, so that the tournament rewards the application of rules and not guessing. Second, the LKPD should offer more than a summary and exercises, given the 42.9% of students who said that the worksheets they know did not help them understand the material. Third, the LKPD should structure group work, because 75.5% of students said that they understand the material more easily through group discussion, and each member should have an accountable role, because the SMA Pertiwi 2 Padang teacher reported that less diligent students tend to rely on diligent ones. Fourth, game elements should be included, because 77.6% of students said that they are more motivated when game elements are present, but competition should be kept low-stakes, because 46.9% said that competition between groups made them less active. Fifth, the activities can follow the TGT stages (material presentation, team work, academic games, tournaments, and team rewards), which are designed to let students help one another master the material (Gayatri, 2009), and the LKPD should state how heterogeneous teams are formed.

These requirements are drawn from two classes, a 13-item yes/no questionnaire, a 10-item test, and two teacher interviews. They are a starting point for design and expert validation, not evidence that a TGT worksheet will improve learning, which must be tested in the later development and evaluation stages.

This study has several limitations. Participants were one convenience-sampled class per school, so the findings describe these classes and cannot be generalized. The grade records came from each teacher's own assessment, so the two schools' scores are not directly comparable, and the teachers' estimates of student activeness are rough estimates and not measurements. The questionnaire used yes/no responses, and some items were worded in a way that may invite agreement (for example, that enjoyable learning makes students more active). The instruments were validated for content by one expert, the supervising lecturer, and no reliability estimate is reported. The comprehension test was short (10 items) and not diagnostic, so it cannot identify misconceptions. Finally, individual responses were not cross-tabulated, so relationships between, for example, difficulty with the topic and preference for games remain untested.

CONCLUSION

The needs analysis in one class each at SMAN 3 Padang and SMA Pertiwi 2 Padang indicates a need for hydrocarbon LKPD that combines structured practice with cooperative games. Fewer than half of the students at SMAN 3 Padang and one-third at SMA Pertiwi 2 Padang had reached the mastery criterion. Students recalled definitions well but had most difficulty applying nomenclature rules and counting isomers, and their errors in naming suggest that selecting the principal chain was a main problem. Students reported that the topic is hard and that group discussion and games help them, while competition between groups reduced the involvement of nearly half of them. Both teachers already use group work and quizzes but not tournament-based or TGT-structured materials, and they were open to such LKPD.

These results give practical direction for the next stages. The LKPD should (a) provide graduated, scaffolded practice on chain selection, numbering, and naming before any game; (b) organize the tournament around team progress, with low-stakes competition and individual accountability; (c) specify how teams are formed and monitored; and (d) keep the academic content at the center, with the game as the means of practice. Theoretically, the study shows how constructivist and cooperative learning ideas can be translated into needs-based design criteria for a worksheet, instead of being applied after the product is made. Because the study is limited to two convenience-sampled classes and to instruments validated by expert judgment, these requirements

are design hypotheses. The design, development, and validation stages should test them, for example through expert and teacher validation of the prototype and a try-out with students of different prior achievement.

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AUTHOR CONTRIBUTIONS

The first author contributed to the research design, data collection and analysis, product development, preparation of the research instruments, and the writing and revision of the research article. The second author contributed by providing guidance and supervision throughout the research process, giving input on product development and the analysis of results, and reviewing and revising the research article. All authors have read, provided input on, and approved the final version of the article for publication.

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