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Improving Physics Learning Outcomes through Two Stay Two Stray Cooperative Learning on Work and Energy: A Classroom Action Research Study

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ABSTRACT

This classroom action research examined changes in physics learning mastery during implementation of the Two Stay Two Stray (TSTS) cooperative learning model on work and energy. The study involved 36 Grade X Welding Engineering students at SMK Negeri 1 Gandapura, Indonesia, during August–October 2019. Two action cycles followed planning, implementation, observation, and reflection. Data came from a 20-item preliminary multiple-choice test, cycle-end achievement tests, observation sheets completed by two observers, and interviews. At baseline, 17 of 36 students (47.22%) met the reported mastery criterion. Mastery increased to 27 students (75.00%) in Cycle I and 33 students (91.67%) in Cycle II, an increase of 44.45 percentage points from baseline. Teacher-activity observations increased from 90.00% to approximately 94.17%, and student-activity observations increased from 83.75% to 93.75%. The findings indicate progressive improvement during the two cycles; however, the single-class design without a comparison group does not isolate the effect of TSTS from other instructional changes. The results suggest that structured peer exchange may support active participation and mastery in vocational physics lessons.

Keywords: Two Stay Two Stray; cooperative learning; physics education; work and energy; classroom action research

INTRODUCTION

Physics teaching in vocational secondary schools must help students connect abstract principles with technological practice. In welding engineering, concepts of work, energy, power, and efficiency are relevant to interpreting tools, processes, and energy transfer. Nevertheless, the original classroom observation at SMK Negeri 1 Gandapura described teacher-centred instruction, limited student questioning, and weak engagement. A preliminary test showed that only 17 of 36 students (47.22%) achieved the stated mastery threshold. This local instructional problem motivated an iterative classroom intervention.

Research on active learning highlights the importance of moving beyond passive reception toward meaningful cognitive engagement. Theobald et al. (2020) demonstrate how active learning can address achievement disparities, while Darling-Hammond et al. (2020) situate effective learning in supportive social and cognitive environments. Brod (2021), Fiorella (2023), and Agarwal et al. (2021) further suggest that

generative processing, explanation, and retrieval are mechanisms through which students can consolidate conceptual understanding. These mechanisms are relevant to physics problems that require explanation as well as numerical calculation.

Two Stay Two Stray (TSTS) is a cooperative structure in which students work in small groups; two members remain to explain their group's findings while two visit another group to exchange information. Studies in physics and science education report promising outcomes for TSTS (Selvianti et al., 2015; Rachmawati & Ernawati, 2018; Apriakanti et al., 2020). Related studies in other subjects associate TSTS with cooperation, motivation, and learning achievement (Hidayat & Muhson, 2018; Al Falah & Rosy, 2021; Huda, 2021). Such findings motivate classroom-level investigation, although differences in subjects and designs limit direct generalisation.

This study aimed to document (1) changes in student mastery across baseline, Cycle I, and Cycle II, and (2) observed teacher and student learning activities during the implementation of TSTS in a vocational physics class. Its contribution is a contextual account of iterative TSTS implementation for work and energy, rather than a controlled estimate of causal effectiveness.

LITERATURE REVIEW

Cooperative learning and the TSTS interaction structure

The TSTS sequence requires learners to produce a group explanation, communicate it to visiting peers, listen to an alternative explanation, and reconcile differences after returning to their original group. This creates repeated opportunities for verbalisation, peer feedback, and knowledge reconstruction. Evidence from TSTS implementations spans science, mathematics, language, and social studies (Firman et al., 2020; Aji & Wulandari, 2021; Rusmiati et al., 2023; Bachtiar et al., 2024). These studies suggest that the structure is adaptable, but they do not establish identical effects across learning contexts.

More recent applications combine TSTS with discovery learning or explicit scientific communication objectives (Rahmadani et al., 2025; Ernawati et al., 2026). Sitanggang et al. (2026) similarly examine TSTS in primary integrated science. Such extensions underline that a cooperative grouping label alone is insufficient: task quality, explanation requirements, and opportunities for feedback determine what students actually learn.

Conceptual learning, engagement, and instructional design

In work-and-energy lessons, students must distinguish force, displacement, kinetic and potential energy, and conservation relationships. Well-designed peer discussion can expose misconceptions, but poorly structured interaction may reinforce them. Sweller (2020) cautions that unnecessary cognitive demands can overwhelm learners; Mayer et al. (2020) and Noetel et al. (2022) emphasise coherent

representations, while Sundararajan and Adesope (2020) discuss the costs of irrelevant details. These perspectives justify short, clearly defined group tasks supported by worked examples and focused questions.

Instructional engagement is multidimensional rather than synonymous with achievement. Bond et al. (2020) map diverse engagement indicators; Wong and Adesope (2021) discuss affective design, and Skulmowski (2024) critically examines the distinction between doing an activity and learning from it. Accordingly, observer ratings and test mastery are treated here as separate outcomes. Broader teacher and school conditions, including professional knowledge, preparation, and instructional support, may shape how consistently an intervention is enacted (Backfisch et al., 2020; Sims & Fletcher-Wood, 2021; Leithwood et al., 2020).

Classroom action research and evidence interpretation

Classroom action research uses repeated cycles of planning, acting, observing, and reflecting to improve a specific practice. It is well suited to local instructional improvement but cannot by itself rule out maturation, repeated testing, or differences in assessment difficulty. Qualitative observation and interview material may illuminate how implementation changed, although interpretation requires transparent coding and attention to evidentiary limits (Braun & Clarke, 2021; Byrne, 2022; Hennink & Kaiser, 2022). The present report therefore emphasises descriptive changes, not population-level treatment effects.

METHODS

Research setting and design

The study was conducted from August to October 2019 at SMK Negeri 1 Gandapura with one Grade X Welding Engineering class (N = 36) in the 2019/2020 academic year. The original report identifies a two-cycle classroom action research design based on planning, implementation, observation, and reflection. There was no parallel control class or random assignment. The original report does not specify the number of meetings per cycle or provide student-level scores; these details are not inferred.

Intervention procedure

In each action cycle, students were organised into heterogeneous cooperative groups. They worked on work-and-energy tasks, after which two students remained to explain their group's solution while two visited another group to gather alternative information. Visiting students then returned to their original group to report and compare results. The teacher facilitated discussion and clarified difficult physics concepts. Reflection after Cycle I informed the continuation of Cycle II. This account follows the instructional sequence described in the source manuscript; exact session duration and task sheets were not supplied.

Instruments and analysis

The initial achievement assessment comprised 20 multiple-choice questions administered over 45 minutes. End-of-cycle tests were used to classify mastery relative to the reported minimum mastery criterion (KKM) of 70. Two observers independently scored teacher and student activities using observation sheets, and interviews were conducted with selected students. Frequencies and percentages were reported descriptively. Because item-level test scores, instrument validation results, and inter-rater reliability statistics were not available, no significance test, effect size, or reliability coefficient is presented. Original inconsistencies in a few percentages are identified transparently below.

RESULTS AND DISCUSSION

Changes in achievement mastery

At baseline, 17 students met the reported mastery criterion and 19 did not. By the end of Cycle I, 27 students met the criterion; by the end of Cycle II, 33 students did so. Table 1 reports the original counts alongside percentages recalculated directly from N = 36. These data show a descriptive increase in mastery of 27.78 percentage points between baseline and Cycle I, 16.67 points between cycles, and 44.45 points overall.

Table 1. Student mastery across the classroom action research phases

Phase	Mastery n (%)	Not mastered n (%)	Total
Baseline	17 (47.22)	19 (52.78)	36
Cycle I	27 (75.00)	9 (25.00)	36
Cycle II	33 (91.67)	3 (8.33)	36

Note. Percentages are calculated as n/36 × 100. The source abstract incorrectly labels the nine non-mastered students in Cycle I as 55%; the mathematically consistent value is 25%. The source uses 91.66% and 8.34% for Cycle II; rounding to two decimals gives 91.67% and 8.33%.

The baseline-to-Cycle-II improvement is compatible with a productive iterative teaching process, but it cannot be attributed uniquely to the TSTS structure. Repeated exposure to the topic, teacher adaptation between cycles, and potential differences among assessments are plausible alternative explanations. This caution is consistent with research stressing that learning gains depend on task design and student cognitive activity rather than mere participation (Brod, 2021; Fiorella, 2023; Skulmowski, 2024).

Observed teacher and student activities

Teacher activity was rated 53/60 (88.33%) and 55/60 (91.67%) by the two observers in Cycle I. The corresponding Cycle II scores were 56/60 (93.33%) and 57/60 (95.00%). Student activity was rated 33/40 (82.50%) and 34/40 (85.00%) in Cycle I, rising to 37/40 (92.50%) and 38/40 (95.00%) in Cycle II. Table 2 retains the original observation counts and derives arithmetic means from those counts.

Table 2. Observation scores for teaching and student activities

Indicator	Cycle I: Observer 1	Cycle I: Observer 2	Cycle I mean (%)	Cycle II: Observer 1	Cycle II: Observer 2	Cycle II mean (%)
Teacher activity	53/60	55/60	90.00	56/60	57/60	94.17
Student activity	33/40	34/40	83.75	37/40	38/40	93.75

Note. The original Cycle II teacher table lists a mean score of 85 despite observer scores of 56 and 57; the arithmetic mean is 56.5. The original Cycle II student table reports 83.75%, whereas its observer scores imply 93.75%.

The observed improvement in participation is consistent with the peer-interaction mechanisms proposed in TSTS studies (Apriakanti et al., 2020; Hidayat & Muhson, 2018; Selvianti et al., 2015). It also aligns with broader evidence on active participation and meaningful explanation (Theobald et al., 2020; Darling-Hammond et al., 2020). However, without documented observation rubrics and inter-rater agreement, the ratings should be interpreted as descriptive process indicators rather than validated measures of engagement.

Pedagogical interpretation and implications

The practical value of TSTS in this classroom lies in making every group responsible for explaining and comparing physics solutions. This may reduce reliance on teacher exposition and offer students multiple opportunities to articulate reasoning. The findings are broadly compatible with positive reports on TSTS learning outcomes and motivation across educational settings (Al Falah & Rosy, 2021; Aji & Wulandari, 2021; Rachmawati & Ernawati, 2018; Rusmiati et al., 2023). Nevertheless, teachers should monitor conceptual accuracy, ensure equitable participation, and reserve time for synthesis after the visiting phase.

Physics concepts can benefit from diagrams, demonstrations, and carefully sequenced problems. Research on multimedia learning and instructional design supports combining peer explanation with coherent visual representations and manageable task complexity (Hillmayr et al., 2020; Mayer et al., 2020; Sweller, 2020; Noetel et al., 2021). Teacher readiness and the wider learning environment may also condition implementation quality (Antonietti et al., 2022; Falloon, 2020; Fernández-Batanero et al., 2022; Howard et al., 2021; König et al., 2020). In this context, the cooperative method should be treated as one element of an integrated instructional approach.

Several other studies illuminate implementation considerations without serving as direct TSTS effectiveness evidence. Teacher professional development and classroom design research highlights planning, feedback, and sustained instructional support (Sims & Fletcher-Wood, 2021; Backfisch et al., 2020; Leithwood et al., 2020). Research on learning environments and instructional communication also underscores the importance of clear expectations and active learner contributions (Martin et al., 2020;

Rapanta et al., 2020; Scherer et al., 2021; Seufert et al., 2021). Related studies on teachers' digital competence, school change, and professional preparedness (Lucas et al., 2021; Pettersson, 2021; Tondeur et al., 2021; Trust & Whalen, 2020; Wohlfart & Wagner, 2023) provide additional implementation context, not direct evidence of TSTS effectiveness. These literatures provide contextual guidance, not evidence that the particular class achieved a controlled treatment effect.

Limitations

The study involved one class of 36 students in a single vocational school and used two action cycles without a comparison group. Test equivalence, score distributions, item validity, and observer agreement were not reported. Some original tables and narrative passages contain arithmetic or transcription inconsistencies; the present tables distinguish source counts from recalculated percentages. The manuscript also lacks documented ethics approval and participant consent procedures. Future studies should report these procedures, use consistent assessments, provide item-level data, and triangulate observations with student explanations of work-and-energy concepts.

CONCLUSION AND RECOMMENDATIONS

In this classroom action research, mastery on work-and-energy content increased from 47.22% at baseline to 75.00% in Cycle I and 91.67% in Cycle II. Observer ratings of teacher and student activity also increased. These descriptive findings support continued exploration of TSTS as a structured cooperative-learning option in vocational physics, but they do not establish that TSTS alone caused the improvements. Teachers should prepare concise tasks, assign explicit visiting and hosting roles, verify conceptual explanations, and reflect on achievement and participation after each cycle. Replication with stronger measurement and comparison designs is recommended.

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