EduMa: Mathematics Education Learning and Teaching
December 2023, Vol 12 No 2 Page 188 – 201
https://syekhnurjati.ac.id/jurnal/index.php/eduma/eduma/article/view/14241
p-ISSN: 2086-3918, e-ISSN: 2502-5209
Published by Tadris Matematika IAIN Syekh Nurjati cirebon

EduMa
MATHEMATICS EDUCATION LEARNING AND TEACHING

Enhancing Quadratic Function Learning Outcomes with TGT Cooperative Learning, Desmos, and Quizwhizzer

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article info

How to cite this article:

Hardini, K., Kriswandani, & Nikmah, A.R. (2023). Enhancing Quadratic Function Learning Outcomes with TGT Cooperative Learning, Desmos, and Quizwhizzer. *Eduma : Mathematics Education Learning and Teaching,* 12(2), 188 - 201. doi:http://dx.doi.org/10.24235/eduma.v12i2.14241

Article history:

Received: 06 25, 2023

Accepted: 07 25, 2023

Published: 12, 2023

abstract

This collaborative action research, CAR, aimed to improve the learning outcomes within the material of quadratic function with TGT typed cooperative method, assisted by desmos and quizwhizzer for X-9 graders of SMA N 3 Salatiga. The subjects were the X-9 graders, consisting of 34 participants, 14 males and 20 females. The research lasted from precycle, cycle I, and cycle II. Each cycle consisted of four stages: planning, applying, observing, and reflecting. The data collecting techniques were learning outcome test, observation, and documentation. The applied research instruments were observation sheet for the learning process and questions for each end of cycle. The researchers analyzed the data with descriptive statistics and qualitative description. The results showed the applied model with desmos and quizwhizzer assistances could improve the learning outcomes. The obtained mean scores increased, starting from the pre-cycle with 68.8, cycle II with 75.3, and cycle II with 82.6. The classical achievement was 80%. The achievement increased from the precycle with 47.1%, cycle I with 70.6%, and cycle II with 85.3%.

Keywords:
Learning outcomes, Cooperative learning, TGT, Desmos, Quizwhizzer

INTRODUCTION

Mathematics is a compulsory lesson for senior high schools. Learners must study mathematics to apply it to their daily routines. Rachman & Amelia (2020) stated that the mathematics concept is observable in various life sectors, such as technology, economy, science, etc. Thus, mathematics requires further development. Unfortunately, learners find mathematics a difficult and boring lesson. They also perceive mathematics as a troublesome lesson. Found many learners perceived mathematics as a boring and challenging lesson (Matulessy & Muhid, 2022; Nisa, MZ, & Vebrianto, 2021). Thus, they thought of mathematics as a burden and did not realize the daily benefits of mathematics.

The observation results in May 2023, on learners from the X-9 class at SMA N 3 Salatiga, found 34 learners still had difficulties in learning mathematics, especially the quadratic function with table assistance. The evidence, based on the interview results, showed that the learners had difficulties 1) calculating with a quadratic function specifically to determine the quadratic function point that they would put on the table; 2) putting the quadratic function point on the cartesian coordinate so that the produced figures did not have an excellent curve, and 3) write the interpreted results of the produced quadratic function. The learning outcomes showed the mean score was 68.8, with a minimum score of 30 and a maximum score of 90. The classical accomplishment obtained was 16 (47.1%). On the other hand, 18 learners, 52.9%, could not reach the minimum mastery standard score. Figure 1 shows the results.

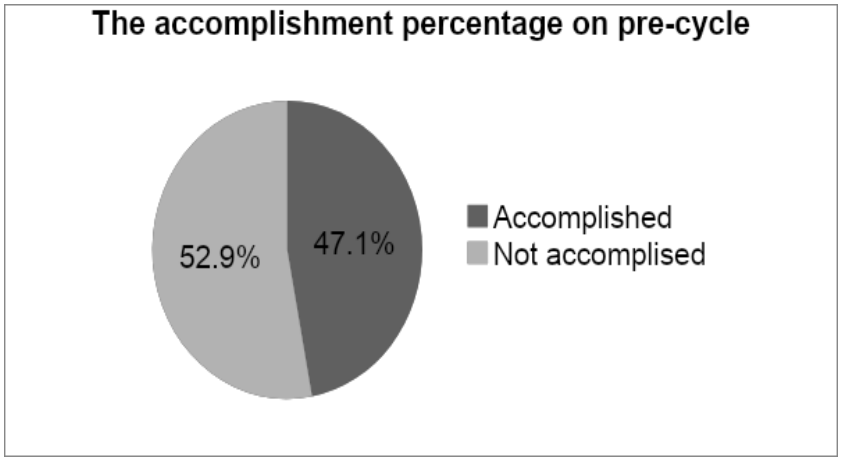

Figure 1.
The accomplishment percentage on pre-cycle

The figure shows the learning outcomes do not reach the accomplishment. The learners seemed to have difficulties with quadratic function material. Therefore, the creative and innovative action of a teacher is important to realize an innovative learning model to this research. efforts that can be implemented and are important to support this research are by finding solutions through cooperative learning models and the media to be used.

The cooperative learning model can be used as a solution in maximizing student involvement in the learning process regardless of status. The cooperative learning model can be carried out by involving students to form small groups and collaborating with each other, having social relations, having self-confidence, and trusting group members. Thus, the role of the teacher here is to become a facilitator and mentor who can direct students in increasing their knowledge. There are several types of cooperative learning, including STAD, jigsaw, TGT, Group Investigation, and others. Here, the teacher takes an alternative solution by using the TGT type of cooperative learning model because the learning provides a pleasant atmosphere compared to other types. This is in line with

Ivana (2020) research that the TGT model can also add a dimension of joy obtained from playing, which is different from other models such as STAD.

TGT learning is realized by playing a game in a tournament. This realization becomes something unique and could involve the learners' activeness in every group. Hasanah, Wijayanti, & Liesdiani (2020) explains that the TGT type cooperative model is applicable. This model involves all learners' activities heterogeneously. They also have the roles of peer tutors. In this model, learning occurs by playing games and empowerment. This learning model applied a collaboration among 4 to 5 learners by presenting material, involving all learners' participation, discussing within groups, and playing and competing in a tournament. Gunarta (2019) explains that the syntax of the TGT cooperative type learning model includes 1) class presentation - the teachers provide materials in front of a class, 2) teams – the learners discussed and presented collaboratively, 3) games – the learners worked on the questions individually, 4) tournament – the groups competed for each other to get the highest score, and 5) team recognition – the group with the highest score obtained acknowledgment. Ivana (2020) explains the superiorities are 1) the game and tournament syntaxes to provide joyful and competitive nuances within a full of concentration atmosphere, 2) the existence of knowledge aspect of the learners and their responsibilities to understand and master the material concepts, and 3) the challenge to perform excellent academic by competing to earn points. Found that the TGT cooperative type learning model could improve the learning outcomes (Armidi, 2022; Merti, 2020; Suardin & Andriani, 2021).

The TGT cooperative-type learning model is adjustable with various classroom learning media. In this research, the researchers used desmos to facilitate the learners' understanding of quadratic functions by interpreting the challenging curve for the learners. Desmos is an online and offline learning material for geometric (Kusumaningtyas, Trapsilasiwi, & Fatahillah, 2018). Desmos could facilitate users without any programming skills with online and offline access via smartphone. This application also motivates learners to solve mathematics problems. Lestari, Senjaya, & Ismunandar (2019) explains that an android-based learning media could motivate and train learners to study mathematics independently. The other supporting media was quizwhizzer. This media is an online quiz to apply by having a tournament. Quizwhizzer is an educational game application with flexible and narrative natures (Wahyuningsih et al., 2021). This application provides attractive, joyful, and accessible learning evaluation. Quizwhizzer is applicable for both teachers and learners to play tournament games. The application also motivates learners to keep up their hard work, collect the point, and discuss with their groups. Secondly, this learning media could improve the activeness, motivation, and learning interest of the learners to improve their learning outcomes. Besides that, this media could facilitate learners to make quadratic function graphics. Thus, the learners will not encounter challenges to create the graphics.

Teachers can combine the TGT cooperative-type learning model with online media to provide fun learning, especially in understanding quadratic function problems. From the background, the researchers attempted to improve the learning outcomes of quadratic function material with TGT-type cooperative learning assisted by desmos and quizwhizzer for X-9 graders at SMA N 3 Salatiga.

LITERATURE REVIEW

The success of learning is observable from the learners' learning outcomes, skills, habits, and experience from the learning. The teachers could measure the learners' understanding of the materials by evaluating them. The evaluation is useful to facilitate the learners' learning outcomes to reach the minimum mastery standard criteria.

Teachers could provide various learning from various learning models. A different learning model could be an influential factor in learning success, effectiveness, and efficiency. Teachers could use the TGT cooperative type learning model. This learning model has a gaming element and involves all learners. The gaming element still contains the material element, such as quizzes with question-type items (Merti, 2020). Gunarta (2019) explains the syntax of the TGT cooperative type learning model are 1) class presentation, 2) teams, 3) games, 4) tournament, and 5) team recognition. The chosen learning model by teachers could be the alternative to support the learning activity, motivate learners, and to invite learners actively improve their learning outcomes.

Teachers could use their digital skills to facilitate the learning promotion with digital and online-based learning media, for example, desmos as the alternative and supporting media. This media helps teachers to illustrate an object and makes the learners able to practice mathematics questions individually or collaboratively. Desmos is a web calculator that learners from various educational backgrounds could easily use in mathematics learning (Haerunnisa et al., 2021). Teachers could use the features of Desmos to visualize any abstract mathematics materials correctly, accurately, and efficiently (Husna, Setiawani, & Hussen, 2020). Thus, the implementation in the classroom could facilitate the teachers to visualize any geometric-associated graphics and facilitate learners understanding of the given materials.

Teachers could also use an interesting online quiz application to evaluate the learning process, named quizwhizzer. (Wahyuningsih et al., 2021) explain that quizwhizzer is useful for evaluation and monitoring purposes. The application also makes the learners, as the users connect with the game questions of the teachers. The learners could access quizwhizzer only by inputting the quiz code from the teacher. This application is interesting for learners because the application has a gameboard and adequate quiz items. Teachers could also prepare various question banks with various question types, such as multiple choice, multiple responses, numerical answer, short answer, true/false, open-ended, drag and drop into text, ordering, and slide. Teachers could insert figures, videos, and voice recordings into the questions. Thus, quizwhizzer is applicable for teachers to support the evaluation digitally.

METHODS

Sample

The research subjects consisted of X-9 graders of SMA N 3 Salatiga, Salatiga. They were 34 learners, consisting of 14 males and 20 females. The sampling technique is purposive sampling.

Reseach Design

This collaborative classroom action research lasted within two cycles, applying Kemmis & Taggart. The step consisted of planning, implementing, observing, and reflecting (Rasyimah & Kumala Sari, 2022). One of the indicators of success in each cycle was - learner learning accomplishment for more than 80%. Learners who did not meet the criteria had to join remediation. Then, the researchers would commence the next cycle.

Data Collection and Analysis

The researchers collected the data from learning test results of each cycle, observation, and documentation. The assessment instruments were 1) question rubrics, question types, and question numbers. Cycle I consisted of rubrics and essay questions with three questions on the tests about the implementation of the quadratic function formula. Cycle II consisted of three essay questions with quadratic function application material and an

observational sheet about how the teachers promoted teaching and learning and the learners' responses. The applied data analysis techniques were 1) descriptive statistics to determine the maximum, minimum, mean, and accomplishment scores; and 2) qualitative descriptive to explain the reflection after the learning.

RESULT AND DISCUSSION

Description of data

A. Cycle I

The discussed action process in this sub-chapter consisted of four stages, starting from planning, implementing, observing, and reflecting. Here is the explanation.

1. The Plan of Cycle I

The reflection and evaluation results on pre-cycle on March 29 to 31, 2023. The researchers obtained the results from teaching-learning activities, interviews with the teachers, and learning test results. The obtained results were the applied learning by teachers and learners running smoothly although the learning encountered challenges. The delivery process of a quadratic function applied for table assistance. However, this implementation was interrupted due to a blackout so the teacher could not use the LCD. On the other hand, the material reception indicated that the learners had mistakes in calculating the quadratic function value. Thus, the produced points and figures on the Cartesian coordinate, in the form of a curve, were not smooth. Some learners also had difficulties to interpret the other figures.

From the reflection results and pre-cycle of the earning result, the researchers found alternative solutions, such as planning the lesson with the TGT cooperative model. Thus, learners could learn by playing as the solution. The learning media, with desmos, could make the learners understand the quadratic function problems and quizwhizzer as the game media while having a tournament. This effort made a joyful situation and motivated the learning in cycle I.

In this activity, the researchers realized the plan within 3 days, from April 2 to 4, 2023. The details of the plan were: a) arranging the learning instrument in the form of teaching materials based on the TGT type cooperative learning model, worksheet, quiz on quizwhizzer, desmos link, question test, and assessment criteria on quadratic function formula; b) organizing every 4 to 5 learners to learn in a group with diverse academic levels based on the pre-cycle test results; c) preparing laptop and LCD for learning process; and d) preparing camera to document the learning activities. The applied material was associating the quadratic function figures with the table (pre-cycle) and the quadratic function formula (new material).

2. The Implementation of Cycle I

The activities in cycle I lasted for two days. The first meeting was on April 5, 2023, and the second meeting was on April 6, 2023. This cycle applied TGT with desmos and quizwhizzer. The first activity included: a) class presentation - the teacher stimulated the learning for the learners about the requirement of a curve crossing the X-axis and Y-axis, the discriminant requirement, the unsymmetrical point, the optimum value formula, and the peak point; and b) teams - the teacher grouped the learners into some groups consisting of 4 to 5 learners with various academic capabilities based on the pre-cycle results. The teachers shared the worksheet to discuss and input the results into the distributed quizwhizzer codes. In this activity, all learners were responsible to

comprehend the given and discussed materials collaboratively. At the end of the activity, one of the group representatives shared the discussion results.

In the second meeting activity, the researchers continued the previous the TGT syntax, such as c) games - the teachers explained the game with the given rules by the researchers, using the quizwhizzer, to solve by the learners about 8 quadratic function questions based on the academic levels; d) tournament - the teacher commenced a tournament to make joyful learning atmosphere by competing; all learners attempted to collect the scores for their original groups; and e) team recognition - the teachers recognized the best team by rewarding them with pins for their efforts of collecting scores. The researchers also ended the activities by introducing the desmos learning media introduction.

3. The Observation on Cycle I Action

The data processing activity in cycle I lasted within one day, April 7, 2023. The learning outcomes showed the mean score was 75.3, with a minimum score of 40 and a maximum score of 100. The accomplishment obtained was 24 (70.6%). On the other hand, 10 learners, 29.4 %, could not reach the minimum mastery standard score. Figure 2 shows the accomplishment percentage in cycle I.

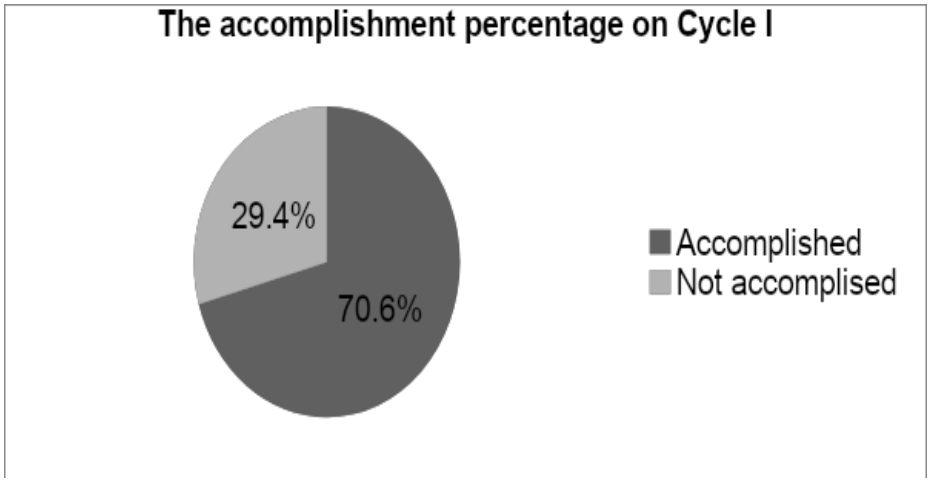

Figure 2.
The Accomplishment Percentage of Cycle I

Figure 2 shows 70.6% of learners do not reach the accomplishment criteria, 80%. Thus, action and empowerment were important to apply in cycle II.

4. The Reflection of Cycle I Action

The researchers reflected on a day on April 8, 2023. The reflection showed that in cycle I the implementation of the TGT type learning assisted by desmos and quizwhizzer could run properly although the implementation encountered challenges. The challenges of the teacher were: a) introducing the implementation of desmos at the end of the team recognition meeting instead of during the data display. This matter made the learners have no ideas about the implementation of desmos while discussing; 2) applying link as the medium to share the quizwhizzer code seemed to be inefficient; and 3) organizing the learners to sit for tournament purposes was not effective because the learners had to move from the original group to the academic groups. The challenges dealt with the provision of alternative solutions. This matter included how the teachers a) explained the function and the implementation of desmos after providing the group reward, b) met the students twice and shared the barcode for the learning media access, and c) single group rotation while discussing. During the meeting, the learners found the learning

activity joyful because they could play games and receive different learning media. The learners could also understand the implementation of desmos as the supportive media to confirm the answers and interpret the quadratic function correctly.

Based on the reflection results and the learning outcomes in cycle I, compared to pre-cycle, the researchers found the learning outcome mean increment in cycle I, 6.47, from 68.8 in pre-cycle to 75.3 in cycle I. The percentage of the learners' accomplishment increment was 23.5%. The pre-cycle was 47.1% into 70.6% in cycle I. Figure 3 shows the results.

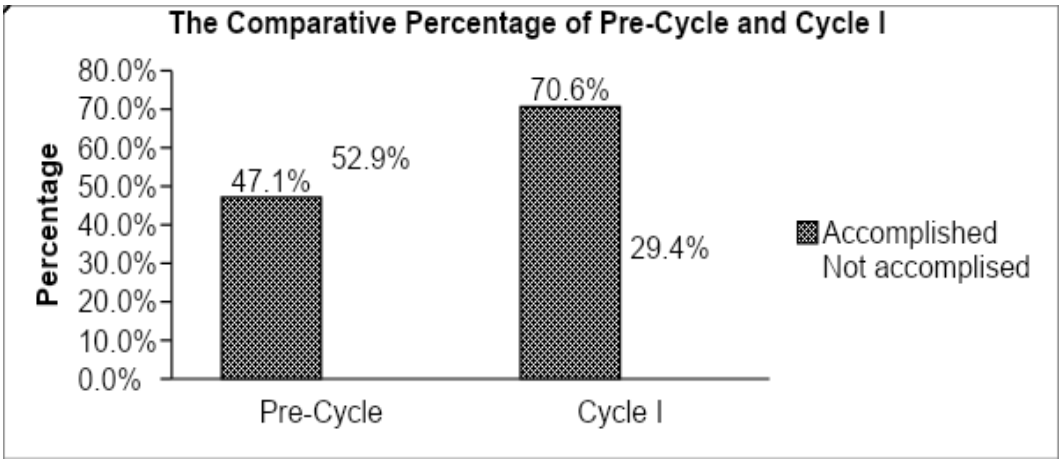

Figure 3.
The Comparative Percentage of Pre-Cycle and Cycle I Accomplishments

B. Cycle II

The discussed action process in this sub-chapter consisted of four stages, starting from planning, implementing, observing, and reflecting. Here is the explanation.

1. Cycle II Action Plan

The reflection and evaluation results in cycle I, on April 7 and 8, 2023. The researchers obtained the reflection results of teaching and learning, interviewed the lesson teacher, and observed the teaching material. The obtained results were the applied learning by teachers and learners running smoothly although the learning encountered challenges. The encountered problems by the teachers were a) asking the learners to move from the original groups into the academic groups while having a tournament. This phase took longer time; b) sharing the access code took longer time compared to sharing the bar code, and c) having the habit of a quick speech made the learners not understand the explanation about quadratic function formula material.

The encountered problems provided alternative ideas for the follow-up actions of the learning outcomes. Thus, the learning outcomes could be improved in the second cycle. The researchers did the revisions by a) planning the seat movement while discussing, b) sharing the bar code for the learners while using desmos and quizwhizzer, and c) providing notes about desmos media implementation to manage the learners' quadratic function difficulties.

Cycle II applied the same learning media and model as in cycle I, the TGT cooperative learning model assisted by desmos and quizwhizzer. In this activity, the researchers realized the plan within 3 days, from April 9 to 11, 2023. The details of the plan were: a) arranging the learning instrument in the form of teaching materials based on the TGT type cooperative learning model, worksheet, quiz on quizwhizzer, desmos link, question test, and assessment criteria on quadratic function formula; b) organizing every 4 to 5 learners to learn in a group with diverse academic levels based on the pre-cycle test

results; c) preparing laptop and LCD for learning process; and d) preparing camera to document the learning activities. The applied materials dealt with the general formula to describe the quadratic function in cycle I and the quadratic function application in daily life.

2. The Action Implementation of Cycle II

The learning activity in cycle II lasted for 2 days, from April 12 to 13, 2023. The first activity included: a) class presentation – the teacher stimulated the learning, providing materials about the formula of axis interception, Y-interception, discriminant, unsymmetrical matter, optimum value, and peak value; The researchers provided a lesson about quadratic function for daily life with the assistance of desmos to confirm the answers; b) teams - the researchers put the learners in smaller groups. The groups were different from cycle I, consisting of 4-5 learners with diverse academic skills from cycle I. The researchers shared the worksheet for further collaborative discussion. Thus, every learner would be responsible to understand the given materials and discuss together. At the end of the activity, one of the group representatives shared the discussion results.

The second meeting activity consisted of the continuation of the previous meeting, such as c) games - playing a game with the given rules by the researchers, using the quizwhizzer, to solve the learners about 10 quadratic function questions based on the academic levels; d) tournament - commencing a tournament to make joyful learning atmosphere by competing. All learners attempted to collect high scores for their original groups; e) team recognition - the learners and the best team received rewards in the forms of pins and bottles. The last activity was the final test.

3. The Action Observation of Cycle II

The data processing in cycle II lasted within a day, April 14, 2023. The learning outcomes of the learners showed a mean score on quadratic function material implementation in daily life 82.6. The minimum score was 55 and the maximum was 100. The accomplishment obtained was 29 (85.3%). On the other hand, 6 learners, 14.7%, could not reach the minimum mastery standard score. Figure 4 shows the percentage of learning accomplishments in cycle II.

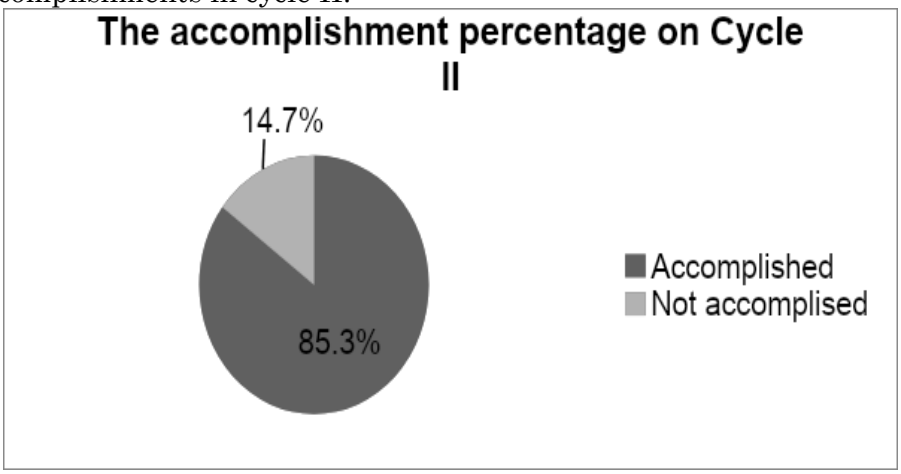

Figure 4.
The Accomplishment Percentage of Cycle II

Figure 4 shows a percentage of 85.3% of learners reached the accomplishment criteria of 80%. Thus, the cycle stopped and did not proceed in cycle III.

4. The Action Reflection of Cycle II

The reflection results in cycle II consisted of learning promoted by teachers with a TGT type of cooperative learning model assisted by desmos and quizwhizzer. The implementation ran smoothly. Learners felt happy while practicing with desmos as the learning media. They could receive a clear explanation and look at the figures directly. While playing the game, the learners were confused when they had incorrect codes of quizwhizzer from the academic codes. However, the activities were anticipated by sharing the correct codes. Since the time was running out, the test only lasted within a lesson period. For the other activities, the researchers did not find any fatal situations.

Based on the reflection results and learning outcomes in cycle II, compared to cycle I, the results showed a learning outcome increment in cycle II for 6.47. The result was higher than in cycle I, 75.3, into 82.6 in cycle II. The percentage of accomplishment also had a 14.7% increment, from 70.6% in cycle I to 85.3% in cycle II. Figure 5 shows the results.

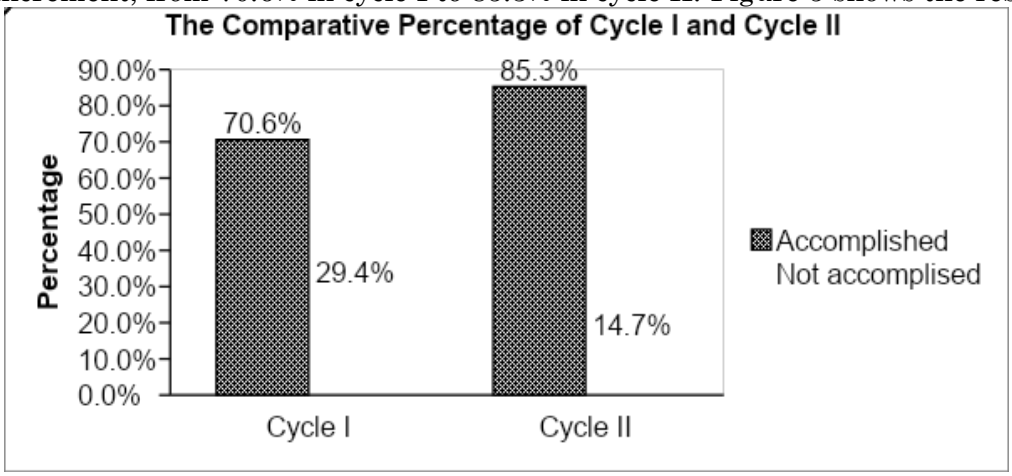

Figure 5.
The Percentage Comparison between Cycle I and Cycle II

C. The comparison among cycles

The researchers analyzed the data by comparing the learning outcomes among the cycles. The researchers could determine the accomplishment percentage and compare the improvements. Figure 6 shows the comparison of accomplishment percentages among the cycles.

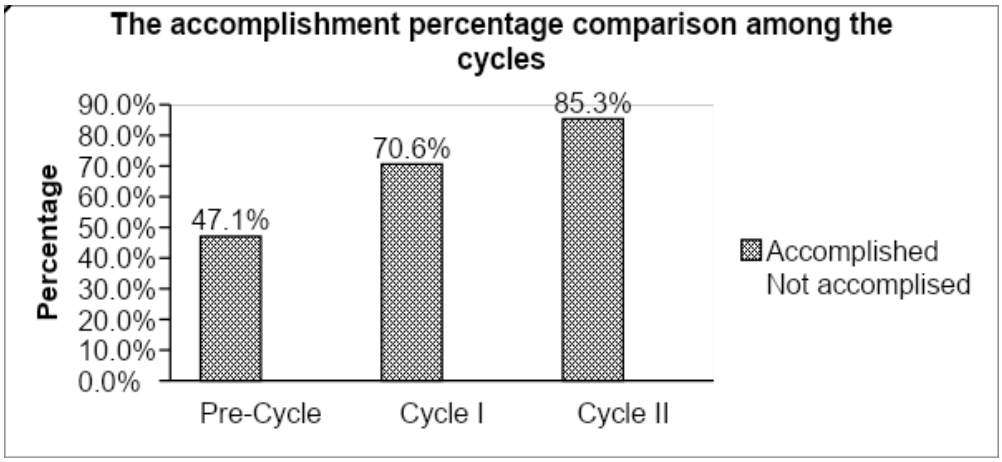

Figure 6.
The Accomplishment Percentage Comparison among Cycles

Table 1 shows the test results among the cycles.

Table 1. The Test Score Comparison among the Cycles

	Pre-cycle	Cycle I	Cycle II
Mean	68,8	75,3	82,6
The percentage of learners with minimum mastery standard accomplishment	47,1%	70,6%	85,3%
The percentage of learners without minimum mastery standard accomplishment	52,9%	29,4%	14,7%
Minimum score	30	40	55
Maximum score	90	100	100

Figure 6 and Table 1 show the percentage increments of the accomplishment test scores on each cycle. The accomplishment in cycle I did not reach 80%. Thus, the researcher proceeded in cycle II by focusing on and adding materials. On the other hand, the accomplishment in cycle II reached higher than 80%. Thus, the researchers stopped the cycle in cycle II.

Learning model with desmos and quizwhizzer could improve the learners' activities and enthusiasm to join the learning process in each meeting. The learning stages of the team-game-tournament-type cooperative model were: 1) class presentation - the teacher guided the learners about the materials, 2) teams - teaming up the learners to make them discuss, take responsibility, and master the material, 3) games - playing game to encourage learners to solve the quadratic function based on their academic skills, 4) tournament - allowing the learners to participate in collecting the points for their original groups and competing for each other to get the highest score, and 5) team recognition - finding the best team with the highest point.

The activity of playing the game brought a joyful situation by activating the learners. Thus, the learners had the spirit to learn by competing. Then, the researchers gave the reward at the end of the lesson. This observable spirit during the learning model implementation better influenced the learners' learning outcomes than the common learning. The evidence was the score increments among cycles. Ivana (2020) also found that learning outcomes with the team-game-tournament-type cooperative learning model were better than conventional learning. The TGT learning was more interesting and attractive because the game was competitive. Thus, learners were more active and motivated in learning.

The team-game-tournament-type cooperative learning model could establish the material concept of the learners, challenge the learners, and motivate the learners with various questions. The questions were useful to encourage the learners to master the skills comprehensively and immediately. The evidence was the difference in the attitude and the outcomes after playing the game. Sugiata (2018) explained that the team-game-tournament-type learning model could provide better results in cycle II than conventional teaching. This improvement happened because the learners were motivated to work on the questions.

The given quadratic function material with the TGT cooperative type learning model should receive any applicable learning media support. This matter could manage the difficulties of the learners to understand the quadratic function questions, such as drawing and interpreting figures and solving real-life problems. The alternative solution, the teachers could use desmos to facilitate the learners' comprehension of quadratic function material. The learners only needed to use handphones to access desmos. The

learners seemed very focused and active to join the learning process due to their high curiosity level on the real application. TLS & Herman (2020) also found a correlation between the correlation and the real desmos application due to the social activity supports for the learners. Thus, the learners actively participated in the learning.

Desmos media facilitated teachers to make the learners understand the necessity of drawing carefully and visualizing the graphics. The figure shows that the implementation of desmos was easy to understand and visualize compared to the personal imagination of the learners. The learners could also understand the confirmatory answers after they worked on the questions manually. (Haerunnisa et al., 2021) found that desmos as alternative learning was suitable for applied drawing with high carefulness. The implementation of desmos was more understandable because the graphic visualization was clear, attractive, and colourful (Husna, Setiawani, & Hussen, 2020).

The other supportive evidence was how the teacher attempted to introduce and use the online questions, the quizwhizzer, for the learners while having the tournament. Before working on the questions, the teachers directed the learners to input the quiz codes in quizwhizzer. During the implementation of quizwhizzer, the learners seemed enthusiastic to work on the questions. The learners were challenged due to the implementation of a direct ranking rule so they were motivated to do their best. Zhao (2019) also found that the quiz game features made the learners interested. The learners were also interested in the leaderboard to see their performance directly. Thus, they were motivated and could concentrate to learn.

The applied questions for the quiz were about conceptual understanding and quadratic function. The teacher could provide the questions repeatedly and increase the question difficulties. Thus, the learners would find themselves challenged to work on the questions. Faijah, Nuryadi, & Marhaeni (2022) also found that quizwhizzer-based educative games could improve the initial conceptual understanding of the learners. The researchers provided the quiz repeatedly to challenge the learners in each material. (Wulan et al., 2021) found that the implementation of quizzes could challenge the learners in comprehending the learning initiation.

The implementation of digital-based media, with desmos and quizwhizzer, could provide benefits for both teachers and learners. The benefits were observable when the teachers involved and motivated the learners with digital literacy and technology literacy matters. Saluky, Riyanto, & Rahmah (2022) also found that learners had to integrate technology into their daily life, especially in learning. Thus, teachers should provide digital and technology literacy activities. The digital-based learning provided external-motivational messages positively (Udin, Maufur, & Riyanto, 2022).

In this research, the results proved that new actions for the learners repeatedly with quizzes could facilitate the learners by remembering and understanding the delivered materials. From the learning implementation, the team-game-tournament-type cooperative learning model assisted by desmos and quizwhizzer could improve the learning outcomes of the learners from X9 class at SMA N 3 Salatiga on quadratic function material.

CONCLUSION

From the learning implementation, TGT-type cooperative learning model assisted by desmos and quizwhizzer could improve the learning outcomes of the learners from X-9 class at SMA N 3 Salatiga on quadratic function material. The evidence showed the pre-cycle mean was 68.8. In cycle I, the mean score improved to 75.3. Then, in cycle II, the mean improved to 82.6. The same results were observable in the accomplishments. In the pre-cycle, the accomplishment percentage was 47.1%. In cycle I, it was 70.6%, and in cycle II with 85.3%. The impacts of this research include: 1) students know and recognize the existence of new media such as desmos and quizwhizzer which have never been used in learning; 2) students are more active in learning by using the TGT type cooperative model, seen from the discussion activities carried out together and the activity of collecting as many points as possible on the quizwhizzer for the home group, so that students compete to get awards; 3) students better understand the forms and problems in quadratic functions with the help of desmos media because the images produced are very clear and easy to understand.

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