AlphaMath
Journal of Mathematics Education, 10(1) May 2024
p-ISSN 2477-409X, e-ISSN: 2549-9084
Available online: https://jurnalnasional.ump.ac.id/index.php/alphamath/

Mathematical Connections of Students Viewed from Adversity Quotient in Problem-Based Learning Using Math City Map

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http://dx.doi.org/10.30595/alphamath.v10i1.21662

ABSTRACT

The connection between mathematics and adversity quotient (AQ) has an important role in a person's ability to make decisions to solve problems in life. One of the efforts to improve it is through the application of technology in learning. The Math-City Map (MCM)-assisted Problem-based learning (PBL) model is one of the learnings that utilizes technology combining the PBL model and MCM-assisted learning. This study aims to (1) the quality of learning with a problem-based learning model using a math city map on mathematical connection ability (KKM, (2) test the effect of AQ on students' mathematical connection ability in MCM-assisted PBL learning. This research is a mixed method research with an explanatory sequential design with a quantitative portion greater than qualitative. The population of this study was grade VII students of SMPN 2 Ambarawa. Qualitative data was taken based on students' AQ, namely the climber, camper, and quitter categories. Quantitative data analysis techniques with parametric statistics such as mean tests, classical due diligence, and regression tests. Qualitative data analysis techniques use data reduction, presentation, and conclusions. The results showed that (1) MCM-assisted PBL learning was effective in improving students' mathematical connections (2) there was an influence of AQ on students' mathematical connection abilities in MCM-assisted PBL learning
Keywords: Math Connection Ability, Adversity Quotient, PBL, Math City Map

ABSTRAK

Koneksi matematika dan adversity quotient (AQ) memiliki peranan penting dengan kemampuan seseorang dalam membuat keputusan untuk memecahkan permasalahan yang ada di kehidupan. Salah satu upaya dalam meningkatkannya adalah melalui pengaplikasian teknologi dalam pembelajaran. Model Problem-based learning (PBL) berbantuan Math City Map (MCM) merupakan salah satu pembelajaran yang memanfaatkan teknologi menggabungkan model PBL dan pembelajaran berbantuan MCM. Penelitian ini bertujuan untuk (1) kualitas pembelajaran dengan model problem-based learning menggunakan math city map terhadap kemampuan koneksi matematis (KKM, (2) menguji pengaruh AQ terhadap kemampuan koneksi matematika peserta didik pada pembelajaran PBL berbantuan MCM. Penelitian ini adalah penelitian mixed method dengan desain sequential eksplanatory dengan porsi kuantitatif lebih besar daripada kualitatifnya. Populasi penelitian ini adalah siswa kelas VII SMPN 2 Ambarawa. Data kuantitatif dipilih dengan teknik simple random sampling. Data kualitatif diambil berdasarkan AQ siswa yaitu kategori climber, camper, dan quitter. Teknik analisis data kuantitatif dengan statistika parametrik seperti uji rata-rata, uji ketuntasan klasikal, dan uji regresi. Teknik analisis data kualitatif menggunakan reduksi data, penyajian, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa (1) pembelajaran PBL berbantuan MCM efektif dalam meningkatkan koneksi matematika peserta didik (2) terdapat pengaruh AQ terhadap kemampuan koneksi matematika peserta didik pada pembelajaran PBL berbantuan MCM
Kata kunci: Kemampuan Koneksi Matematika, *Adversity Quotient*, PBL, Math City Map.

Received : April 22, 2024
Accepted : May 17, 2024
Published : May 18, 2024

Introduction

Facing the challenges of the 21st century, students are required to master connection skills (Laar et al., 2017). Classify 21st century abilities into seven namely technical, information management, communication, collaboration, creativity, critical thinking, and problem solving. Connection skills, based on these seven abilities, are one of the mathematical abilities that play an important role in achieving mathematics learning goals. The ability of students to understand the three aspects of connection is called mathematical connection ability. According (García & Dolores, 2018; Jäder et al., 2020) define that mathematical connection ability is the ability of students to understand the relationship between mathematical concepts, both between concepts themselves and with other fields. A student has mathematical connection ability if he or she can recognize and use connections among mathematical ideas, understand how mathematical ideas are interconnected, build on each other to produce a coherent whole, and identify and apply mathematics in contexts outside mathematics. Although math connection skills are essential to learning maths, students still face barriers to mastering them (Rafiepour & Faramarzpour, 2023). This is according to research by Rahmawati et al., (2019) and (Siregar & Surya, 2017) show that the math connection ability of high school students is categorized as very low. The low percentage of achievement shows it in indicators of connections between mathematical concepts, connections between mathematical concepts and other disciplines, as well as relationships between mathematical concepts and everyday problems. In addition, other research by Kenedi et al., (2019) showed that as many as 8 students or 6.67% of the research sample had scores between 60 and 69 which were included in the sufficient category. A total of 98 students or 81.67% had scores between 45 and 59 which belonged to the less category. Meanwhile, 14 students or 11.67% had scores between 0 and 44 which were included in the very low category. This proves that the mathematical connection ability of elementary school students in solving math problems is still low. In addition, it is proven that the results of observations of several students of SMPN 2 Ambarawa obtained data that students generally have low mathematical connection abilities. This can be seen from the results of the initial ability test of mathematical ability of students who obtained an average score of 58 far below the minimum completeness criterion of 70. This proves that students still have difficulties in the process of mathematical connection abilities. Basically students who lack interest in learning mathematics, then these students naturally do not have the desire to seriously study mathematics and do not try to improve their ability to mathematical connections.

Students' mathematical competence is not only influenced by mathematical connections as a cognitive element but also influenced by adversity quotient as one of the affective aspects. According to (Qin et al., 2019) Adversity quotient is one of the keys to successful learning mathematics, where AQ is used to measure people's ability to withstand setbacks, get rid of difficulties and transcend difficulties. Another opinion is by (Marie & Luni, 2014) which states that the adversity quotient is the method by which a person's brain is redesigned to achieve success. In addition, according to (Parvathy & Praseeda, 2014) Adversity quotient is the capacity to face the difficulties of life. Thus, it is the science of human Resilience. In addition, AQ has a role as individuals will face challenges in daily life, such as competition, productivity, learning, and endurance (Matore et al., 2015). This is confirmed by (Parvathy & Praseeda, 2014), who stated "Students face many situations or challenges in their daily lives." Students who have a high AQ will be able to survive in the face of various difficulties in learning. Students who have a high AQ will try to find as many solutions as possible in solving math problems. Therefore, AQ is needed by students facing problems in learning mathematics. But the fact is that there are still many students who have low AQ, therefore a model is needed that can increase students' mathematical connection ability in solving mathematical problems, the model that is considered suitable is Problem-Based Learning.

PBL is an engaging and effective learning method that centres on the student and utilizes real-world problems. This approach not only helps students understand concepts but also develops important skills valuable for their future endeavours (Abushkin et al., 2018; Ali, 2019; Havenga & Athur, 2022; Prasad & O'Malley, 2022) highlight its effectiveness in knowledge retention and long-term application. Additionally, PBL is recognized for its emphasis on contextual learning (Guerra, A. & Holgaard, 2019) and its promising history in addressing contemporary educational needs (Blundell & Berardi, 2016). However, it's important to acknowledge that implementing PBL effectively can be challenging**.** These challenges can include factors like requiring strong facilitation skills, ensuring access to appropriate resources, and adapting the approach to different learning styles and student needs**.** Despite these potential hurdles, PBL remains a powerful tool for educators seeking to promote deeper learning and transferable skills in their students.

The use of the PBL model in this study aimed to improve students' abilities in several key areas. One focus was on developing students' communication and connection skills through collaboration and the need to explain their ideas clearly. Additionally, the application of PBL fostered critical thinking and problem-solving skills. By grappling with real-world problems, students were challenged to analyze information, think critically, and develop effective solutions. This aligns well with the Ministry of Education and Culture and Technology's self-curriculum learning and assessment guidelines, which emphasize providing students with engaging, contextual learning experiences that develop critical thinking skills.

What distinguishes this research is the specific focus on the development of communication skills alongside critical thinking and problem-solving within the PBL framework. Many previous studies have explored the effectiveness of PBL in promoting critical thinking and problem-solving. This study adds to the existing body of knowledge by investigating how PBL can be used to cultivate both critical thinking and communication skills simultaneously.

Based on the above problems, researchers are interested in taking the title "The ability of mathematical connections in terms of Adversity quotient on problem-based learning assisted by math city map".

Research Methods
The research employed a mixed methodology design, with quantitative research as the primary approach and qualitative research as a secondary approach. A pretest-posttest control group design was utilized to assess the effectiveness of the PBL model with project-based assessment. Two classes from SMPN 2 Ambarawa participated: an experimental class and a control class. Students in the experimental class engaged with problem-based learning activities using Math City Map, while the control class received traditional problem-based learning assignments. The study population included all grade VII students at SMPN 2 Ambarawa, with a sample of 63 students selected through cluster random sampling. Class 7C served as the control class and class 7E as the experimental class.

Data analysis involved a two-pronged approach aligned with the mixed methods design. Quantitative data, such as scores from the self-efficacy questionnaires and mathematical connection ability tests, were analyzed using descriptive statistics and inferential statistics (specify the specific tests used, e.g., independent samples t-test). Qualitative data from the adversity quotient questionnaires and interview data were analyzed thematically to identify emerging patterns and insights related to student experiences with the PBL intervention.

Result and Discussions
Adversity Quotient (AQ) categorization was carried out on 32 experimental class learners (VII E) using AQ measures verified by experts and checked for validity and reliability. The AQ measure has 20 statements. Students with high AQ levels ranging from 143 to 200 fall into the Climber category, medium AQ levels ranging from 109 to 142 fall into the Camper category, and low AQ levels ranging from 0 to 108 fall into the Quitter category. There are 5 students with high AQ levels, 24 with medium AQ levels, and 3 with low AQ levels. Six students were selected as interview subjects to

characterize the math connection abilities of students in the experimental class in terms of AQ.

Quantitative Data Analysis

The first test to be performed is the normality test. This test is used to determine whether the data includes normally distributed data or not.

Normality test

Table 1. Data Normality Test Results

Class	Sig.	Information
Eksperimen	0,200	Normal distributed data
Control	0,200	Normal distributed data

Based on Table 1, the sig values of the two classes are 0.200 and 0.200 so if the sig values of the two classes are more than 5%, then H_0 is accepted, meaning that the final data comes from a normally distributed population. So, the sample comes from a normally distributed population sig value

Homogeneity test

Table 2. Data Homogeneity Test Results

Levene Statistic	df1	df2	Sig.	Information
0,200	3	124	0,506	Homogen

Based on the Table 2, sig values of 0.506> 0.05 are obtained. Since the sig value is more than 5% then H_0 is accepted, this indicates that the variance of the experimental class is equal to the variance of the control class.

Hypothesis Test 1 (Test of Average Mathematical Connection Ability)

Table 3. Average Test Results for Mathematical Connection Ability

The result t uses the formula

	N	Mean	Std. Deviation	t	Sig.(2-tailed)
TKKM_Eks	32	79.6250	9.89868	1.74986	0.000

Based on the calculation results with the formula t (Table 3), obtained the value of T_{hitung} = 1.74986 > 1.64 = T_{tabel} then H_0 rejected. This means that the average Mathematical Connection Ability (KKM) of students in Problem-based Learning (PBL) assisted by math city map reaches KKM.

Hypothesis Test 2 (Classical Completeness of Mathematical Connection Ability)

Table 4. Results of the Experiment Class Classical Completeness Test

Class	X	n	π_0	z_{count}	$z_{(0,5-\alpha)}$	Criteria	Results
Eks	30	32	0,70	2,932	1,64	$z_{hitung} > z_{tabel}$	H_0 rejected
Control	25	32	0,70	4,111	1,64	$z_{hitung} > z_{tabel}$	H_0 rejected

Based on Table 4, the z_{hitung} value in the experimental class was 2.932 > 1,64 and in the control class the z_{tabel} value was 4.111, then H_0 was rejected. That is, more than 70% of the final test results of students' mathematical connection abilities in math city map Problem-based learning are declared complete and achieve classical completeness.

Hypothesis Test 3 (Test The Average Difference of Mathematical Connection Ability)
In testing this third hypothesis, researchers use an independent sample t-test, where this test is intended to determine the average difference from unpaired samples. The results of hypothesis testing data are presented in the following table:

Table 5. Average Test Results of Mathematical Connection Ability

F	Sig.	T	df	Sig (2-tailed)	Mean Difference	Std. Eror Difference
1.585	0.212	-10,011	70	0,000	-22,278	2,225

Based on the data output (Table 5), a sig value of 0.000 <0.05 was obtained, so the H_0 was rejected. This means that the average mathematical connection ability of students with PBL learning using math city map is better than the average result of students' mathematical connection ability using PBL learning.

Hypothesis Test 4 (Test The Proportion Difference of Mathematical Connection Ability)

Table 6. Result Test The Proportion Difference Of Mathematical Connection Ability

Proportion Difference Test						
π_1	π_2	$\hat{p}$	$\hat{q}$	z_{tabel}	z_{hitung}	*Result*
0,875	0,8125	0,8438	0,1562	1,64	2,3234	H_0 rejected

The $H_0$was rejected as the data output return $z_{hitung} > z_{tabel}$ (Table 6). This indicates that the percentage of students who can link mathematical ideas via PBL using a math city map is higher than the percentage of students who can do so through PBL instruction. The H_0 was rejected as the data output return $z_{hitung} > z_{tabel}$. This indicates that the percentage of students who are able to link mathematical ideas via PBL using a math city map is higher than the percentage of students who are able to do so through PBL instruction.

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Hypothesis Test 5 (Mathematical Connection Ability Regression Test and Linearity Test)

Table 7. Result from Mathematical Connection Ability Regression Test

Model	B	Std.Eror	Beta	T	Sig.
(Constant)	64,402	6,433		10,011	0,000
AQ	0,150	0,067	0,380	2,249	0.32

Based on the calculation results (Table 7), the value of F = 5.060 and the value of significance (Sig.) = 0.000 because < 0.05 then H_0 rejected. That is, there is an influence of students' adversity quotient on students' mathematical connection ability in math city map-assisted PBL learning

Table 8. Result from Mathematical Connection Ability Linearity Test

Sum of Squares	Df	Mean Square	F	Sig.
455.668	12	37.972	0.714	0,721

The computation results indicate that the H_0 is rejected with a significance value (Sig.) = 0.721 because > 0.05 (Table 8). That is, the capacity of students' mathematical connections in PBL learning supported by math city map is directly correlated with their adversity quotient.

Subject Determination Based on AQ

Subject determination based on AQ is divided into three categories, namely climber, camper, and quitter. The grouping of participants based on AQ was carried out before and during the implementation of the learning process. The data used in determining this subject is from the results of the AQ questionnaire. The grouping of subjects and the percentage of students based on the AQ questionnaire can be seen in Table 9 below:

Table 9. Grouping of Subjects and Percentage of Students Based on the AQ Questionnaire

Category	Many Students	Percentage (%)
Climbers	5	15,63%
Campers	24	75%
Quitters	3	9,37%
Amount	32	100%

Based on the grouping of subjects from the results of the AQ questionnaire, two subjects from each category were selected to be interviewed regarding students' mathematical connection abilities. This aims to clarify the relationship between AQ and students' mathematical connection skills. Sampling from each level of student AQ is carried out using proportionate stratified random sampling techniques, namely sampling data sources based on proportion. The selection of samples is based on certain characteristics that are considered to have something to do with previously known characteristics of the population and based on the recommendations of the grade VII Mathematics teacher.

Mathematical Connection Ability with AQ Climber

Students who have AQ climber categories as many as 5 (five) students, namely A22, A26, A27, A28 and A29. The percentage of students who have AQ climber category is 15.63% of the total number of experimental class students. The results of the learners' math connection ability test are shown in the following Table 10.

Based on Table 10, it can be seen that learners with climber AQ scores have a fairly high mathematical connection ability of 78 to 85 with an average of 80,8. This means that the mathematical connection ability of students with AQ climbers has reached completion.

Table 10. Test Results of Students' Mathematical Connection Ability with AQ Climber

Code	Adversity Quotient Score	TKKM Score
A22	127	78
A26	155	85
A27	152	80
A28	144	83
A29	135	78
Average	143	80,8

Mathematical Connection Ability with AQ Camper

Students who have AQ camper category as many as 24 (twenty-four) students, namely A10, A2, A3, A6, A5, A6, A23, A13, A9, A100, A101, A102, A103, A104, A105, A106, A107, A108, A109, A21, A23, A24, A25, A30, A31, and A32. The percentage of students who have AQ camper category is 75% of the total number of experimental class students. The results of the learners' math connection ability test are shown in the following Table 11.

Table 11. Test Results of Students' Mathematical Connection Ability with AQ Camper

Code	Adversity Quotient Score	TKKM Score
A1	85	75
A2	94	80

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p-ISSN 2477-409X, e-ISSN: 2549-9084

A3	91	72
A6	88	65
A5	91	85
A23	83	85
A13	96	83
A9	90	78
A10	89	83
A11	75	80
A12	90	80
A14	83	85
A15	76	80
A16	89	78
A17	79	73
A18	77	75
A19	83	85
A21	85	75
A23	87	78
A24	77	73
A25	98	85
A30	105	73
A31	93	75
A32	102	75
Average	87,75	79,42

Based on the table, it can be seen that students with AQ camper scores have adequate mathematical connection abilities, namely 65 to 85 with an average of 79,42. This means that students with AQ Camper can complete the math connection ability test well, but camper students do not re-examine the completion that has been obtained because they are satisfied with the results.

Mathematical Connection Ability with AQ Climber

Students who have AQ climber categories are 6 (nine) students, namely A4, A6, A8, A14, A25, and A32. The percentage of students who have the AQ Quitter category is 18.75% of the total number of experimental class students. The results of the learners' math connection ability test are shown in the following table.

Table 12. Test Results of Students' Mathematical Connection Ability with AQ Quitter

Code	Adversity Quotient Score	TKKM Score
A4	45	40

A6	40	56
A8	48	59
A14	58	48
A25	55	50
A32	50	52
Average	296	50,83

Based on Table 12, it can be seen that students with AQ camper scores have sufficient mathematical connection abilities, namely 40 to 58 with an average TKKM score of 50.83. This means that students with AQ Camper can complete math connection ability tests well but quitter students cannot solve problems with correct answers.

Mathematical Connection Ability with AQ Quitter

Students who have AQ quitter category as many as 3 (three) students, namely A20, A6 and A13. The percentage of students who have AQ quitter category is 9.37% of the total number of experimental class students. The results of the learners' math connection ability test are shown in the following table.

Qualitative Data Analysis

In this study, connection ability was described based on the AQ category, namely climber, camper, and quitter on four components of mathematical connections, namely connections to the same material, connections between topics in mathematics, connections between subjects, and connections with the real world. 5 students are in the AQ climber category, 24 students who are in the AQ camper category, and 3 students who are in the AQ quitter category. The climber and quitter categories were taken by 2 students, while the camper was taken by 2 students who were selected as qualitative research subjects to describe their connection abilities.

In general, learners belonging to the AQ climber group have excellent mathematical connection skills. Learners with an AQ climber can master the four components of mathematical connections very well. In addition, climbers have relatively high scores on aspects of control, origin & ownership, reach and endurance. Because they have a good control score, students increasingly master the situation when facing problems.
Furthermore, students who belong to the AQ Camper group can solve problems with the right answers. However, they did not re-examine the settlement that had been obtained because they were satisfied with the results. This can cause them not to realize any errors in the resolution. Learners with AQ Camper have sufficient ability to solve problems. However, they have high self-confidence and tend to feel satisfied with the results they have achieved. This can cause them to be unmotivated to continue learning and improving their abilities.

On the other hand, learners with AQ Quitter cannot solve problems with the right answers. This can be caused by several factors, such as lack of understanding of the material, lack of critical thinking skills, or lack of motivation. Learners with AQ Quitter tend to give up easily when faced with challenges. They also have low self-confidence and tend to blame conditions or others for their failures.

Based on the description above, students in different AQ categories (climbers, campers, quitters) may exhibit varying levels of mathematical connection ability in solving problems. This aligns with research by Zubaidah Amir et al., (2021) who found that each AQ level has distinct problem-solving characteristics influenced by student personalities. Yoga (2016) further differentiates the personalities of climbers, campers, and quitters. While this suggests a potential link between AQ and mathematical connection abilities, further qualitative analysis of the student interviews in this study is needed to explore this relationship in more depth.

Quantitative anf Qualitative

The idea of Adversity Quotient (AQ) pertains to an individual's capacity to manage obstacles and failures (Zubaidah Amir et al., 2021). Studies indicate a connection between AQ and the ability to solve problems. The association between students' mathematical connecting ability and AQ was examined in this study pupils with greater AQ (climber category) showed stronger mathematical connection abilities compared to pupils with lower AQ (camper and quitter categories), according to our quantitative data analysis. This result supports the idea that children may overcome obstacles and make connections in arithmetic problems with the help of persistence and strong motivation—qualities linked to higher AQ.

Additional insights were obtained from the qualitative analysis of the student interviews. When challenged with challenging arithmetic issues, kids in the climber group frequently stressed tactics like perseverance and attempting several techniques, according to interviews with them. Students who fell into the quitter group, on the other hand, occasionally displayed signs of irritation and a propensity to give up quickly when faced with difficulties. The results of the interviews corroborate the quantitative data, indicating that AQ may have an impact on students' methods for solving problems and their capacity for mathematical inference.

This quantitative and qualitative data analysis is carried out by comparing quantitative research data and qualitative research data. The results of his analysis are presented in Table 13:

Table 13. Quantitative and qualitative data analysis

No	Quantitative	Qualitative	conclusion
1	Mathematical Connection Ability Students in PBL models using math city maps reach more than 75%	Learners with Adversity Quotient climbers can achieve all indicators of mathematical connection ability	Quantitative data is used to prove, deepen and expand qualitative data
2	The average mathematical connection ability of students in the PBL model with math city map is better than the mathematical connection ability of students with PBL	Students with Adversity Quotient Camper are only able to meet 2 indicators of mathematical connection ability	
3	The proportion of completeness of students' mathematical connection ability in PBL learning using math city map is higher than students' connection ability with PBL learning	Students with Adversity Quotient Quitter are only able to meet 1 indicator of mathematical connection ability	
4	There is an influence on the ability of mathematical connections and Adversity Quotient of students who obtain PBL learning using math city maps.		

Conclusion

The following conclusions were drawn from the study's findings and discussion: Research participants in the AQ Climber group can fulfil all indications of Mathematical Connection Ability, and (1) the PBL learning approach with math city map enhances the quality of mathematics learning for students with Mathematical Connection Ability. Only two markers of mathematical connection ability could be met by subjects in the AQ Camper group, and only one sign could be met by those in the AQ Quitter category.

Acknowledgement

Thanks to Dr. Masrukan, M.Si, Head of the Mathematics Education Masters Study Program, UNNES.

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