# A GAME-BASED LEARNING ANALYTICS PLATFORM FOR THE ASSESSMENT OF CREATIVITY AND LOGIC DEVELOPMENT IN 3-4 YEAR-OLD CHILDREN



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SULTAN IDRIS EDUCATION UNIVERSITY

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# A GAME-BASED LEARNING ANALYTICS PLATFORM FOR THE ASSESSMENT OF CREATIVITY AND LOGIC DEVELOPMENT IN 3-4 YEAR-OLD CHILDREN

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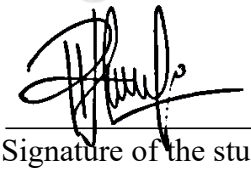

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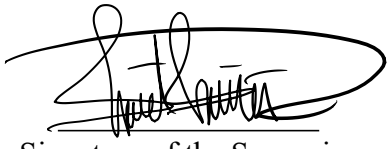

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# ABSTRACT

The Game-based Learning Analytics Platform (GBLAP) is an innovative solution to the challenges currently facing the education sector. Its main benefits include improving assessment accuracy and providing more personalized and engaging data-driven learning experiences. This study examines the effectiveness of GBLAP in enhancing the accuracy of creativity and logic assessments in 3-4 year-old children compared to traditional methods, evaluates its acceptability among teachers and parents, and assesses the effectiveness of machine learning models in classifying child development data based on game interactions. The platform integrates artificial intelligence to create a more personalized and optimized learning environment. The System Usability Scale (SUS) instrument was adopted and adapted to obtain feedback from 2 teachers, 10 parents, and 10 children from Manhajul Husna Early Childhood Education, South Kalimantan, Indonesia, and 2 teachers, 10 parents, and 10 children from TASKA PERMATA Universiti Pendidikan Sultan Idris. The children's creativity and logic development data were classified using machine learning techniques by comparing three classification algorithms: Naïve Bayes, Multilayer Perceptron, and Decision Tree, into three categories: Good, Medium, and Low. The usability study demonstrated that GBLAP is an effective tool for real-time tracking of children's progress in creativity and logic assessments. The high average SUS score, above 70, indicates that the platform is well-accepted. For classification, the Multilayer Perceptron algorithm showed the best performance, with an accuracy of 72.97% on training data and 79.17% on testing data. The results suggest that GBLAP is effective, efficient, and engaging, and capable of providing accurate analysis of child development. This system offers valuable insights into children's understanding in the areas of creativity and logical thinking.

# PLATFORM ANALITIK PEMBELAJARAN BERASASKAN PERMAINAN UNTUK PENILAI PERKEMBANGAN KREATIVITI DAN LOGIK DALAM KANAK-KANAK BERUMUR 3-4 TAHUN

## ABSTRAK

Platform Analitik Pembelajaran Berasaskan Permainan (GBLAP) adalah penyelesaian inovatif kepada cabaran yang dihadapi dalam sektor pendidikan masa kini. Faedah utamanya termasuk peningkatan ketepatan penilaian dan penyediaan pengalaman pembelajaran yang lebih diperibadikan dan menarik berdasarkan data. Kajian ini menilai keberkesanan GBLAP dalam meningkatkan ketepatan penilaian kreativiti dan logik kanak-kanak berumur 3-4 tahun berbanding kaedah tradisional, menilai kebolehterimaan GBLAP dalam kalangan guru dan ibu bapa, serta menilai keberkesanan model pembelajaran mesin dalam mengklasifikasikan data perkembangan kanak-kanak berdasarkan interaksi permainan. Platform ini mengintegrasikan kecerdasan buatan untuk mencipta persekitaran pembelajaran yang lebih diperibadikan dan dioptimumkan. Instrumen Skala Kebolehgunaan Sistem (SUS) telah diterima dan diubah suai untuk mendapatkan maklum balas daripada 2 orang guru, 10 orang ibu bapa, dan 10 orang kanak-kanak dari Pendidikan Awal Kanak-Kanak Manhajul Husna, Kalimantan Selatan, Indonesia, serta 2 orang guru, 10 orang ibu bapa, dan 10 orang kanak-kanak dari TASKA PERMATA Universiti Pendidikan Sultan Idris. Data perkembangan kreativiti dan logik kanak-kanak telah diklasifikasikan menggunakan teknik pembelajaran mesin dengan membandingkan tiga algoritma klasifikasi: Naïve Bayes, Multilayer Perceptron, dan Decision Tree, ke dalam tiga kategori: Baik, Sederhana, dan Rendah. Kajian kebolehgunaan menunjukkan bahawa GBLAP adalah alat yang berkesan untuk penjejakan masa nyata kemajuan kanak-kanak dalam penilaian kreativiti dan logik. Skor purata SUS yang tinggi, melebihi 70, menunjukkan bahawa platform ini diterima baik. Bagi klasifikasi, algoritma Multilayer Perceptron menunjukkan prestasi terbaik, dengan ketepatan 72.97% pada data latihan dan 79.17% pada data ujian. Hasil kajian mencadangkan bahawa GBLAP adalah berkesan, cekap, dan menarik, serta mampu menyediakan analisis yang tepat tentang perkembangan kanak-kanak. Platform ini menawarkan pandangan berharga mengenai pemahaman kanak-kanak dalam bidang kreativiti dan pemikiran logik.

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| | |
|---|---|
| A | Able |
| AI | Artificial Intelligence |
| ANN | Artificial Neural Network |
| CL | Collaborative Learning |
| DT | Decision Tree |
| EDM | Education Data Mining |
| GBLAP | Game Based Learning Analytics |
| IP | In Progress |
| LA | Learning Analytics |
| LAP | Learning Analytics Platform |
| LMS | Learning Management System |
| ML | Machine Learning |
| MLP | Multilayer Perceptron |
| MOOC | Massive Open Online Courses |
| MSE | Mean Squared Error |
| NA | Not Able |
| NB | Naïve Bayes |
| NCDC | The National Child Data Center |
| NCDRC | The National Child Development Research Center |
| PAUD | Pendidikan Anak Usia Dini |

| | |
|---|---|
| SUS | System Usability Scale |
| TAP | Technology And Play |
| TASKA | Taman Asuhan Kanak-Kanak |
| UPSI | Universiti Pendidikan Sultan Idris |
| VMTwG | Virtual Math Team with Geogebra |

## LIST OF PUBLICATION

1. "Learning Analytics Contribution in Education and Child Development: A Review on Learning Analytics ", International Journal of Assessment and Evaluation in Education , Vol 8, Dec 2018 (36-47), ISSN 2 232-1926 / eISSN 2600 -870X.
2. "Educational Game for Learning Skills in Creative and Logic Development on Children Aged Three Years ", International Journal of Advanced Research in Technology and Innovation, Vol. 1, No. 3, 12-20, 2019, e-ISSN: 2682 -8324.
3. "LACLOD: Learning Analytics for Children's Logic Development ", The International Journal of Multimedia & Its Applications (IJMA), Vol.13, No. 1/2, April 2021.

# APPENDIX

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction



This chapter is an introduction to the research topic, the problem statement, and the research objectives. It also presents and describes the scope of the study as well as the experimental and technical aspects of the study. The background to the research is presented in Section 1.2. In section 1.3 the problem statement is presented, which forms the basis for the direction of the research. The research objectives are described in section 1.4. Section 1.5 is a discussion of the scope of the research, while section 1.6 is a provides a brief outline of how the final Dissertation gets structured. Finally, section 1.7 provides a summary of this chapter.

## 1.2 Research background

The Covid-19 pandemic has had a profound effect on the education sector throughout the country. The response to this event has created a challenge to innovate, necessitating extraordinary adjustments in all aspects of education. In response to the challenges posed by the pandemic, educational institutions and countries have implemented a range of innovative measures, including the introduction of new forms of learning, the integration of online courses, and the provision of teacher training. The increasing requirement for distance learning, the rapid adaptation to technology, and the focus on child welfare have emphasised the importance of flexible and resilient learning solutions. It is imperative that platforms continue to evolve in order to remain effective and useful tools in supporting children's learning during and after the pandemic.



There were early successes in the integration of interactive technologies into learning in initiatives such as that of (Roberts et al., 2016) prior to the COVID-19 pandemic. The application of learning analytics platforms to analysed children's interactions with mathematical materials showed great potential for understanding how children learn and develop in an educational context. This approach, focusing on children aged 2 to 8, demonstrates an awareness of the importance of starting interactive and engaging learning at an early age.

The use of interactive technologies, such as educational games and learning platforms, has long been recognised as an effective means of increasing children's engagement in learning. This approach not only makes learning more engaging but also

enables personalisation of the learning process, which can help customise the curriculum and learning experiences according to children's individual needs.

The study conducted by Morata et al. (2019) indicates that game-based learning analytics is an invaluable instrument for comprehending and fostering children's academic advancement. The utilisation of this technology enables the collection of more pertinent and comprehensive data on children's interactions with learning games. This, in turn, provides valuable insights for teachers, thereby facilitating more effective teaching and learning. The data generated by in-game learning analytics can demonstrate the specific skills that children are developing or that require further attention (Morata et al., 2019).

By adopting the approach outlined by (M. A. Chatti et al., 2012) this research can make a valuable contribution to the field of game-based learning and learning analytics, with a particular focus on the collection, measurement, analysis and reporting of data on children's interactions with interactive learning platforms. The learning analytics process, as outlined by (Bodily & Verbert, 2017), can be divided into several important stages, including data collection, analysis and intervention, and post-processing. The initial stage of the learning analytics process is data collection and pre-processing. This involves recording user activities from interactions with the platform, after which the data is normalised and transformed for analysis. The process of data analysis and intervention involves the identification of patterns through the application of statistical techniques, machine learning, or analytical algorithms to the pre-processed data. Post-processing is the evaluation of analysis and intervention results for the purpose of continuous improvement, as depicted in Figure 1.1. By following these

stages, learning analytics can make a significant contribution to the improvement of children's learning processes, thereby enabling teachers and decision-makers to design developmental and effective learning (Siemens & Baker, 2012). The role of teachers and parents in the management of the educational changes brought about by interactive technologies is of crucial importance. They have an important role to play in ensuring that these developments proceed smoothly and that they provide the maximum possible advantages for children (Ansari & Purtell, 2017; Hu et al., 2017)

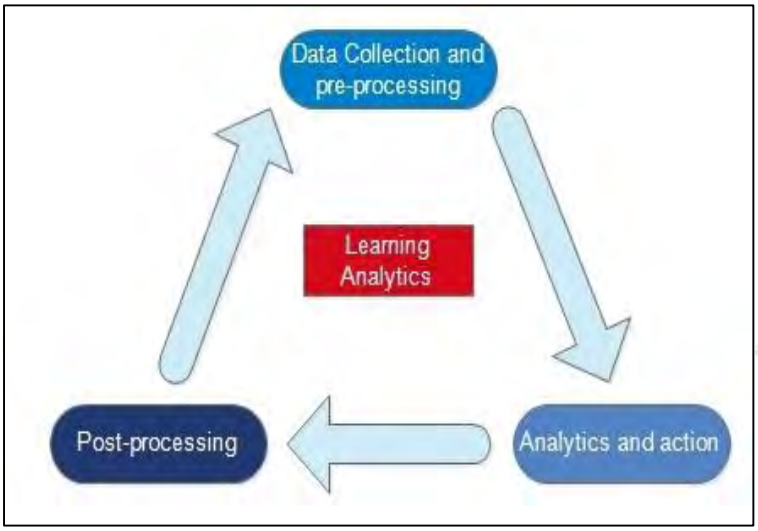


*Figure 1.1.* Learning Analytics Process (Bodily & Verbert, 2017)

Technology education is very important for children between the ages of three and four, as this is a critical early period in children's development. During this period, children are highly receptive to information and can absorb knowledge at a rapid pace (Hinostroza et al., 2013). The use of technology, including smartphones, by children between the ages of two and five years is amazing. According to a study by (Roskos et al., 2017), children in this age group continue to develop their fine motor, cognitive, and creative skills, which allow them to interact with technological devices at a high

level of proficiency. The ability to swipe, tap and use smartphone touchscreens, for example, helps with fine motor development.

The approaches and systems in place for early childhood education in Malaysia and Indonesia highlight the importance of paying special attention to this crucial period in a child's development. In Malaysia, there is a framework, PERMATA Negara, for the learning of children under the age of four, reinforced by national standards. The education centres that work with children under the age of four are known as TASKA. This approach allows for the implementation of a consistent set of standards and a structured curriculum to support children's development at an early age.

In Indonesia, a similar framework is provided by MERDEKA PAUD, which sets national standards for the education of children under the age of the four years. Educational centres that provide services to children under the age of four are known as PAUD (Pendidikan Anak Usia Dini). The purpose of the programme is to provide good and equitable education for children in this age group. They are particularly vulnerable to environmental influences and require special attention in their development.

The two countries have a structured and clear approach to the support of early childhood development through a standardised national curriculum. The focus on the education of children aged four and under highlights the importance of this period in the development of cognitive skills. As such, the effort to provide good quality, standardised educational services at an early age are a very important step in the development of education in both countries.

Developed by the National Child Development Research Centre (NCDRC) at the Universiti Pendidikan Sultan Idris (UPSI) in Malaysia, the National Child Data Centre (NCDC) plays an important part in providing integrated data on children's education. Offering a holistic picture of child development in Malaysia, the NCDC has a varied and comprehensive set of data. As a result, the NCDC is a very important resource for stakeholders to obtain detailed insights into the development of children and to be able to make more informed and better-informed decisions.

The PAUD programme in Indonesia is playing a key role in helping to build a strong foundation for children to develop from a very young age. Focusing on the importance of quality education, individual attention, a developmental approach and collaboration with parents and communities, the programme aims to create a supportive environment for the optimal growth and learning of Indonesia's children.

In this regard, the development of Game-based Learning Analytics (GBLAP) for children aged 3-4 at TASKA PERMATA UPSI, NCDRC in Malaysia and Manhajul Husna Early Childhood Education (PAUD) in South Kalimantan, Indonesia serves to illustrate the significance of integrating technology in early childhood education. This research demonstrates the potential of GBLAP to foster creativity and logical thinking in children at this age. Creativity development through GBLAP is designed to stimulate and develop children's creativity from the age of three years old. The decision to focus on the 3-4 age group for research on game-based learning analytics platforms is based on a number of well-founded considerations related to the developmental stage of children at this age. This phase of development is of great consequence for the establishment of the fundamentals of cognitive, social, emotional and creative skills.

By focusing research on this age group, it is hoped that the positive impact of game-based learning platforms will be maximised, developmental barriers will be detected and addressed at an early stage, and valuable insights will be provided for educators and parents in supporting children's holistic growth.

Games can serve as an engaging tool for children to engage in creative thinking, imagination, and self-expression (Hui et al., 2014; Malaeb et al., 2015; Neumann, 2018a; Siddoo et al., 2016). In addition to fostering creativity, activities in specially designed games also aim to stimulate children's logic skills. These games can include activities that require problem solving, critical thinking, and abstract thinking skills in an age-appropriate setting (Fraassen, 2011). By developing creativity and logic skills through GBLAP, new opportunities may be created to support the building of these important foundations at an early stage of development.



## 1.3 Research Problem

Early childhood education faces significant challenges in measuring and developing children's creativity and logic. At 3-4 years old, children are at a critical stage of development when their brains are highly receptive to new information. Often referred to as the sensitive period, this is an ideal time to introduce educational technologies that can support their cognitive development (Hinostroza et al., 2013). This period of development is characterised by an increased capacity to absorb a wide variety of information, including technological information (Mertala, 2019). It is often the conclusion of researchers that traditional assessment methods are ineffective in

providing deep insights into individual progress (Quansah, 2018). This presents a challenge for educators attempting to provide timely and appropriate interventions. In light of these challenges, it is imperative to explore novel approaches to assessment and teaching methodologies. Consequently, it is imperative to implement effective assessment strategies to enhance the accuracy of assessment and facilitate a more personalised and engaging learning experience.

The Game-based Learning Analytics Platform offers a potential solution by utilising game interaction data to gather deep insights into children's learning. The subsequent question then becomes how learning analytics can be effectively integrated with game elements in order to provide useful insights for curriculum development and learning methods. As Learning Analytics and Games (Morata et al., 2019) demonstrate, the utilisation of these two fields offers advantages in the acquisition of data from children's engagement with games. This is achieved through the provision of real-time information, which facilitates more effective assessment by educators. Such in-game assessments provide evidence-based data on children's knowledge, as cited by Cariaga and Feria (2016) and Tlili, Essalmi, Jemni, and Kinshuk (2017). The Games-based Learning Analytics methodology enables more effective assessment of early childhood development by utilising data generated from interactions with educational games. The data generated from educational games can provide valuable insights into various aspects of children's development, including cognitive, motor and social skills. The application of game-based learning analytics can optimise the utilisation of educational games in the classroom. This has the potential to alleviate the burden on teachers (Emerson et al., 2020). This approach enables the use of game-based learning analytics

to overcome challenges in childhood developmental assessment, and provides data that can be used to improve teaching methods and learning outcomes.

## 1.4 Research Objective

The research's main objective is to develop a game-based learning analysis (GBLAP) that focuses on the development of creativity and logic in children between the ages of 3-4 years old. A number of objectives have been identified in order to achieve the main objective, which are as follows:

1. To investigate the factors that 'Do Not Achieve' the development of creativity and logic in children 3-4 years old.
2. To identify the elements and attributes used in educational games and the process of evaluation of the development of creativity and logic on the basis of objective 1.
3. To develop a Game-Based Learning Analytics Platform (GBLAP) with a focus on creativity and logic development based on objectives 1 and 2.
4. To conduct a usability study of the Game-Based Learning Analytics Platform (GBLAP) through using the System Usability Scale (SUS).
5. To validate and evaluate the Game Based Learning Analytics Platform (GBLAP), which has been constructed for creativity and logic development.

## 1.5 Research Question

The questions to be asked in objective research are the following:

1. What are the factors that are 'Do Not Achieve' the development of creativity and logic in children aged 3-4 years?
2. What elements and attributes are always used in the evaluation process of creativity and logic development, especially in educational games?
3. How to develop a Game-Based Learning Analytics Platform (GBLAP) with a focus on creativity and logic development?
4. How to evaluate the usability study of Game-Based Learning Analytics Platform (GBLAP) using System Usability Scale (SUS)?
5. How to validate and evaluate the Game Based Learning Analytics Platform (GBLAP)?



## 1.6 Research Scope

This study focuses on the development of game-based learning analytics to develop and improve educational methods that focus on the use of educational games and children's interaction data to improve the teaching of creativity and logic development. The children in this study are between the ages of 3 and 4. It is important to select children at the age of 3 to 4 years because this is their early developmental period, which is a critical period in the formation of the foundations of child development (Hinostroza et al., 2013).

Children in this age group have a high level of information intake from different types of information, including technology (Lehto et al., 2012). The development of creativity and logic in children between the ages of 3 and 4 years is a significant process in the formation of developmental foundations (Fraassen, 2011; Mumford & Gustafson, 1988). An environment that pays attention to the development of creativity and logic in children at this age can contribute significantly to the optimisation of skill development and help them become more flexible and creative learners in the future (C. H. Yoon, 2017). The limitations of this study, therefore, are the development of a game-based learning analytics platform for the assessment of the development of creativity and logic in children between the ages of 3 and 4 years.

The platform provides a powerful tool for teachers, parents and the children themselves to support the development of skills and provide the required support for children who need extra help in their learning process. This framework provides a strong foundation for the various people involved in the learning process of 3-4year-olds. It also gives clear direction and enables early years professionals and others to support children's development at a critical stage.

## 1.7 Research Organization

The research is divided into five sections. which are briefly summarised in the following section:

CHAPTER 1 INTRODUCTION

This chapter provides an overview of the background to the study, the research questions, the research objectives and the scope of the study.

CHAPTER 2 LITERATURE REVIEW

This chapter discusses the development of creativity and logic in children between the ages of 3 and 4. It also reviews the literature on game-based learning analysis. A brief description is also given of the PERMATA curriculum and the MERDEKA PAUD curriculum, which are used as a basis for learning for 3–4-year-olds.

CHAPTER 3 RESEARCH METHODOLOGY

This chapter provides a comprehensive explanation of the research methodology, which consists of several stages: preliminary study, identification, development, and validation and evaluation. Each stage has one or more research objectives and is in response to one or more research questions.

CHAPTER 4 RESULT AND DISCUSSION

This chapter presents the results and discussion of the research conducted using the proposed method for the development of a game-based learning analytics platform. The chapter is divided into eight sections for discussion.

CHAPTER 5 DISCUSSION AND FUTURE RESEARCH

Finally, in this chapter, the conclusions and the contributions of the study are presented. Suggestions for future research areas are also provided.

## 1.8 Chapter Summary

This chapter presents the background to the development of a game-based learning analytics platform for the assessment of the development of creativity and logic in children between the ages of 3 and 4 years. The statement of the problem, the objectives of the research, the scope and the limitations of the research are presented. The final part of this chapter provides an overview of the other chapters of this thesis.