



Development of Smart Box Media Based on QR Code Technology to Improve Early Childhood Numerical Literacy Skills

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Abstract: Children's numerical literacy skills have not developed optimally. This can be seen in learning, where although children can mention numbers 1 to 20, they still have difficulty recognizing number symbols and matching the number with the number symbol. This condition is caused by the lack of use of technology-based learning media specifically designed for children. This research aims to develop QR Code-based smart box media to improve early childhood numerical literacy skills. This research method uses the Research and Development model from Borg and Gall. Validation was carried out by 3 experts, the test subjects were Pertiwi 1 Padang kindergarten students. Data collection techniques using interviews, questionnaires, and observation sheets. Data analysis was carried out validity analysis, practicality analysis, and effectiveness test analysis using SPSS V. 25. Based on the results of the analysis, the QR Code-based smart box media has 96% instrument validation test results, 90% media validation test and 92% material validation test with very valid eligibility criteria. Based on the calculation of the N-Gain test results of 0.52, meaning that the development of QR Code-based smart box media to improve early childhood numerical literacy skills is in the medium category. Furthermore, a paired sample t-test was conducted with the results of sig. (2-tailed) of 0.000 < 0.05 with $\alpha = 0.05$ which means that there is a difference in the average value between the pretest and posttest scores of numerical literacy skills in early childhood. It can be concluded that the development of QR Code-based smart box media is effective for significantly improving the numerical literacy skills of early childhood in kindergarten.

Keywords: Early childhood; Media; Numerical literacy; QR code; Smart box

Introduction

Numerical literacy is an important aspect of early childhood development that forms the basis for their understanding of further mathematical concepts (Durak et al., 2016; Flewitt et al., 2015). Numerical literacy includes understanding numbers, number symbols, and the ability to relate the number of objects to the correct number symbol (Aktaş, 2017; Ramalho et al., 2019). However, while many young children can name

numbers from 1 to 20, many still struggle to recognize number symbols and match quantities to the appropriate number symbols (Xezonaki, 2022). This shows that although children are able to pronounce numbers, they do not fully understand the concepts behind the numbers (Poultsakis et al., 2021).

This problem often occurs because math learning is too focused on memorization and oral repetition, without providing hands-on experiences that help children understand how numbers relate to the real

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world. The lack of use of interesting and interactive learning media is one of the reasons why early childhood numerical literacy has not developed optimally (Gözüm et al., 2022; Ramalho et al., 2019). Therefore, it is crucial to develop learning methods that are more fun, innovative and in line with the developmental needs of today's children.

In this connected digital era, technology has great potential to improve the quality of education, including in early childhood education (Padli et al., 2024b, 2024a; Sari, Bafirman, et al., 2023). The use of technology in learning can not only attract children's attention, but also allow them to learn in a more flexible and fun way (Mukhlisin et al., 2020; Padli et al., 2024b; Selviani et al., 2023). One technological innovation that can be used in early childhood education is the QR Code (Bodrova et al., 2024; Essa et al., 2019). QR Code is a two-dimensional code that can store information in the form of links or digital content that can be accessed through a cell phone or tablet. QR Code-based media allows children to access learning materials independently, thus increasing their independence in learning (Fraillon, 2020).

However, although the use of QR codes in education is well known, its application to improve numerical literacy in early childhood is still limited. QR Code-based learning media, designed to teach children to recognize numbers and their symbols in an interactive way, is very rare (Helm et al., 2023; Marrison, 2018). Therefore, there is a need for media development that utilizes QR Code technology as a fun and effective tool in teaching basic math concepts. One of the media that can be developed is the QR Code-based Smart Box (Burns, 2016; Wong et al., 2015).

This QR Code-based Smart Box is designed as a learning tool that can help children learn to recognize numbers in a more visual and fun way (Freina et al., 2015; Mukherji et al., 2022; Samuel et al., 2020). Each box in the Smart Box contains images, objects, or games that can be scanned with a QR Code to access interactive learning materials. This way, children are not only listening or memorizing, but also interacting directly with the material they are learning. Learning becomes more interesting and children can learn while playing. This method is very suitable with the characteristics of early childhood who tend to prefer activities that involve their senses directly (Noble et al., 2015; Rahmadeni, 2022; Wong et al., 2015).

In addition, technology-based media such as Smart Box can also provide flexibility in learning. Children don't always have to be in the classroom to learn - they can access the material anytime and anywhere, as long as there is a supporting device. This gives them the opportunity to practice their numerical literacy skills more often, without the restrictions of time and place

(Nur et al., 2022). With easier access, learning can be more fun and children will be more motivated to learn.

Therefore, this research aims to develop QR Code-based Smart Box Media as a learning tool to improve early childhood numerical literacy skills. Through this research, it is expected to create media that is easily accessible, fun, and very useful in helping children recognize and understand basic mathematical concepts, especially in terms of numerical literacy. Hopefully, with this media, learning becomes more interesting, and children can develop their numerical skills more optimally, accompanied by better cognitive development.

Method

This study used a Research and Development (R&D) approach with a development model based on the steps proposed by Borg and Gall. This approach was chosen because the research aims to develop a product - in this case, QR Code-based Smart Box learning media - to improve early childhood numerical literacy skills (DePascale et al., 2022). In the process, this research involves two main stages, namely media development and testing, to ensure the resulting product can be used effectively and in accordance with the needs of children (Suryana, 2017).

The subjects in this study were children aged 5-6 years totaling 54 children with details of small group tryout subjects involving 9 children in class B3 Pertiwi 1 Padang Kindergarten and for medium class test subjects (field tryout) in class B5 Pertiwi 1 Padang Kindergarten involving 16 children, where the test results were used to revise the product or design. This procedure refers to the steps in the Borg & Gall model development procedure (Durak et al., 2016). Researchers simplified it by following the 9 steps of Borg and Gall's R&D research as in Figure 1.

QR Code-based Smart Box media development is carried out through several stages: needs analysis, media design, prototype development, and media validation. Data was collected in various ways to obtain complete information, namely: Observation was used to observe how children interacted with the developed media, as well as to assess the extent to which this media helped them understand the concept of numerical literacy. Interviews were conducted to achieve certain objectives. Interviews were conducted by researchers to teachers to obtain initial needs data. Questionnaires in this study were used to validate instruments, materials and media. Documentation is a measuring tool in the form of pictures, writings or other works related to the research. Documentation is needed for written data.

Data analysis was conducted using several techniques: validity test, practicality test, and effectiveness test. To measure the effectiveness of the media in improving children's numerical literacy, the

difference between pretest and posttest scores was tested using the paired sample t-test with SPSS V statistical tool 25 with a significance level of 0.05.

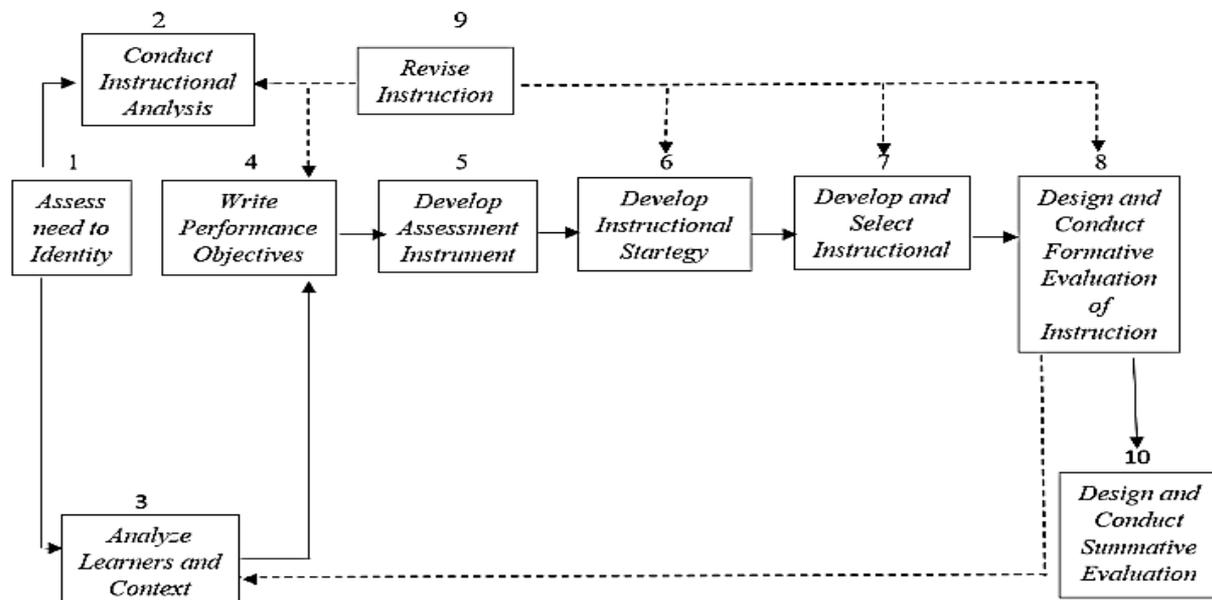


Figure 1. Research procedure

Result and Discussion

In table 1, the media validity is 90% which means it has a very valid feasibility. Material validity of 92% which means it also has very valid feasibility. Expert validity of 96% which means it also has very valid feasibility.

Table 1. Develop Assessment Instrument

Validity	Percentage (%)	Feasibility Criteria
Media	90	very valid
Material	92	very valid
Expert	96	very valid

Table 2. Instrument Validity Test Results

Item Number	R Table Value	R Count Value	Description
1	0.553	0.716	Valid
2	0.553	0.754	Valid
3	0.553	0.582	Valid
4	0.553	0.586	Valid
5	0.553	0.677	Valid
6	0.553	0.690	Valid
7	0.553	0.614	Valid
8	0.553	0.596	Valid
9	0.553	0.655	Valid
10	0.553	0.864	Valid
11	0.553	0.582	Valid
12	0.553	0.614	Valid
13	0.553	0.614	Valid
14	0.553	0.596	Valid
15	0.553	0.655	Valid

Table 3. Practicality Test of Smart Box Media

No	Total Score	Max Score	Percentage
1	62	65	95
2	63	65	97
Total	125	130	
Average			96%
Categories			Very Practical

In table 2, the validity test found that all items have a value of r count > 0.553, so all items are valid. Based on table 3, the results of the practicality assessment in the FGD activity at Pertiwi 1 Padang Kindergarten with the percentage assessment result is 96%. This states that smart box media based on QR Code technology to improve early childhood numerical literacy skills is declared practical.

Researchers conducted large-scale trials taking pretest and posttest data to see the ability of numerical literacy in large-class trial children after learning with the developed product. Figure 2 explains the data description of the results of using smart box media.

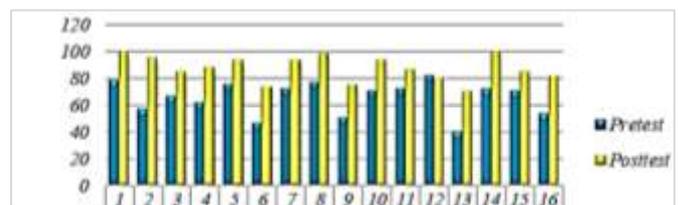


Figure 2. Large scale test pre-test post-test comparison

$$N - gain = \frac{\text{Mean posttest} - \text{mean pretest}}{\text{Max Skor} - \text{mean pretest}} \quad (1)$$

Based on the calculation of the N-Gain test results, the N-Gain score of children's numerical literacy skills in the large class trial was 0.638. This means that the development of *smart box* media is effective for improving numerical literacy skills in early childhood in the medium category.

Based on table 4, the sig (2-tailed) value is 0.000 < 0.05 with $\alpha = 0.05$. The results of this data analysis indicate that, the results of the development of *smart box* media based on QR Code technology are effective for

significantly improving numerical literacy skills in early childhood.

Tabel 4. Paired Sample t-Test Results

Data	Mean	Stdev	95% CI		t	Sig
			Low	Up		
Pre - Post	-13.375	5.252	-16.174	-10.576	-10.187	.000

The following are the results of product development "Smart Box" based on QR Code technology to improve numerical literacy skills in early childhood.



Figure 3. Opening display, home page, scannable display



Figure 4. Numerical literacy smart box media content

The results of this study show that the use of QR Code technology-based media in learning has a positive impact on early childhood numerical literacy skills. The smart box media proved to be faster and more effective in teaching numerical literacy compared to traditional methods. This technology allows children to more easily understand numerical concepts by relating them to their daily lives. In addition, QR Code-based media also supports teaching various mathematical concepts such

as algebra, numbers, measurement and data analysis in a more interesting and interactive way (Festiyed, 2019).

In the world of early childhood education, technology plays an important role in creating a more dynamic and engaging learning experience (Aktaş, 2017; Selviani et al., 2024). Constructivism theory states that children construct their knowledge through direct experience and interaction with the surrounding environment (Indika et al., 2023; Sari et al., 2024). By using QR Code media, children can connect numerical

lessons with things they encounter daily, making learning more meaningful (Suryana, 2018). This is in line with Vygotsky's thinking, which emphasizes the importance of support in learning, where technology becomes a tool that helps children to achieve their cognitive development through a more personalized and targeted approach (Susanto, 2021).

Technology also gives children the freedom to learn in a more independent way, where they can access learning materials anytime and anywhere (Ilham et al., 2024; Selviani et al., 2024). The QR Code-based smart box media allows them to scan the code and dig deeper into the numerical material at their own pace. This concept also supports the theory of knowledge construction-based learning, where learning experiences should be relevant to the child's world, providing opportunities to understand the material in a more authentic way (Ilham et al., 2024; Sari et al., 2023). Not only that, but learning through devices such as smartphones also makes it easy for children to access materials flexibly, according to their needs and abilities (Yaswinda et al., 2019).

In addition, this interactive technology helps children understand numerical concepts in a more visual and procedural way. Using multimedia learning theory, QR Code media provides a fun learning experience by combining images, sounds, and text to visualize abstract concepts (Eliza, 2013; Suryana, 2017). The results of the pilot test conducted on the instrument show that this media is very valid and practical to use in kindergarten. Small and large class trials showed that QR Code-based smart box media can significantly improve children's numerical literacy skills. This also aligns with motivation theory, which shows that technology can increase children's interest and engagement in the learning process (Suryana, 2016, 2021).

Overall, the QR Code-based smart box media proved to be effective, practical and valid in helping early childhood develop their numerical literacy skills. With this technology-based approach, children not only learn the basic concepts of numerical literacy, but also experience a fun and developmentally appropriate learning experience.

Conclusion

Based on the significance value (2-tailed) of $0.000 < 0.05$ with $\alpha = 0.05$, which means that there is a difference in the average value between the pretest and posttest scores for numeracy literacy in early childhood the development of QR Code-based smart box media proved effective in improving early childhood numerical literacy skills. This media shows excellent feasibility, both in terms of instruments, media, and

materials. The use of technology in the form of a QR Code-based smart box has a positive impact on improving children's understanding of numerical concepts. Therefore, this technology-based learning media can be an innovative solution in supporting numerical literacy learning in early childhood education.

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Author Contributions

Resa Tifeni Az-Zahra: Research concept, media design, data collection, analysis, article writing. Dadan Suryana: Theory development, methodology, data analysis, article revision. Yaswinda: Initial media design, product trial, data collection, analysis. Delfi Eliza: Field testing, data processing, media evaluation, writing trial results.

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Conflicts of Interest

The authors declare no conflict of interest.

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