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Indonesia-Germany MathCityMap training: Shifting mobile math trails teacher training to a hybrid environment

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Abstract

The purpose of this study is to explore how MathCityMap training for teachers can be designed and implemented in a hybrid setting. Design research has been carried out involving teachers from 34 provinces in Indonesia. A four-day model training program for indoor and outdoor activities in a hybrid setting has been designed. The core concept of designing modeling tasks and math trails, as well as the introduction to MathCityMap, were delivered in a hybrid mode between Indonesia and Germany. The activity continued with the development of MathCityMap Trails in city parks. Post-training activities were conducted in their respective places of origin, in schools, and in city parks. Participants have successfully designed trails in both their schools and the city parks where they live supported using Learning Management System. The findings of the MathCityMap team's review indicate that most of the trails fulfilled the requirements. The trainee teachers then disseminate their knowledge and experience to their colleagues. They also used MathCityMap Trails for classroom learning as well as other activities such as MathCityMap competitions and public educational activities. The hybrid environment helps to accelerate the attainment of training objectives while also broadening the program's reach and network.

Keywords: Hybrid Learning, MathCityMap, Teacher Professional Development, Teacher Training

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Numerous locations have one-of-a-kind landmarks and artifacts that provide opportunities to apply mathematical concepts in the actual world. Then, students can follow a "math trail," or a planned path consisting of a series of activities at various locations and items, to learn more about the mathematical content of their surroundings (Shoaf et al., 2004). In 1984, Dudley Blane and his colleagues were the first to establish a mathematical trail in Melbourne. The advent of modern technological advancements, such as the MathCityMap (MCM) system, makes it possible to create math trails using digital technology. The MCM-Project has been implemented to develop a novel app that employs mobile technology with the concept of a math trail (Ahsan et al., 2020; Cahyono, 2018; Cahyono et al., 2020; Cahyono & Ludwig, 2019; Gurjanow et al., 2019; Ludwig & Jesberg, 2015; Zender et al., 2020). Mobile devices provide an opportunity to integrate elements of effective learning, such as engaging content, collaborative work, and authentic scenarios (Wijers et al., 2010). In the MathCityMap Project, the smartphone app is packed with gamification elements. Gamification has a positive impact on learning achievement, anxiety, motivation, and autonomy (Fuentes-Cabrera et al., 2020). It also offers hints and feedback. There are already some initiatives underway to train teachers for MathCityMap (Jablonski et al., 2018, 2021; Jablonski & Ludwig, 2019; Milicic et al., 2020; Taranto et al., 2021) as a teacher professional development program.

In-service teacher training programs improve teacher competence, talents, and attitudes (Cheung, 2013). Teacher training has been carried out in various places to improve teacher professionalism (Jablonski et al., 2018, 2021; Milicic et al., 2020; Rusiyanti et al., 2022; Sala-Sebastià et al., 2022; Suryanti et al., 2022; Taranto et al., 2021). According to Hattie (2008), the four most effective ways of teacher knowledge and behavior education are observation of real-world classroom processes, micro-teaching, video/audio feedback, and practice. Higher effects were found in studies where: A varied variety of teachers participated in training groups; training programs were originated, sponsored, or produced by the government or university rather than by schools or teachers; participants were chosen for training; and training was more practical than theoretical.

Sims and Fletcher-Wood (2021) describe professional development for teachers is effective when it is ongoing, collaborative, draws on outside information, is practice-based, and is constantly monitored by instructors. Adopting new regulations or standards, developing collaborative groups, or employing specialist resources to teach certain curricular topics might all be subjects in a related training. Mathematics teachers participating in professional development initiatives aimed to improve their own grasp of mathematics by delving further into certain subjects or learning about a new mathematical discovery (Matos et al., 2009). A training of this kind may take place in person, online, or by utilizing a mix of the two methods (hybrid).

Some universities throughout the world provide their students with several other forms of learning activities/lectures. The goal is for students to be able to organize their lecture activities around their schedules and other obligations. There are three types of learning activities available: face-to-face (traditional), face-to-face and online (blended learning), and entirely online (Cahyono et al., 2019a, 2019b; Corell-Almuzara et al., 2021; López Belmonte et al., 2019). This method can also be used in teacher education programs. Training in a hybrid setting combines the greatest features of traditional training with the benefits of online learning (Cahyono & Asikin, 2019). Participants in hybrid training programs can take online courses while also having the option of face-to-face training to enhance their education based on their individual needs. Most hybrid programs are classified as one of four types: rotation, flex, a la carte, and/or enriched virtual (Horn & Staker, 2015).

Students in the rotation model alternate between online and conventional instruction on a set schedule or at the discretion of the teacher. Even though it steers students to offline activities, online learning is the backbone of the flex model. A La Carte students attend online courses to enhance their in-person experiences. Students must complete face-to-face learning sessions with their instructor of record before completing their remaining coursework remotely in the Enriched Virtual model. The Station Rotation, Lab Rotation, and Flipped Classroom blended learning models are frequently implemented by educators in a pattern like how hybrids are employed in other industries. This is known as a hybrid deployment pattern. In a hybrid educational strategy, the benefits of traditional classroom training are combined with the benefits of online learning to provide the "best of both worlds" (Horn & Staker, 2015). Training may be carried out by integrating the activities of studying content online, interacting with instructors and trainees online and offline, and on-site practice offline. It is okay to use mobile technology in math trails training. The question was how to design and implement MathCityMap training for teachers in a hybrid environment.

METHODS

The goal of this research is to explore how MathCityMap training for teachers can be designed and implemented in a hybrid setting. We were going to do research to design a teacher professional development program focused on MathCityMap and assessing the impact of such program with the participant teachers. Exploratory design research was undertaken, in which training instructors and participants were involved. This strategy integrates research, development, implementation, and dissemination and engages researchers, developers, instructors in a dialogue in the field (Bakker, 2018; Gravemeijer & Terwel, 2000). The exploratory study was applied to provide a good groundwork for the growth of a grounded theory since the obtained data revealed detail, breadth, and validity (Stebbins, 2001). Following the theory of Didactical Situations in Mathematics (Brousseau, 1997), we designed MathCityMap training for teachers in a hybrid setting.

Subject

A design research study involving teachers representing all Indonesian regions was conducted to address the question raised in this study. There were 211 teachers from 34 provinces in Indonesia who participated in training at the national level held in 4 batches with 4 days for each batch and continued with follow-up in their respective regions with supervision from the trainers. They have different backgrounds from geographical location, socio-cultural, age, technology utilization ability, and they also teach at different levels. This program included numerous sessions, including increasing literacy and numeracy, ethnomathematics, PISA microlearning, and MathCityMap, which was one of the special sessions that lasts longer than the others.

Designing the Teacher Professional Development Program

The Professional Development Program was planned as a four-day training program that is carried out centrally at the national level and followed up on in their respective regions by disseminating to other teachers and implementing in their own schools. Trainees have previously engaged in sessions on increasing literacy and numeracy, ethnomathematics, and PISA microlearning prior to participating in math trails with technology. These sessions were valuable to teachers as a foundation for developing local wisdom-based math trails with the purpose of boosting students' mathematical literacy.

Through this research, we designed a hybrid training model. Hybrid in this case is the use of the Learning Management System to provide training materials that can be accessed online at any time asynchronously before and after training, as well as facilitating interaction through online discussions and assignments as an important part of a training. Hybrid here also means a mixed class where speakers are abroad, and participants are in the country and are in the same room but different from the room where the speakers are. This concept is needed in this case because we facilitate the delivery of material and direct interaction between participants and experts in this field even though they are far away.

Intervention and Timeline

This program assists intervening teachers in developing math trails with technology, notably augmented reality mobile math trails, to improve teaching across school diversity in Indonesia. This intervention includes a series of training sessions, followed by follow-up and implementation on the field with the help of trainers, as well as the establishment of a community. In this training, participants get an explanation of math trails, practices for designing math trails, and workshops on utilizing technology in math trails. This program equips all teachers enrolled in this training with the same knowledge and abilities regarding math trails and the use of supporting technology. During training, they receive the same lessons and can cooperate and discuss with other teachers.

Afterwards, the participants created math trails based on well-known landmarks in their own neighborhoods, which they then posted to the MathCityMap portal. Post-training services and supervision are provided to guarantee that the concept is being implemented correctly. Furthermore, supervision is required to determine the impact of interventions and to evaluate programs.

Data Collection Methods

Data is gathered through interviews with teachers, observations of teacher activities in task design, and portfolio analysis, both during and post training. Data is collected both during and after training, although most of the information is obtained after training, when teachers use the concepts learned during training to create math trails with technology and implement them in schools. We collected data by observing and interviewing teachers during the process of designing math trails with the supporting technology. Then the results of their work were reviewed based on the MathCityMap Task criteria, namely: clarity, presence, activity, numerous solutions, reality, school math, solution formats, tools, and example solutions (Cahyono & Ludwig, 2019; Gurjanow et al., 2019; Zender et al., 2020). The teachers reported the implementation in the school, then we review the documentation. Table 1 depicts data and collection methods.

Table 1. Data and collection methods

Type of Data	Collection Methods
Teacher activities	Results of interviews and observations
Quality of math trails	Portfolio
Implementation in the classroom	Photo and video documentation

Analysis of the Implementation

The data was organized, annotated, and described before being analyzed. To analyze the teachers' activities, we were working on transcribing and evaluating the outcomes of interviews and observations. The classification, comments, and explanations of data obtained because of an examination of math trails created by teachers. We examined how the math trail tasks fit the requirements for the mobile math trails activities when reviewing them (Cahyono & Ludwig, 2019; Gurjanow et al., 2019; Zender et al., 2020). We were analyzing picture and video documentation to assess classroom implementation. Table 2 displays the data and techniques for analysis.

Table 2. Data and techniques for analysis

Type of Data	Analysis Methods
Teacher activities	Transcription and analyzing the results of interviews and observations
Quality of math trails	Evaluation of the Math trails
Implementation in the classroom	Documentation review

RESULTS AND DISCUSSION

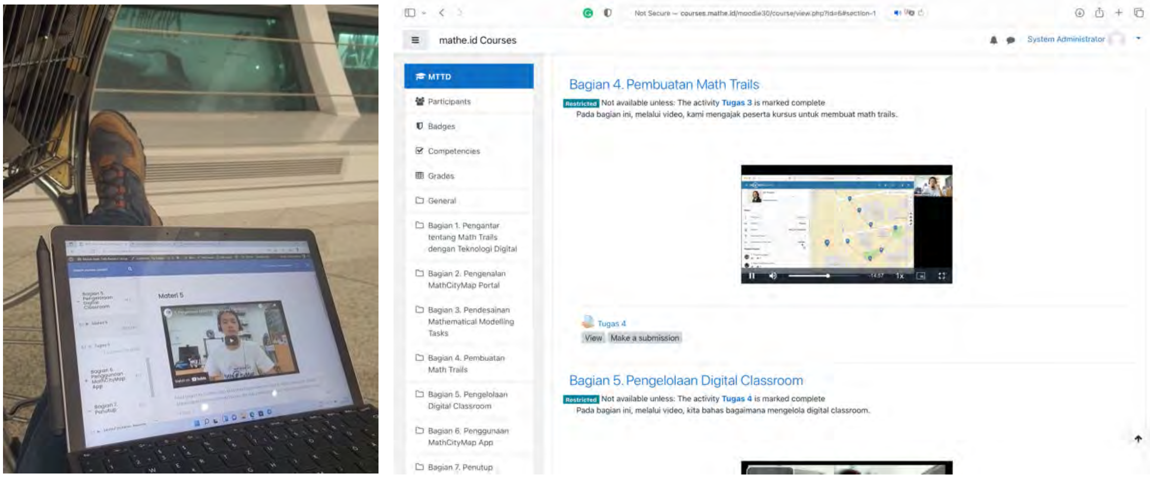
A MathCityMap (MCM) Teacher Training Program in a Hybrid Setting has been completed successfully. The training was divided into three stages, which were completed in theory and practice both inside and outdoors, and included an introduction to math trails, developing math trails, and integrating technology into math trails. The following was the training time allocation: 3 hours are spent presenting the concept of math trails; 6 hours are spent practicing building math trails; and 6 hours are spent training the technical devices that will be utilized in the math trails.

Figure 1. Instructors from Germany and Indonesia collaborated in the training

As a synchronous event, MCM instructors from Germany led training sessions about introduction to MathCityMap for participants in one location in Indonesia, who were joined by Indonesian MCM instructors (Figure 1). This was followed by face-to-face training with Indonesian MCM instructors as participants to discuss the idea and practice of MCM in the field. MCM training is delivered synchronously as well as asynchronously using a learning management system designed for this purpose. Participants design math trails in city parks around the training venue using MathCityMap (Figure 2).

Figure 2. Outdoor training activities

Following the training, the teachers perform follow-up activities with specific time allocations: 10 hours of practice building a math trail activity utilizing technology in their individual areas, and 7 hours of implementation of the activities in the school under the supervision of the trainers. Instructors accompanied participants online through system management learning during the training's follow-up process, which included distribution to colleagues and deployment at school (Figure 3).



First column translation:

Part 1. Introduction to Math Trails with Digital Technologies
Part 2. Introduction to MathCityMap
Part 3. Designing Mathematical Modeling Tasks
Part 4. Creating Math Trails
Part 5. Digital Classroom Management
Part 6. Using MathCityMap
Part 7. Closing

Second column translation:

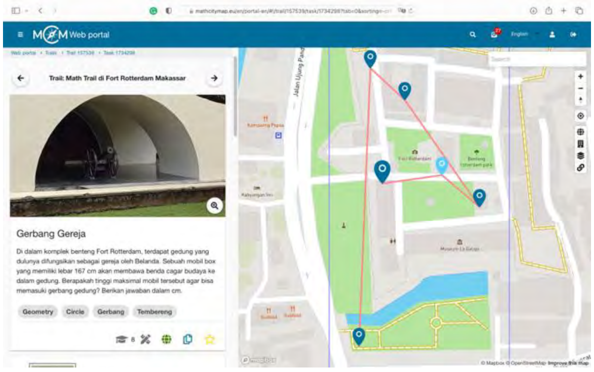
Part 4. Creating Math trails
Restriction. Not available unless: The activity Task 3 is marked complete.
In this section, through videos, we invite course participants to make math trails.
Task 4

Part 5. Digital Classroom Management
Restriction. Not available unless: The activity Task 4 is marked complete.
In this section, we will discuss how to manage a digital classroom.

Figure 3. MathCityMap online module

This program assists intervening teachers in developing math trails with technology, notably mobile math trails, to improve teaching across school diversity in Indonesia. This intervention includes a series of training sessions, followed by follow-up and implementation on the field with the help of trainers, as well as the establishment of a community. In this training, participants get an explanation of math trails, practices for designing math trails, and workshops on utilizing technology in math trails. This program equips all teachers enrolled in this training with the same knowledge and abilities regarding math trails and the use of supporting technology. During training, they receive the same lessons and can cooperate and discuss with other teachers. Afterwards, the participants developed math trails based on well-known locations in their own regions, which they then uploaded to the MathCityMap site. Post-training services and monitoring are offered to ensure that the idea is properly applied. Furthermore, supervision is essential to determine the impact of interventions and to evaluate programs. Figure 4 shows one example of a task created in a historic building in one of the cities in Indonesia.

In general, participants used what they learnt throughout training well. They can use technology to build math trails. According to the review findings, reviewers approved 81 percent of the assignments created for publication. The review was carried out by 6 reviewers in Indonesia who had passed the selection and attended MathCityMap reviewer training. The review activity was carried out by starting with the equalization of perceptions and using the standard criteria set by the MathCityMap Team. The tasks met the math trails task criteria, namely: clarity, presence, activity, multiple solutions, reality, graduated hints, school mathematics, solution formats, tools, sample solution (Jablonski et al., 2018).



Gerbang berbentuk setengah lingkaran.
Diameter gerbang = 560 cm.
Tinggi gerbang (r) $= \frac{560}{2} = 280$ cm.
Untuk mendapatkan tinggi maksimal mobil box maka lebar mobil box harus sama dengan panjang tembereng yaitu 167 cm. Tinggi maksimum mobil box merupakan jarak tembereng dari titik pusat lingkaran. Dengan menggunakan Teorema Pythagoras diperoleh tinggi tinggi maksimum mobil box adalah sebagai berikut

$$t = \sqrt{r^2 - \left(\frac{167}{2}\right)^2} = \sqrt{280^2 - (83.5)^2} = \sqrt{78400 - 6972.25} = \sqrt{71427.75} = 267.26 \text{ cm}$$

Translate:
The gate is semicircular in shape.
Gate Diameter = 560 cm.
Gate Height (r) = 560 : 2 = 280 cm.
To get the maximum height of the transport car, the width of the box car must be the same as the length of the section, which is 167 cm. The maximum height of the transport car is the partial distance from the center point of the circle. Using the Pythagorean Theorem, the maximum height of a freight car is 267.26 cm.

Figure 4. One example of a task created in a historic building in one of the cities in Indonesia

The overall clarity score is 4.00 out of 5.00. This aspect illustrates that an image must be developed for each activity that allows for the clear identification of the situation or object being handled. The presence score is 4.06 out of a possible 5.00. It denotes that the work may only be completed on-site, for as by measuring certain features of an object. This also indicates that the image or job description cannot be solved without being present at the spot. The activity rating is 4.23 out of 5 stars. This feature shows that the individual who solves the problem must be active and act (e.g., measuring or counting). The score for multiple solutions is 4.07 out of 5.00. It means that the problem can be solved in several ways. Reality had a rating of 3.83 out of 5 stars. This component indicates that the assignment should be practical, application-oriented, and not unduly manufactured. Graduated suggestions have a rating of 3.98 out of 5.00. This feature highlights the need of including at least one hint in each challenge.

The school math aspect score is 4.04 out of 5.00. This component shows that the work should have a clear connection to classroom mathematics. The work should also be graded on a class level. The solution formats received a rating of 4.19 out of 5.00. This element specifies whether the task solution should be provided as a solution interval (good and medium interval), an exact number, a multiple-choice task, or anything else. The tools have a score of 4.19 out of 5.00. This element illustrates that the procedure does not require any special tools. A score of 4.00 out of 5.00 was assigned to the sample answer, suggesting that a solution and ideas should be offered. In general, the generated assignments had the qualifying clarity, presence, activity, multiple solution, reality, graded suggestions, school mathematics, solution format, tools, and example solution.

The tasks of the landmarks were linked into a math trail (Figure 5). The program informs students about the cultural and historical significance of the artifacts, allowing them to learn about math and key objects in their country. Math trails may be done island-wide using this application, extending its use, and allowing all sociocultural different students to obtain the same arithmetic experience. The Indonesian Mobile Math Trail Community assists teachers with everything from training to follow-up and dissemination. This community shares math trail initiatives and puts them into action. In this project, inclusiveness is essential for students and teachers to collaborate to give varied learning resources to foster a diverse society.

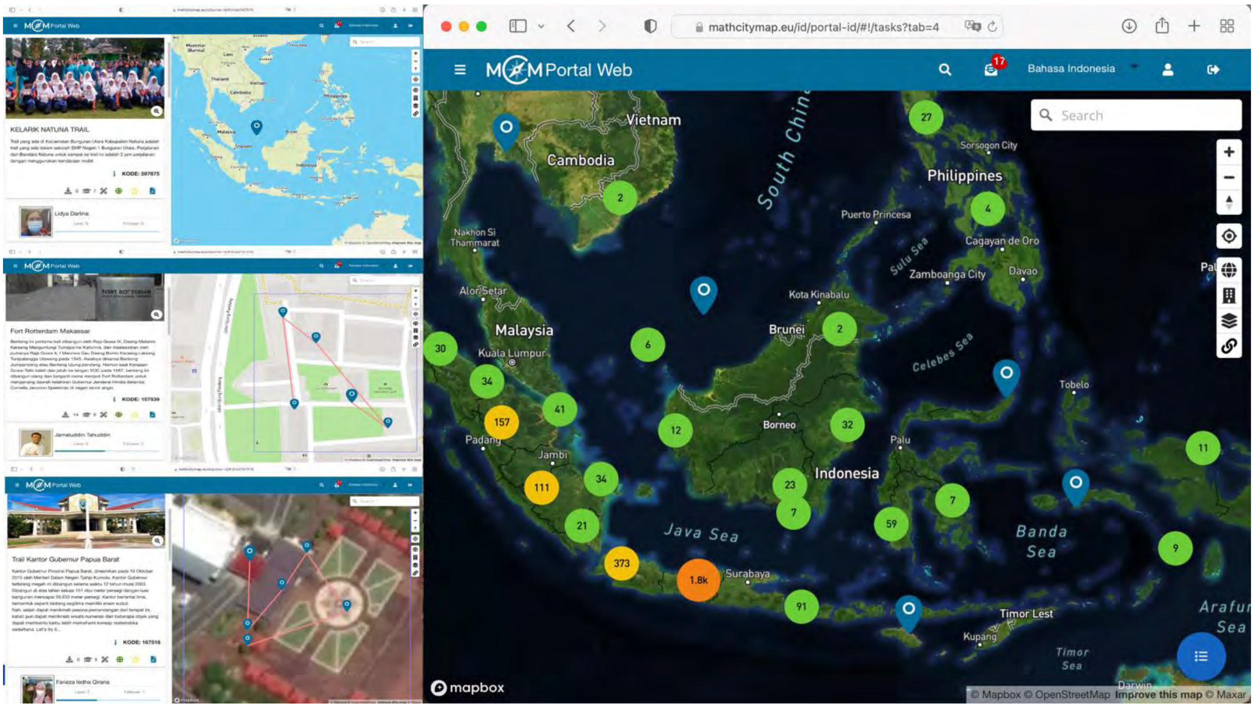


Figure 5. Math Trails in various regions in Indonesia.

Teachers at their various schools have created math trails. Some of them do this outside of school, particularly at tourist attractions. When asked how they determined the location of the action, they explained as follows: "Every year, students travel on a study excursion to Fort Rotterdam and work on a team project. After obtaining instruction on how to boost numeracy abilities through math trails utilizing technology, I became interested in building a Math Trail at Fort Rotterdam. Students will be able to participate in numeracy activities at Fort Rotterdam in addition to historical tours. As a result, this activity may cover subjects such as mathematics, Indonesian, English, history, and science."

Fort Rotterdam is one of Makassar's historical landmarks. This place is well-known among Makassar residents, particularly students. So far, they had only viewed Fort Rotterdam from a historical perspective. They will, however, be able to study Fort Rotterdam from a numerical aspect. The teacher has picked various elements within the fort that might be utilized as number contexts. As a result, in addition to historical tours, visitors to Fort Rotterdam will be able to participate in numeracy excursions. Students in this class can use the app for exercises to develop numeracy skills outside of the classroom. Students are divided into different groups of three to four students apiece. Each group simply requires one smartphone, allowing all students to participate even if they do not all have smartphones.

The study generated a teacher training model that encouraged instructors to construct a range of real-world challenges, according to the findings. This program also promotes mathematical literacy abilities through learning exercises including math trails and mobile devices. Math trails that use technology increase participation and enthusiasm in math study. The curriculum also allows for the development of significant and diverse talents. These findings imply that the teaching strategies developed via these training programs have a considerable influence on student learning that is also mentioned by Stipek et al. (1998). This is the impact of a teacher training program, according to Hattie (2008) and Sullivan (2011). According to Skilling (2014), with this success, the program has the potential to boost academic accomplishments.

The program includes teachers from diverse locations and socio-cultural backgrounds. This variety is beneficial in this exercise because it allows teachers to share their experiences and collaborate. The training findings also reveal that by receiving this intense teacher professional development training, most participating teachers gained the skills necessary to build high-quality math trails, regardless of their socio-cultural origins.

Teachers built math trails in accordance with the concept of math trails proposed by Shoaf et al. (2004). Math trails comprise tasks that vary according to category and topic. Math trails are designed to include a variety of topics such as quantity, uncertainty and data, changes and relationships, and space and shape. Although most activities developed by instructors fall into the space and form categories, the results reveal that tasks are also created in the other categories. This indicates that teachers understood the concept of math literacy (OECD, 2021) and applied it to the math trail using mobile devices. Math trails have been created in communities by teachers utilizing technology. Algebra, Arithmetic, Calculus, Geometry, Probability and Statistics, Number Systems, Set Theory, and Trigonometry are among the subjects covered. While geometry was a popular topic among instructors, other topics were as popular, according to the research.

MCM reviewers accept most of the created tasks for publishing. The math trail tasks fit the MathCityMap Team's requirements, which are as follows: clarity, presence, activity, numerous solutions, reality, school math, solution formats, tools, and example solutions (Cahyono & Ludwig, 2019; Gurjanow et al., 2019; Zender et al., 2020). This indicates that the work satisfies the math trail task criteria, with no variance in quality across Indonesian teachers. This demonstrates that having a diverse social background and physical location are not impediments to reaching equality in math trails aided by mobile technology. The implementation of this teacher professional program might solve the issues highlighted by Granado et al. (2007) and Jung and Lee (2020) about a lack of equity in schools.

A Mobile Math Trail Indonesia community was created to aid educators in their location with everything from training to follow-up and socialization, to improve sustainability and collaboration. The community serves as a discussion and exchange venue for field implementation experiences, as well as the sharing of mathematical trail projects. In this project, inclusivity is critical not only for students, but also for all instructors working together to provide varied learning resources to develop a diverse society.

CONCLUSION

This study devised and implemented an effective model of professional teacher development program concentrating on mobile technologies in the context of math trails. The results of this training show that there is no variance in the quality of math trails made by all teachers, regardless of diversity. The program includes teachers from diverse places and socio-cultural backgrounds, allowing them to share their experiences, collaborate, and get the same course throughout the training.

By constructing math trail assignments, teachers learnt about mathematics literacy and applied it to math trails. Most of the activities created met the following requirements: clarity, presence, activity, various answers, reality, school math, solution formats, tools, and sample solutions. While geometry was a popular topic among educators, other topics were as popular. Math trails are intended to cover a wide range of topics, including amount, uncertainty and data, changes and relationships, and space and form.

This curriculum assists instructors in creating learning environments that increase students' mathematical literacy while leveraging cutting-edge technology. Students have used the program to help them run math trails. A community was developed to serve as a place for debating and exchanging field implementation experiences, as well as sharing mathematical trail initiatives, to increase sustainability and collaboration.

Finally, through this research we succeeded in designing an innovation in the MathCityMap training which was designed and implemented in a hybrid setting. Participants have successfully designed trails in both their schools and the city parks where they live supported using Learning Management System. Most of the trails fulfilled the requirements. The trainee teachers then disseminate their knowledge and experience to their colleagues. They also used MathCityMap Trails for classroom learning as well as other activities such as MathCityMap competitions and public educational activities. The hybrid environment helps to accelerate the attainment of training objectives while also broadening the program's reach and network.

We suggested a novel hypothesis for how cutting-edge technology for online education may assist math pathways while fulfilling local needs and achieving global justice. This initiative provides suitable learning opportunities and fair access to a geographically and culturally diverse student population in Indonesia. The ideas discovered can be used elsewhere, enabling for cross-national development in distant education.

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Declarations

Author Contribution	:	ANC: Conceptualization, Writing - Original Draft, Data Analysis, and Visualization. M: Writing - Original Draft and Editing. M: Writing - Original Draft and data analysis. ML: Validation and Supervision. SJ: Writing - Review, Formal analysis, and Methodology. D-XKO: Writing - Review and Proofreading.
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Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is not available for this paper.

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