

# Game Development to Train Critical Thinking in Science Subjects using Model of Digital Game Based Learning-Instructional Design

Handoko Supeno, Mellia Liyanthy, Eri Herlin Nurul Huda

**Abstract:** *Critical thinking ability is one of the important things that needs to be developed because using critical thinking human can to evaluate arguments, and determine acceptance based on the evaluation. As we improve our critical thinking skills, we can improve our problem-solving and thinking skills. Games can generate excitement and excitement while learning, gaming offers solutions for the educational environment. Evidently, there are studies that show that the use of computer games in students can improve critical thinking skills. Therefore, a critical thinking game can be devised to help solve the above problems. Critical thinking games are built using the Digital Game Based Learning - Instructional Design method, paradigm that uses computer games as a way to deliver learning content and utilize gamification to attract end users and engage them to understand the intended content. Design of Digital Game-Based Learning consists of several stages that must be carried out, including analysis, design, development, quality assurance, implementation, and evaluation. This critical thinking training game is named Lulu's Friend. Lulu's Friend game only implements 3 critical thinking skills, namely interpretation, analysis, and conclusions. The content of learning material in Lulu's Friend game is derived from IPA 4th grade science syllabus. So this game consists of 3 stages, namely the stage of animal food, animal life cycle stage, and stage care to animals.*

**Keywords:** *Critical thinking; Elementary school; Science lesson; Education Game; Game Development*

## I. INTRODUCTION

There are various external challenges faced by the world of education, particularly those related to future challenges and capabilities required. Future challenges include globalization, environmental issues, the economy, and others. To be able to face the challenges of the future, it is necessary that people are able to think critically. Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action [HOW15]. This critical thinking ability is one of the important things that need to be developed because critical thinking ability will be an important foundation in life that determines one's success in the future.

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Handoko Supeno, Pasundan University, Indonesia  
Mellia Liyanthy, Pasundan University, Indonesia  
Eri Herlin Nurul Huda, Pasundan University, Indonesia

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As stated in the Ministry of National Education regulation No. 58 of 2009 that children's development in the aspect of cognitive development for children aged 5-6 years in achieving child development is they can predict causes (knowledge). Predicting causation means one demonstration of children's thinking skills that will produce critical thinking in its development. So that children from 5-6 years old can be taught critical thinking skills. According to Boyle (1997), games can involve feeling happy and enthusiastic while learning so that it can be stated that the game offers a strong format for the educational environment. Digital Game-Based Learning Design Learning has the role of generating the application of computer game characteristics to interesting and in-depth learning experiences to provide learning objectives, results and appropriate learning experiences[ZIN09]. Educational games transform education, including changing the way learning through game mechanics, how learning materials are delivered, how the learning progress is evaluated, and the potential for learning in groups [DIC15].

## II. LITERATURE REVIEW

### Digital Game Based Learning-Instructional Design Model

Digital Game Based Learning-Instructional Design (DGBL-ID) model is the development stage of the game software for educational purposes adopted from the ADDIE model. DGBL-ID consists of analysis, design, development, QA, implementation and evaluation. Stage analysis includes the process of determining learning objectives, learning analysis, and problem and needs analysis. Problems faced by students in learning and readiness of students for learning based on digital games are analyzed through interviews and questionnaires.

Students' characteristics, such as student learning styles and their existing knowledge, are also analysed.



The Design stage is the determination of teaching methods and strategies to be used in educational games. DGBL-ID divides the design phase into two parts:

**Instructional design**

The instructional design stage is the stage where the introductory method and instructional strategy is determined so as to obtain the expected result. In making instructional design in educational games it is necessary to determine 4 main aspects of instructional instruction, i.e. general instructional objectives, special instructional objectives, materials, and learning methods. This instructional design refers to the learning objectives resulting from the analysis of learning objectives.

**Game design**

It is a stage where game elements such as storyboard, character, art design, multimedia elements, design level, scoring, control system, interface design, and asset list are specified. Meanwhile, in the prototype development stage, the game is created by considering various techniques and types of existing technology. The type of technology is in the form of software that supports in game development. Selection of the right game engine can save time and facilitate the development in this stage of development. There are 3 stages of development in the educational game, they are:

- Development of lesson plans
- Development of learning resources
- Development of game prototype

Besides DGBL-ID researchers have offered several concepts of game development, such as GDLC (Game Development Life Cycle), GDSE (Game Development Software Engineering), EGD (Extreme Game Development), etc.

However, DGBL-ID is the most suitable method for the construction of educational games based on curriculum because at the stage of Instructional Design there is an integration process between the concept of the game and the material being taught.

**Critical thinking**

Critical thinking is a purposeful thinking activity (proving a thing, interpreting the meaning of a thing, solving a problem). Critical thinking implies a process of judgment or decision-making which is full of consideration and is carried out independently. It is the process of formulating reasons and considerations regarding facts, circumstances, concepts, methods and criteria. Richard Paul defines critical thinking as the process of formulating active and skillful reasons from conceptualizing, applying, evaluating analytical information, integrating through synthesis, process or observation, experience, reflection, reasoning or communication as a basis in determining the action [FAC13]. Critical thinking has some core skills, they are:

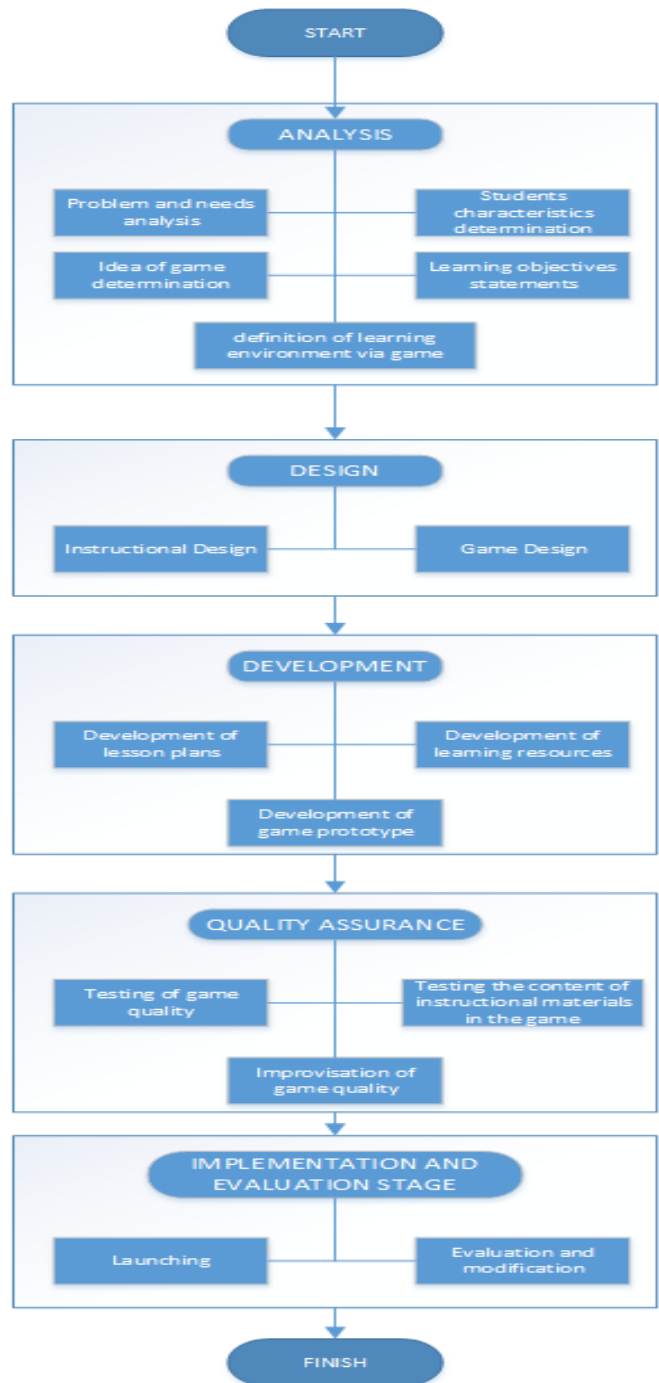
**Interpretation**

To understand and express the meaning of different experiences, situations, data, events, considerations, agreements, beliefs, rules, procedures, or criteria.

Subcategories included in this skill are categorization, meaning interpretation, and clarification of understanding.

**Analysis**

To identify the intended and actual infernal relations between statements, questions, concepts, descriptions, or other forms of representation intended to express trust, consideration, experience, reason, information, or opinion. Subcategories included in this skill are testing ideas, identifying arguments, identifying reasons and statements.



**Fig. 1 Digital Game Based Learning-Instructional Design Model**



## Conclusions

To identify and ensure the elements needed to illustrate a reasonable conclusion, to establish the allegations and hypotheses, to consider the relevant information and to decide the consequences of following the data, statements, principles, evidence, considerations, beliefs, opinions, concepts, descriptions, questions, or other form of representation. Subcategories included in this skill include: Proof of statement, alleged alternative, drawing conclusions, using inductive or deductive thinking

## Evaluation

To assess the credibility of a statement or other representation where the account or description of one's perceptions, experiences, situations, judgment, beliefs, or opinions; also, to assess the power of logic on the inferential relations between statement, description, question or other form of representation. Subcategories included in this skill are assessing the credibility of a statement, and assessing the quality of arguments made using inductive or deductive thinking.

## Explanation

To declare and justify that thoughts in terms of proof, conceptual, methodological, and contextual considerations which are based on one's outcome and to present one thought in the form of a strong argument. Subcategories included in this skill are result of statement, procedure justification, argument presentation.

## Self-Management

Self-awareness to monitor one's cognitive activities, the elements used in the activity, and outcomes decision, especially by applying skills in analysis, and evaluating owned inferential considerations with views towards questions, confirming, validating, or refining other thoughts or results. Sub-skills included in this skill are self-monitoring, self-justification.

## III. ANALYSIS AND DESIGN

The characteristics of the audience, the concepts used in game development, the functional requirements of the game, to kakas are explained by the analysis map. The analytics map is used to facilitate the description of the analysis stages and to utilize the content or components performed in the manufacture of the application. There is an input, analysis process, and output based on the content obtained from a number of libraries or analyzes as the argumentation of game development trains critical thinking. Here is a picture of the analysis map along with the explanation

### Concept Analysis

Concept analysis is done to find out the basic concepts that are used in this critical thinking exercise game. So the game is expected to help in solving problems that arise. In concept analysis there are syllabus and critical thinking theory which become object of analysis. The syllabus is used to refer to the design level, whereas critical thinking theories are used as a reference for any critical thinking

skills to be applied to this critical thinking exercise game. As regulated in regulation of Ministry of National Education no 58 of 2009 that the development of children in the aspect of cognitive development for children aged 5-6 years i.e. in the achievement of the child is able to predict cause and effect (science). Therefore science subjects are chosen as the material to be used for the construction of this game. Science Syllabus grade 4 of Primary School is used as an idea of game development so that the material used comes from direct teaching staff so that its reliability can be trusted.

### Functional Analysis

Functional analysis aims to find out the functionality required in the game to achieve the goal of developing this critical thinking game. In functional analysis there are 2 object analyses: game reference and Digital Game Based Learning-Instructional Design.

### Game Concepts

Game concept is used in this research to be a reference when designing game for instructional design and game design have suitability, and game balancing to final product in accordance with initial purpose of game development. Parrish [PAR09] provide principles for the design of learning:

Principle 1: Learning experiences have beginnings, middles and endings.

Principle 2: Learners are the protagonists of their own learning experiences.

Principle 3: Learning activity, not subject matter, establishes the theme of instruction

Principle 4: Context contributes to immersion in the instructional situation

Principle 5: Instructors and instructional designers are authors, supporting characters and model protagonists

Brown divide the type of knowledge into 3 types. Declarative Knowledge relating facts, data, concepts, and principles. Procedural Knowledge consists of knowledge to perform a task, action, and process. Strategic Knowledge is the basic problem-solving, that is understanding of how to apply knowledge, principles, and experiences to various situations. Metacognitive Knowledge consists of reflection and regulation of one's thinking during an activity.

### Digital Game Based Learning-Instructional Design Concept

The Digital Game Based Learning-Instructional Design concept is used for the entire development process, including analysis, design, development, and quality assurance. The concept of games, the concept of Digital Game Based Learning-Instructional Design, and basic concepts that have been analyzed previously become a reference in determining the functionality of the game. Here, the function of the game is to train critical thinking.

Game is able to train user interpretation skills by categorizing animals based on food type and life cycle, and able to clarify the definition of food type and animal life cycle.



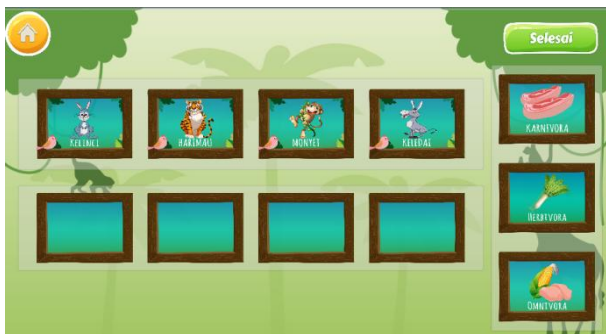
Game is able to train the user's ability in analyzing by identifying arguments and identifying reasons and revelation when studying the types of food and animal life cycle, as well as animals caring

Game is able to train the user's ability in making conclusions by proving revelation and drawing conclusions using inductive or deductive thinking while studying the types of food and animal life cycle, as well as animals caring.

**IV. RESULT**

Lulu's Friend game implements critical core skills consisting of 3 skills, namely interpretation, analysis, and conclusions.

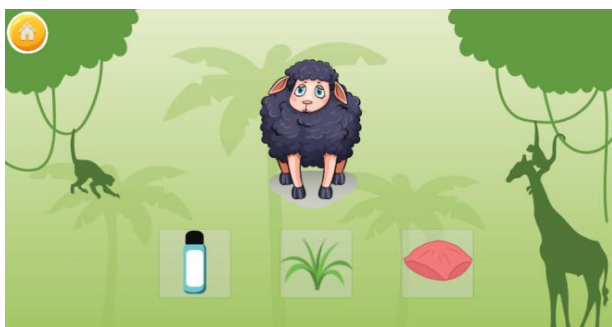
No	Skill	Implementation
1	Interpretation	Deciding Type of food
2	Analysis	Animal Lifestyle for teach analysis
3	Conclusions	Animal Grooming Game for teach conclusion



**Fig. 2 Deciding Type of food for teach interpretation**



**Fig. 3 Animal Lifestyle for teach analysis**



**Fig. 4 Animal Grooming Game for teach conclusion**

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