Improving Children's Cognitive Ability Through Information Processing Theory-Based Digital Content

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A B S T R A K

Terbatasnya media pembelajaran digital untuk tema-tema di PAUD memberikan hambatan terhadap guru dalam menyampaikan materi selama pembelajaran daring. Begitupula, siswa mengalami kesulitan memahami materi yang disampaikan guru selama pembelajaran daring tanpa menggunakan media. Tujuan penelitian ini adalah mengembangkan dan menguji efektivitas konten digital dalam meningkatan kemampuan kognitif anak usia dini (AUD). Produk penelitian dikembangkan menggunakan model Hannafin dan Peck yang meliputi: (1) tahap analisis kebutuhan, (2) tahap desain, (3) tahap pengembangan dan implementasi. Subjek yang terlibat dalam penelitian ini adalah 2 orang ahli yaitu ahli media sekaligus ahli desain pembelajaran dan 1 orang ahli konten pembelajaran di TK. Metode dan instrumen yang digunakan untuk mengumpulkan data dalam penelitian ini adalah observasi, wawancara, kuesioner, dan tes. Data yang diperoleh melalui observasi, kuesioner, dan wawancara dianalisis secara statistik deskriptif. Data yang diperoleh dari tes dianalisis menggunakan uji-t sampel berkorelasi. Hasil penelitian menunjukkan bahwa aspek desain, media, dan aspek isi produk yang dikembangkan berada pada kategori sangat baik dan konten digital efektif untuk meningkatkan kemampuan kognitif. Dengan demikian, konten digital berbasis teori pemrosesan informasi mampu memudahkan siswa mengingat dan memahami materi pelajaran selama pembelajan daring.

A B S T R A C T

The limited digital learning media for themes in Early Childhood Education provides obstacles for teachers in delivering material during online learning. Likewise, students have difficulty understanding the material presented by the teacher during online learning without using media. This study aims to develop and test the effectiveness of digital content in improving early childhood cognitive abilities. The research product was developed using the Hannafin and Peck model, which includes: (1) needs analysis phase, (2) design phase, (3) development and implementation phase. The subjects involved in this study were 2 experts, namely media experts and learning design experts, and 1 learning content expert in kindergarten. The methods and instruments used to collect data in this study were observation, interviews, questionnaires, and tests. The data obtained through observation, questionnaires and interviews were analyzed descriptively statistically. The data obtained from the tests were analyzed using the correlated sample t-test. The results showed that the design, media, and content aspects of the products developed were in the very good category and digital content effectively improved cognitive abilities. Thus, digital content based on information processing theory is able to make it easier for students to remember and understand subject matter during online learning.

1. INTRODUCTION

In today's digital era, the role of learning media is felt to be very important. With information technology and internet technology, the learning media should be transformed following the characteristics of targets or learners (Chatzara et al., 2016; Yamin & Karmila, 2019). As it is known, learners at the level of early childhood education (PAUD) are currently born in the range of 2015-2016, or known as an alpha generation. Generation Alpha is the generation most familiar with digital technology because it was born in rapid development (Fadlurrohim et al., 2020; Yuliandari, 2020). Generation Alpha has characteristics that can not be separated from smartphones: less social, lack of creativity, and individualist Mc Crindle (Fadlurrohim et al., 2020; Oktarina et al., 2019). The alpha generation wants instant things and lacks respect for the process. The results showed that the use of smartphones in the alpha generation, especially kindergarten children aged 4-6 years, is 94%. Causes of high levels of smartphone use, among others: 1) smartphones and tablets as a means of introduction to information and communication technology; 2) smartphones and tablets as educational media to add insight to children; and 3) smartphones and tablets as a means of entertainment so that children are not fussy and fussy (Zaini & Soenarto, 2019). The

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development of technology and the habit of children accessing smartphones certainly change the way parents, including teachers, facilitate their learning process. These characteristics challenge teachers to prepare various learning resources and digital learning media appropriate following child development.

Learning during the covid-19 pandemic was implemented through online distance learning (PJJ Daring) (Adnan & Anwar, 2020; Talidong & Toquero, 2020). During this learning, the level of interaction of children with smartphones is very high. Almost all learning content or information is accessed through smartphones so that children can still learn. Smartphones are one of the effective media for distance learning. Students benefit from smartphones as a learning medium, smartphones as an information center, smartphones adding students' insight, and smartphones as a tool to facilitate communication. The results of this study indicate that the role of smartphones is very high and strategic (Firmansyah, 2020; Jazuli et al., 2018). But on the other hand, smartphones cannot fully help physical growth and development, the development of intelligence or cognitive, socio-emotional, language and communication. Based on the results of observations at Lab Undiksha Kindergarten Singaraja-Bali, students' cognitive development has not been optimal during distance learning. Students have difficulty understanding the material delivered by the teacher through video conferences. Other research results also show that many children experience cognitive development barriers online (Djangkali, 2021; Khafid, 2019; Pravitasari & Yulianto, 2018).

Online PJJ conducted during the covid-19 pandemic to facilitate the development of aspects of intelligence (cognitive), socio-emotional, language, and communication did not run smoothly. Teachers still have many complaints about difficulties operating computers, accessing internet networks, unstable internet, teacher readiness in preparing digital materials, difficulties in online learning planning, and assessment difficulties (Fauziah et al., 2018; Zaini & Soenarto, 2019). Among these difficulties that teachers feel significantly, especially in Lab Undiksha Kindergarten, is the limited digital learning media and digital learning content for certain themes such as vegetable plant themes, fruit plants, universes, and other themes. The limited media is also inseparable from the ability of teachers to design media, especially designing ICT-based media (Arifah et al., 2019; Winda & Dafit, 2021). Although some media for early childhood are available on the internet, presenting content or material on the media is not yet by the characteristics of students, especially in kindergarten lab. The media on the internet has not been designed based on information processing theory. Text messages, images, and sounds are not systematically organized, so they are not attractive and difficult for students to understand. Another disadvantage, namely the model teacher on the media on the internet, has not provided psychological closeness to students. Unlike the case, if the media is produced by design (by design), the teacher can act as a model to convey material, protest, tell stories, and tell storytelling. So on, students feel teachers' presence even in distance learning. On the other hand, complaints also come from parents, namely the difficulty of accompanying children to learn because they do not understand how are not used to using digital technology for children's learning do not understand the meaning of the message conveyed by teachers (Asmuni, 2020; Rofi'ah, 2021). Various problems experienced by teachers and parents of students are feared to interfere with aspects of development in early childhood.

Based on the difficulties experienced by teachers, students, and parents, not all of these problems will be solved in this study. The focus of the problem that will be studied is not the optimal development of cognitive aspects of children during online distance learning. These two aspects can be developed online by developing exciting and innovative digital content. A child's cognitive development is generally influenced by two factors: (1) heredity or traits that determine their intellectual working power and (2) the environment, including the family and school environment. In this case, digital content is an external factor as one form of stimulus that will be given to improve cognitive development and discuss early childhood. Digital content developed adopts information processing theory. Information processing theory is oriented to students' ability to process information ranging from receiving, storing, and disclosing information that has been stored (Khotimah &Risan, 2019; Lloyd & Jankowski, 1999). Digital content developed based on information processing theory has not yet been created. Other researchers focused more on researching the effectiveness of information processing models. Information processing theory is oriented to the student's ability to process information ranging from receiving, storing, and disclosing information that has been stored (Khotimah & Risan, 2019; Lloyd & Jankowski, 1999). This theory also focuses on activities related to processing or information processing activities to improve the capabilities of learners (Rehalat, 2016). The application of information processing theory has a significant impact on learning (Lloyd &Jankowski, 1999).

Information processing theory focuses on visible behavioral changes and internal information processing (within), such as entering and using various information (Kusaeri, 2017). Information processing theory consists of several components, including information storage components and cognitive process components. Information storage components consist of sensory memory, short-term memory, and long-term memory (Sternberg, 2006; Woolfolk, 2008). At the same time, the components of cognitive

processes are attention, perception, retrieval, rehearsal, and encoding (Amamah et al., 2016). The results showed that the application of information processing theory could provide clarity on a message and effectively be applied in reading activities (Khotimah & Risan, 2019; Lloyd & Jankowski, 1999). The change of printed content to digital is a demand in the era of the industrial revolution 4.0. Content realized in digital form is more effective than in print (Torkar, 2021). Thus, applying information processing theory is appropriate for developing cognitive aspects in early childhood. In addition, the results showed that information processing theory based on interactional communication is effectively used in speech learning. Speaking and language are two things that cannot be separated. Language encompasses every form of communication evoked by thoughts and feelings to convey meaning to others (Hurlock, 1988). Based on the problems that have been outlined, research is carried out by developing digital content can be videos, animations, simulations created by adopting information processing theories to improve early childhood cognitive development in online distance learning.

2. METHOD

This type of research is development research. Penelitian development is research-oriented to develop and validate the products used in Education (Borg &Gall, 2007; Sugiyono, 2014). The development model Hannafin &peck used with the development flow as in Figure 1.
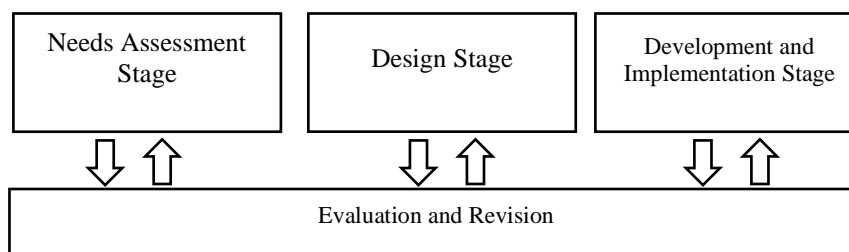
Figure 1. Stages of Development Model (Hannafin & Peck, 1988)

Assessment of the needs in developing a learning product was an essential first thing because it will be obtained learning products that follow the circumstances and characteristics of the target. The needs assessment stage includes activities: (a) analysis of the learning process, (b) conducting material/content analysis, and (c) analyzing target characteristics. An important step that must be considered in the design process is determining the digital delivery strategy. The design phase was focused on three activities: (a) selection of material (theme), (b) designing the type of digital content developed, (c) creating a digital content script by adopting information processing theory. Development activities translate the design into physical form, producing a prototype of development products in digital content. Everything that has been done at the design stage, namely the selection of materials, learning strategies, and media design, was realized in the form of prototypes in the form of digital content. The development results in digital content then go to the implementation stage, validated by experts and tested by targets. Validation and trial aim to obtain input to correct lingering deficiencies in the learning medium. Evaluations and revisions based on Hannafin &peck models were performed at each development step. At the needs assessment stage, an evaluation of the needs analysis results was carried out to determine the priority scale of the problems found in the field. The framework or manuscript evaluation was followed up with manuscript improvements at the design stage. At the development and implementation stage, evaluation of digital content by experts and users and followed up with improvements by the input of experts and students. At this stage, the effectiveness of digital content development was also carried out against students' learning outcomes.

Digital content as a result of development must pass a series of trials to determine its level of validity and effectiveness. The validity and effectiveness of digital content can be known through expert review analysis and field tests. Effectiveness tests used one class as a trial. Thus, the design tests effectiveness using one group pretest-posttest design. The data was collected using observation methods, questionnaires, interviews, and tests. Observation methods and questionnaires were used when conducting preliminary studies. Questionnaires were used to obtain data from experts, and interviews were used during individual and small group trials. Efforts to ensure the validity of the questionnaire were carried out by creating a grid table and writing instruments. Instrument grid of product validity test presented in Table 1.

Table 1. Instrument Grid of Product Validity Test

No.	Formative Evaluation Stages	Aspects	Number of Items
1	Validate media aspects	1. Typography 2. Graphic 3. Audio 4. Systematic	10
2	Validate learning design aspects	1. Learning design 2. Message delivery strategy 3. Interface design	10
3	Validate content aspects	1. Basic competencies, indicators, and objectives suitability 2. Material conformity 3. Material adequacy 4. Depth of material 5. Served material	10
4	Field Test	1. Clarity 2. Attractiveness 3. Readability 4. Language 5. Ability to motivate 6. Technical Quality	5

The data collected using the questionnaire method is further analyzed using statistically descriptive analysis. The guidelines used to give meaning and decision-making are presented in Table 2. Pretest and posttest data are analyzed using inferential statistics in the form of t-tests. If the data obtained did not meet normal and homogeneous assumptions, the non-parametric statistics Wilcoxon test.

Table 2. Achievement Rate Conversion Guidelines with a Scale of 5

Level of Achievement (%)	Qualification	Information
90-100	Excellent	No need to revise
75-89	Good	Slightly revised
65-74	Enough	Revised sufficiently
55-64	Less	A lot of things have been revised.
0-54	Very lacking	Repeatedly making the product

3. RESULT AND DISCUSSION

Result

The results of the research will be presented based on the development stage used using Hannafin and peck models that include 3 stages, namely (1) needs analysis, (2) design, (3) development and implementation. At the needs analysis stage, there has been an assessment of the material or theme of learning in kindergarten-created digital content. The themes developed are two-legged animals and four-legged animals. The theme developed into 7 learning objectives that can be mapped in Table 3.

Table 3. Digital Content Object Mapping

Theme	Learning Objective	Types of Digital Content Objects
Two-legged and four-legged animals	a. Students can name the types of two-legged animals b. Students can distinguish the types of four-legged animals between those that lay eggs and breed c. Students can distinguish four-legged animals that breed and lay eggs d. Students can mention the types of chickens	Text, images, sounds, and videos

Theme	Learning Objective	Types of Digital Content Objects
	e. Students can mention chicken parts	
	f. Students can explain the process of breeding chickens	
	g. Students can mention the benefits of chicken	

The above mapping results were used as a reference to create a digital content script design. The needs analysis stage also carried out an analysis of learning facilities owned by students. From these results that all students have the means in the form of computers and smartphones used during online learning. The design stage is done by creating a storyboard or digital content script. Media scripts are used as a reference for digital content production. Media scripts used column three, namely number, visual, and audio. At the stage of development, the implementation of the manuscript became an accurate visual display of digital content. Manufacturing was done using multiple PowerPoint software, Filmora application, and a PC as hardware for production. At this stage, also collected and produced materials by the mapping results at the needs analysis stage. Objects used in digital content include text, images, videos, animations, sounds. The object was arranged based on the type and characteristics of learning activities. Some appearances from digital content are presented in Figure 2 and Figure 3.

Figure 2. Greeting View from the Teacher

Figure 3. Learning Purpose Presentation View

Digital content uses more images that aim to extract messages. It was known that kindergarten children would be easier to understand if the message was presented in real or concrete. Experts further review digital content that has been produced. Two experts explore namely experts in design and learning media and learning content experts. Based on the expert assessment, aspect digital content learning design scored 96.43 with an excellent category while the learning media aspect obtained a score of 100 with an excellent category. In terms of content, getting a score of 91.66 is excellent. Based on students' and parents of students that digital content was exciting, students are easy to learn and make students happy to learn. Research on the digital content application was conducted online or online at Lab Undiksha Kindergarten. The variable observed was cognitive ability. The study used one class as a sample and a research population. The description of cognitive ability data is presented in Table 4.

Table 4. Description of Cognitive Ability Data

Statistics	Pretest	Posttest
N	5	5
Range	33.00	17.00
Minimum	50.00	83.00
Maximum	83.00	100.00
Mean	60.00	89.80
Std.Deviation	14.82	9.31
Variance	219.50	86.70

Before the hypothesis test, the test-t conducted the prerequisite test using: (1) the normality test and (2) the homogeneity test. Kolmogorov-Smirnov's normality test results showed that the cognitive pretest score data obtained Sig 0.044 (<0.05) so that the cognitive pretest score was not normal. Cognitive posttest data obtained sig 0.026 (<0.05) so that the cognitive posttest score did not distribute normally. The results of the Based on Mean cognitive variables showed that for Sig=0.227. When the significance level is 0.05, the Sig obtained 0.227 was more significant than 0.05. Thus cognitive ability data has homogeneous

variants. Based on the results of the prerequisite test that for cognitive ability variables, only fulfilled 1 prerequisite i.e., cognitive data has homogeneous variants. In cognitive variables only homogeneous conditions, hypothesis tests cannot be done with the t-test. So the hypothesis test was done using non-parametric statistics in the form of Wilcoxon tests. Wilcoxon test results showed that the negative rank or negative difference between the pretest score and the posttest score is (N =0), which means there was no decrease in the pretest score to the posttest score. In the positive rank line, N = 5, 5 respondents experienced an increase in the pretest score to the posttest score. Ties have N=0, which means that no respondent has the same pretest and posttest scores. Based on the results of the analysis, it was known that Asymp. Sig (2-tailed) was worth 0. 042. Because of the value of 0. 042 is smaller than 0. 05 Then Ha was accepted, and H0 was rejected. This means a significant difference in cognitive ability between before learning by applying digital content and after the following learning by applying digital content. It can be concluded that digital content improves the cognitive abilities of kindergarten children in Undiksha Lab in 2021.

Discussion

The validity and validity of digital content developed were inseparable from the theory of information processing used. The display of digital content was designed concerning information processing theories that provide the principle that the presentation of material must pay attention to students' cognitive capacity in digesting information. According to this approach, students gradually develop the capacity to process information and gain complex knowledge and expertise (Santrock, 2011). Based on this theory, digital content was designed in a short duration, presenting the main points of the material so that it was more focused, and abstract materials are clarified using images and animations. Likewise, texts considered necessary are given color or bolded to make it easier for students to capture keywords in the digital content presented. This presentation can improve the learning outcomes of learners (Riyanto & Gunarhadi, 2017). Because the target of digital content was kindergarten children who are not fluent in reading, digital content is also supported by presenting material through audio or teacher narration. Combining visual and audio narratives helped students understand the information presented in digital content. Digital content developed has a position in the category is very good. Digital content is considered attractive by students based on questionnaires given online at the field test stage. Students assess that digital content impressions make them happy to learn and understand the subject matter easier. The use of images, colors, sounds and animations make learning more enjoyable. Other studies support these findings, showing that digital content that makes multimedia elements such as text, images, sounds, videos, and animations foster a comfortable and exciting atmosphere (Jannah et al., 2020). Other research results also showed that the use of images, colors, sounds, able to attract attention and delight learners (Kuswanto et al., 2017).

Digital content developed was able to improve the cognitive abilities of kindergarten students Lab Undiksha. This was known from the increase in scores between the initial and final tests. During observations in learning, digital content made students feel happy and interested in learning. This pleasure was the first factor that could determine the success of students' learning. Presenting images, stories, and questions in digital content keeps students motivated to learn. The application of information processing theory was beneficial for researchers in presenting digital content to be interesting. As is known, information processing theory demands learners' interest and attention (Loc et al., 2019). Not only motivated but digital content for 2-3 minutes also makes it easier for students to listen and remember the main messages in digital content. This was inseparable from the theory of information processing used. By paying attention to the theory, digital visual content becomes more organized and provides students with understanding and remembering content. The results showed that the visual role improved the understanding of concepts by learners (Armansyah et al., 2019). Visualization presented in an integrated and relevant manner will provide students with a complete understanding..

Digital content developed has used text, colors, images, animations, and videos to attract attention and clarify the material. These findings were supported by other studies showing that digital content that makes multimedia elements such as text, images, sounds, videos, animations, and the right color selection can foster a comfortable atmosphere, attract attention, and delight learners (Indah Septiani et al., 2020; Jannah et al., 2020; Kuswanto et al., 2017; Monica, 2010). Presentation of material in audiovisual or video can provide a clear and exciting understanding. Video has proven to be an effective strategy for improving learners' learning outcomes (van Alten et al., 2020). Digital content developed has the advantages of content or other digital media that has been developed, namely by applying information processing theory in media design. Information processing theory refers to cognitive theory so that the presentation of content can undoubtedly facilitate students' cognitive development. Placement of positions and images in digital content is tailored to its level of urgency. If the text was the main focus, it is positioned on the left and the image on the right. If the image is the main focus, then the image is positioned on the left and the image on

the right. Content in the form of text is important in a visual impression. Presentation of text in the video better impacts learners' understanding (Teng, 2019). Long text content is broken down into small pieces to make it easy to remember and understand (Mayer, R.E., Howarth, J.T., Kaplan, 2018; Spanjers et al., 2012). Likewise, unrelated information is omitted not to cause cognitive burdens (McCrudden & Rapp, 2017).

The application of information processing theory also aimed to reduce the cognitive burden on students when viewing content. Cognitive load is a major consideration in designing digital or multimedia content (Mayer & Moreno, 2003). Cognitive load theory emphasizes the importance of delivering material efficiently and interestingly to be stored in long-term memory (Leppink, 2017). Solid presentation of material weighs on students' cognitive capacity (Albus et al., 2021). One way that can be used is the principle of segmentation. The material in digital content has been presented using the principle of segmentation i.e.; large materials are broken down and presented in the form of material points. Through this technique, students will find it easier to find material keywords. The results show that this principle can improve student learning outcomes make it easier for students to organize and integrate complex knowledge (Ibrahim et al., 2012; Mayer, R.E., Howarth, J.T., Kaplan, 2018; Riyanto, 2017). Thus the cognitive students will not be burdened. The presentation of material by paying attention to students' cognitive capacity reduced the cognitive burden and improved their learning outcomes (Hamdi & Hamtini, 2016). Paying attention to the theory so that digital visual content becomes more organized attracts attention and provides students with understanding and remembering.

Another advantage of this study was that it focuses on aspects of student attention. The attention aspect was a staple in visual designing. This aspect becomes fundamental for students when looking at information to store the information in memory management and call that information back (Drigas & Karyotaki, 2019). Information processing theory demands that interest and attention be created from learners (Loc et al., 2019). This indicated that the content must be designed attractively to attract the audience's attention. The digital content developed contained relevant images, animations, colors, and the right typography to attract students. The content design was not only to attract attention but also to understand concepts to students. Digital content has been designed using relevant and concrete images, presenting content with exact words, and presenting clear message points with narrative sounds. The results of this development are supported by research results that showed that the role of visuals could improve understanding of concepts, improve high-level thinking skills, and learning becomes more effective (Armansyah et al., 2019; Raiyn & Jamal, 2016; Rasul et al., 2011). Visualization presented in an integrated and relevant manner will provide students with a complete understanding.

4. CONCLUSION

The resulting digital content has been validated by experts and declared valid from media, design, and content aspects. Digital content also has excellent appeal to students. Digital content designed by applying information processing theory has a positive impact. The messages delivered in digital content became easier to understand and did not cause an excessive cognitive burden on students. So that digital content based on information processing theory becomes one effective way to improve early childhood cognitive support.

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