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TABLE OF CONTENTS

Proceedings of International Conference on Research in Education (ICRE) 2025, pp. 1-12
ISSN: 3124-4467
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DEVELOPING *MATHCITYMAP* ACTIVITIES TO SUPPORT THE HAPPINESS OF JUNIOR HIGH STUDENTS

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Abstract
Math is often seen as a difficult subject and causes anxiety. This is due to students' own perceptions, which make them unhappy in learning mathematics. In fact, student happiness in learning mathematics is an important aspect that can affect student learning outcomes. Therefore, this study aims to develop contextual mathematics learning activities with MathCityMap to support student happiness. This research uses the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model in its development. The data collection techniques used were semi-structured interviews, implementation observation, and questionnaire distribution. The questionnaire responses before the application of the high level of happiness indicated that 16 students reported a high level of happiness. While the results of the questionnaire response after implementation, the level of high happiness amounted to 13 students. There was an insignificant decrease in student happiness. This decrease was caused by technical constraints, high temperatures, and problem places that could not be used.

Keywords: development research, happiness, MathCityMap, neuroscience

Introduction

Most students view math as a difficult subject that can even cause anxiety. This occurs due to students' own perceptions that math is difficult and boring (Aprilia & Fitriana, 2022). Students' perceptions are reinforced by abstract and complex mathematical formulas and concepts that often make it difficult for students to understand the material. The use of learning methods that mostly use conventional methods, so students are less actively involved in learning, also worsens students' perceptions. As a result, students experience a decrease in their interest and happiness in learning mathematics (Aulia et al., 2024). Students' happiness in learning mathematics is an important aspect that affects their learning outcomes. Research by Jannah and her colleagues shows that happiness can improve the quality of learning while contributing to the achievement of better learning outcomes (Jannah & Hadiyanto, 2024). To better understand why happiness relates to these learning outcomes, we next consider a neuroscience perspective.

Neuroscience is a field of science that explores the nervous system, especially the brain mechanisms that control various aspects of human life (Rudhito, 2024). From a neuroscience perspective, happiness is closely related to the function of the nervous system and the activity of chemical compounds in the brain, including

neurotransmitters and the limbic system. Neurotransmitters are chemicals that help the communication process between neurons in the brain (Anggraini, 2023). Neurotransmitters such as dopamine, serotonin, oxytocin, and endorphins have an important role in triggering happiness (Hanim, 2021). Dopamine is a neurotransmitter that functions in the brain's reward system (Duitasari & Safitri, 2022). This chemical is released when a person experiences pleasant things (Pangestuti & Janah, 2023). Serotonin has a role in regulating mood as well as a sense of satisfaction. Serotonin imbalance causes a condition often referred to as depression (Deakin, 2020). Oxytocin, known as the love hormone, serves to strengthen social bonds and increase trust in relationships. Oxytocin can increase when a person has interactions such as physical contact and warmth. On the other hand, endorphins act as painkillers and can increase feelings of euphoria after intense physical activity or exercise (Khairunnisa et al., 2025). The limbic system, consisting of the hypothalamus, amygdala, and hippocampus, is the part of the brain that regulates emotions, including happiness (Wartani et al., 2023).

In our context, three related problems persist: (1) many students perceive mathematics as abstract and difficult; (2) classroom practice is still largely teacher-centered with limited links to everyday situations; and (3) these conditions dampen students' enjoyment and intrinsic motivation to learn. A contextual learning approach offers a solution by emphasizing the active involvement of students in understanding the material by linking it to real situations, so that students are motivated to apply the knowledge gained in everyday life (Muhartini et al., 2023). By being student-centered, this approach allows them to actively build an understanding of abstract and complex mathematical concepts. With students actively involved in learning, mathematical concepts become more meaningful and relevant to students, as well as creating a fun learning experience (Anggin et al., 2023). This positive experience can increase the release of dopamine, one of the neurotransmitters associated with happiness (Pangestuti & Janah, 2023). This increase in dopamine can also increase students' intrinsic motivation (Freed, 2022).

MathCityMap is a GPS-based application that supports math learning outside the classroom by connecting math concepts to real situations through environmental exploration using maps and exploration paths (Muliasari et al., 2023). Based on the definition of *MathCityMap*, this application provides the possibility for students to learn math contextually outdoors by linking it to situations in everyday life. *MathCityMap* can be a math learning application that encourages students to be active in learning (Taufik & Suryani, 2024) and makes math learning fun (Lubis et al., 2021). Based on the explanation of the background above, this research aims to develop *MathCityMap* activities that can support students' happiness in learning math.

Several previous studies are relevant to this research, namely research conducted by Lubis et al. (2021), which aims to facilitate students' mathematical understanding by using ethnomathematics concepts using the *MathCityMap* application. Research by Alamanda and Zainil (2024) aimed to develop *MathCityMap* in flat building materials. Research conducted by Anas and Umar (2021) aimed to determine the factors that can affect student happiness. Lastly, research conducted by Hasibuan (2020) aimed to determine the factors of student learning happiness during COVID-19. The novelty of this research with previous

research is the development of *MathCityMap* with neuroscientific indicators of happiness.

A preliminary needs analysis was carried out involving classroom observations, curriculum review (Grades VII–VIII), and short interviews with the mathematics teacher and 6 student representatives. The results indicated that (1) many students still perceived mathematics as abstract and difficult; (2) instruction was predominantly teacher-centered with limited links to everyday contexts; (3) students' enjoyment and intrinsic motivation fluctuated, especially in outdoor activities due to time of day and heat; (4) schools had mixed device/network readiness for mobile learning; and (5) there was no classroom-ready instrument to monitor happiness aligned with neuroscience-informed indicators. These needs point to the development of a set of MathCityMap activities that are contextual, student-centered, and technically feasible for the school setting, accompanied by a validated happiness questionnaire. The novelty of this study lies in developing MCM activities together with neuroscience-based happiness indicators for middle-school learners.

Method

The type of research used was R&D (Research and Development), with development steps that adopted the ADDIE model (Analyze, Design, Development, Implementation, Evaluation). R&D is research with the aim of producing a specific product. (Okpatrioka, 2023). The research subjects were students of class VIII F SMP Negeri 1 Piyungan, Yogyakarta. The research was conducted in the period of September 2024 - March 2025. The data collection was conducted by several methods, namely semi-structured interviews, observation of implementation, and distribution of questionnaires.

There are two types of data obtained from the data collection, namely qualitative data and quantitative data. The qualitative data were analyzed and used to make improvements to the *MathCityMap* activity. Meanwhile, the qualitative data (interviews, observations, and open-ended responses) were analyzed using thematic content analysis, which involved familiarization, open coding, grouping codes into categories aligned with the happiness indicators, theme generation, and peer debriefing to reach consensus. The findings were summarized in a matrix with representative quotes and used to refine the MathCityMap activities. Meanwhile, the quantitative data were analyzed using the average percentage formula of the scores obtained, then grouped into existing criteria. The quantitative data obtained are the results of the *MathCityMap* activity validation assessment and the results of student responses to the happiness questionnaire. The validation results of the *MathCityMap* activities were then calculated, and the percentages of the score obtained were categorized into the validity category criteria in Table 1. The results of students' responses to the happiness questionnaire, the total score obtained, were categorized into the criteria for the happiness interval category in Table 2, whose calculation was adopted from the object categorization (Azwar, 1999).

Table 1. Criteria Category of Validity of *MathCityMap* Activity

Score (Percent)	Category of Validity
85% - 100%	Very Valid
70% - 84%	Valid
55%-69%	Valid Enough
< 55%	Less Valid

Table 2. Happiness Level Interval Criteria

Calculations	Category
25 - 49	Low
50 - 74	Medium
75 - 100	High

Findings and Discussion

Result

The *MathCityMap* activity was developed by applying material from grades 7 and 8, namely volume of space, number patterns, and surface area. The material was taken by analyzing the material from the Ministry of Education website and based on interviews with math teachers. Researchers developed 4 stopping points in the environment around the school, namely the fish pond, gazebo, back room of the hall, and indoor field. The picture below is a picture of the path that students take in the *MathCityMap* activity.

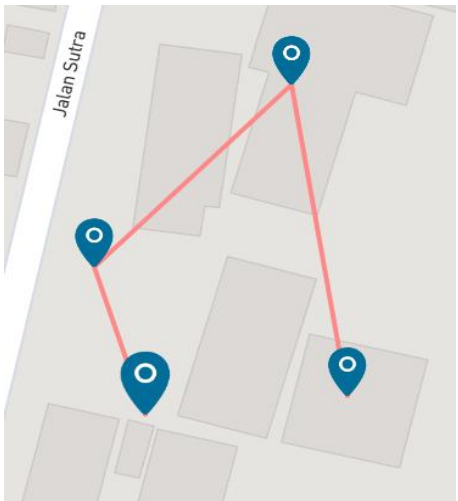

Figure 1. *MathCityMap* Activity Trail

The first activity has a stopping point at the fish pond at the school. The problem that students must solve is to find out the volume of water in the fish pond when it is filled to the brim. As seen in the picture, the fish pond is in the shape of a block, but with one side having a different height. In addition, in the middle of the pond, there is a fountain that looks like a tube. This became a challenge for students in solving the contextual problem. To get the right answer, students simply calculate the volume of the block by taking the smallest height and reducing the volume with the volume of the fountain.

Aktivitas 1: Kolam Ikan

Di dalam area sekolah, terdapat sebuah kolam ikan yang posisinya berada tepat di sebelah lapangan bulu tangkis. Penjaga kebun sekolah ingin mengisi kolam ikan ini dengan air hingga penuh. Berdasarkan ukuran dan kapasitas kolam, berapa liter air yang diperlukan penjaga kebun untuk mengisi kolam ikan tersebut secara penuh?

volume Bangun ruang

Figure 2. First Activity

The second activity is in the gazebo, which is located not too far from the fish pond. The gazebo has a rectangular pyramid-shaped roof. At this point, students are asked to calculate the number of roof tiles needed for the gazebo if the length of the roof side is increased by 1 meter. It is a challenge for students because students will be asked to calculate the number of roof tiles for the gazebo using the arithmetic formula. The gazebo tile is triangular with a tile pattern; each row has a difference of two tiles.

Aktivitas 2 : Gazebo

Di pinggir lapangan basket terdapat dua buah gazebo yang disediakan bagi siswa dan guru untuk beristirahat atau berteduh. Masing-masing gazebo memiliki atap dengan bentuk tertentu, dan kini direncanakan untuk memperluas atapnya dengan cara menambah panjang setiap sisi sebesar 1 meter. Berdasarkan rencana perluasan ini, berapa banyak genteng yang diperlukan oleh pemborong untuk menutupi seluruh permukaan atap dari satu gazebo?

Figure 3. Second Activity

In the third activity, students were asked to determine the paint cans needed to paint the room behind the hall. In this problem, students need to calculate the surface area of the inside wall of the room. It should be noted that in the walls of the room, there are windows, doors, and also unpainted switches, so students need to reduce the surface area of the walls that have windows, doors, and switches. The problem also contains information about how one can of paint can cover 120.000 cm^2.

Aktivitas 3 : Ruangan

Di bagian belakang aula SMP Negeri 1 Piyungan, terdapat beberapa ruangan yang baru saja selesai diperbaharui dan dicat ulang agar terlihat lebih segar. Untuk pengecatan ini, setiap ruangan dicat menggunakan cat berwarna hijau. Jika diketahui bahwa satu kaleng cat dapat menutupi area seluas 120.000 cm^2, berapa kaleng cat yang diperlukan untuk mengecat seluruh dinding dari satu ruangan tersebut?

luas permukaan

Figure 4. Third Activity

The last activity takes place on an indoor court. This activity asks students to calculate the number of paving blocks needed to cover the base of the indoor field. It is known that the paving blocks of the field are hexagonal. Students will certainly find it difficult if they choose to solve the problem by counting the paving blocks one by one. Therefore, the challenge for students in solving this last problem is to calculate the area of the hexagon (paving blocks).

Aktivitas 4 : Lapangan Indoor

Di SMP Negeri 1 Piyungan, terdapat sebuah lapangan indoor yang baru saja selesai dibangun. Untuk menyempurnakan fasilitas tersebut, seluruh permukaan lantai lapangan ditutup dengan paving. Berapa jumlah paving yang dibutuhkan untuk menutupi seluruh permukaan lantai lapangan indoor tersebut, terbatas pada area yang terlindungi oleh atap?

Figure 5. Fourth Activity

In addition to the *MathCityMap* activities above, the researchers also developed research instruments, one of which was a questionnaire for students' happiness in learning mathematics both before and after implementation. The pre-implementation questionnaire consisted of 25 questions, while the post-implementation questionnaire consisted of 22 questions. The researcher used a Likert scale in both questionnaires with four options to avoid doubts in the response results. The *MathCityMap* activities and questionnaires were then validated to determine their quality. This validation was done by two validators who assessed several aspects. Table 3 contains the validation results of the *MathCityMap* activity, while Table 4 contains the validation results of pre- and post-implementation questionnaires.

Table 3. Percentage of Validation Results

Indicator	Percentage Validator 1	Validator 2	Average	Validity Category
Conformance to Curriculum and Learning	87,5%	87,5%	87,5%	Very Valid
Support to Student Happiness	91,6%	83,3%	87,45%	Very Valid
Student Engagement	100%	75%	87,5%	Very Valid
Ease of Use	81,25%	87,5%	84,37%	Valid
Aesthetics and Display	100%	87,5%	93,75%	Very Valid

Table 4. Percentage of Questionnaire Validation Results

Validator	Questionnaire Before	Questionnaire After
1	94%	92%
2	76,5%	81,25%
Total	85,25% (very valid)	86,62% (very valid)

Before applying the *MathCityMap* activities above, students first took a questionnaire about happiness in learning math. After filling out the questionnaire, the students were divided into six groups, and each group had a gadget to be able to access the *MathCityMap* activity above. The first step that students took to access the activity above was to download the *MathCityMap* application. Next, the students selected the "Add Trail" menu, entered the trail code 4923618 in the space provided, and downloaded the trail to be able to access the activity and solve the problem. After the students finished working on the *MathCityMap* activity above, they were given another questionnaire about happiness in learning math after the application. Below are the graphs of student response results from the two questionnaires given.

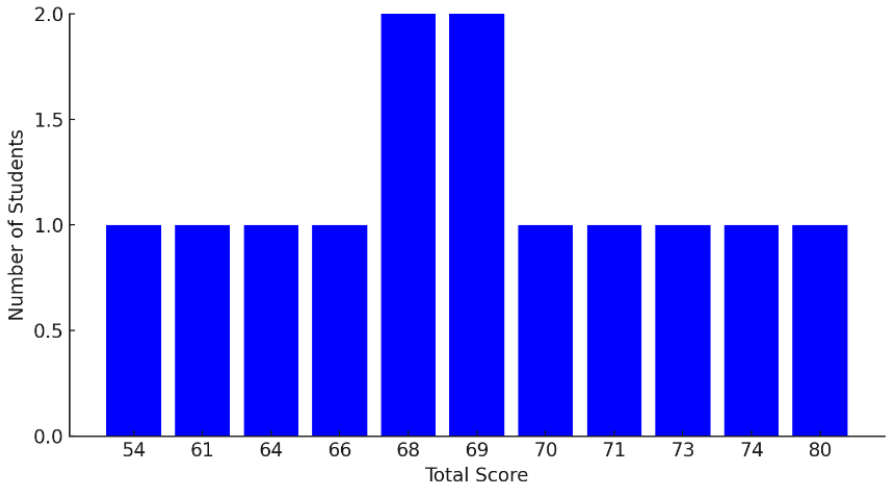

Figure 6. Student Response Results Questionnaire before Implementation

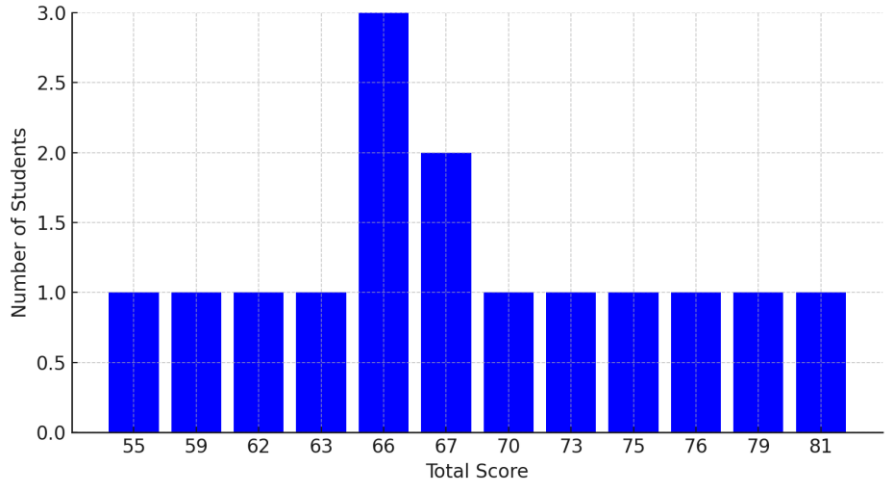

Figure 7. Student Response Results Questionnaire after Implementation

On the criteria for the interval category of happiness levels described in the method section, the students' responses to the questionnaire before implementation in the medium and high categories were the same number, with 16 students. Meanwhile, the students' responses to the questionnaire after implementation showed an increase in the moderate category, namely a total of 19 students, and in

the high category, there was a decrease to 13 students. Overall, the questionnaire before implementation received a total score of 2.332, and the questionnaire after implementation received a total score of 2.300.

Discussion

This study followed the ADDIE model—analyze, design, development, implementation, and evaluation. In the analysis stage, the researchers compiled neuroscience-informed indicators of happiness (engagement, intrinsic motivation, positive affect, social interaction, and learning satisfaction) as the basis for designing the MathCityMap (MCM) activities. The product and the happiness questionnaire obtained high validity, and the implementation produced small shifts in students' happiness categories.

The current findings are consistent with prior research, showing that contextual learning increases students' motivation to apply mathematical ideas to everyday life (Muhartini et al., 2023) and that MCM can support understanding of geometric topics through authentic outdoor tasks (Alamanda & Zainil, 2024). With student-centered tasks, abstract concepts become more meaningful and enjoyable, which echoes evidence that enjoyment and relevance are key contributors to students' learning happiness (Anas & Umar, 2021; Hasibuan, 2020). The present study extends this line of work by integrating a neuroscience-based set of indicators into both the design of activities and the evaluation instrument.

Mechanisms from a neuroscience lens. The positive experience afforded by contextual, collaborative tasks plausibly triggers neurotransmitter activity associated with happiness. Neurotransmitters facilitate communication between neurons (Anggraini, 2023); among them, dopamine, serotonin, oxytocin, and endorphins are implicated in reward, mood regulation, social bonding, and pleasurable states (Hanim, 2021). Learning experiences that are goal-directed, socially interactive, and physically engaging can increase dopamine release, thereby sustaining attention and motivation (Pangestuti & Janah, 2023). Positioning the design within these mechanisms clarifies why well-structured MCM tasks can support students' happiness in mathematics (see also Rudhito, 2024).

Interpretation of the small score changes. The modest aggregate change in happiness after implementation is understandable given contextual constraints noted during fieldwork—mixed device/network readiness and mid-day heat—which reduced time-on-task and comfort for some groups. These conditions likely attenuated the very mechanisms (sustained engagement, positive affect, and smooth social interaction) that the design seeks to activate. Thus, rather than indicating a weak design, the results point to implementation levers.

Implications. To realize the full potential of contextual, neuroscience-informed activities, future implementations should (i) schedule sessions in the morning or in shaded indoor–outdoor transitions, (ii) conduct pre-checks for accounts, device availability, and connectivity, and (iii) provide a brief orientation on MCM use. These adjustments target the same indicators we measure—engagement, positive affect, and social interaction—and are expected to amplify their effects.

Based on the research results above, it is known that there is an insignificant decrease in the level of student happiness. This can be seen in the happiness interval category of three students who decreased from a high level to a moderate level. This decrease was caused by several obstacles in the application of *MathCityMap*

activities. The first obstacle was technical constraints in accessing the activities. There were groups of students who could not access the *MathCityMap* activity even though the access code entered was correct. This technical obstacle was quite time-consuming in implementing the *MathCityMap* activities, so students could only do three out of four activities.

The second obstacle was that one of the places in the *MathCityMap* activity cannot be used because it is being used by the school. This caused students to measure another room next to it, which had a slight difference in size. In addition, the numbers from the measurement results are large enough to confuse students. The implementation time, which was in the afternoon, also caused an insignificant decrease in students' happiness level. During the day, the air temperature increased, which caused students to feel uncomfortable and stressed (Putri, 2022). It is known that stress can cause an imbalance in the neurotransmitters serotonin and dopamine (Dalvi-Garcia et al., 2021).

Conclusion

Based on the results and discussion of the research above, it can be concluded that the *MathCityMap* activities obtained an overall percentage of 87.5% and were valid and feasible to be applied. The students' responses in the questionnaire before implementation showed that the level of moderate and high happiness obtained the same number of 16 students. Meanwhile, the results of student responses in the questionnaire after implementation showed that the level of moderate happiness was 19 students, and a high level of 13 students. There was an insignificant decrease in the level of student happiness. The decrease was caused by several obstacles in the implementation, namely technical obstacles that were quite time-consuming, the unusable room, and the implementation time during the day, when the high air temperature caused the students stress and affected the results of student responses. Therefore, researchers provide several suggestions that the implementation time should be done in the morning, when the air temperature is not too high, so that the response results can be even better. If carried out outdoors, the application of *MathCityMap* activities should consider the weather. Further, there should be a tutorial on how to use the application before the implementation to minimize technical problems.

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