# Development of Multiple Intelligence Based Interactive Ebook to Improve Critical Thinking Ability and Cognitive Learning Outcomes on an Excretory System

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**Abstract:** This research aims to produce a feasible interactive ebook based on multiple intelligence for 11th-grade students of Senior high school, determine the effectiveness of an interactive ebook based on multiple intelligence on excretion system to improve the critical thinking ability of 11th-grade students of Senior High School, determine the effectiveness of interactive ebook based multiple intelligence on excretion system to improve cognitive learning outcomes of 11th-grade students of Senior High School. The multiple intelligence-based interactive ebooks are designed by Flip PDF Corporate application with html5 output converted to the android application by web2apk. The method used for this development was research and development (R&D) with the 4D (Define, Design, Develop and Disseminate) research model. The sampling method for the study was conducted random sampling. Method using one experiment class and one control class. This research in SMA Negeri 1 Ngemplak. Data Collection Techniques were using interviews, visionary, pre-test, and post-test. Ebook validation was carried out by material and media validators. The data analysis technique used a quasi-experimental non-equivalent control group design with the multivariate test by IBM SPSS 24. The ebook has validation and got 92,6% from the biology teacher, that is mean the ebook is valid and possible to use in biology learning. The Effect size shows 0.290 for critical thinking and 0.159 for cognitive learning outcomes, which means ebook has a high effect on both abilities.

**Keywords:** Multiple Intelligence; Excretory system; SMAN 1 Ngemplak

## Introduction

Fun learning requires stimulation from educators. Stimuli or stimuli such as audio, visual, and current issues can establish curiosity while increasing learning motivation and ability. This statement regards the opinion of Rumainur (2016), that it is crucial to apply media that can invite attention so that students become proactive in learning progress. Things have not reached 4C skills in 21st century can be caused by some factors. The most important is the media that is used in the learning process. Learning media is give information as a bridge between teachers and students. Previous century learning emphasized literacy in reading,

writing, and mathematics, in which in the 21st century the three of them were used as basic capital to develop new literacy, namely human, data and technology literacy which is very important to face the current and future era of globalization (Sawitri et al., 2021). According to (Pratiwi & Rini, 2018), learning media is one of the external factors which give affection to students' achievement. Role of media as equipment that helps teachers to finish their mission as facilitators. It is accepted by Nurohma in (Intaliana, 2020) that learning media used by teachers have high affection for motivation and student learning outcomes. For students, the learning process gave them many interesting

experiences, stimulated their curiosity, and student processes thinking.

An interactive e-book is one of the media that contains digital information network units consisting of text, graphics, video, animation or sound, and questions which are all packaged in the form of flash animation visualizations combined in one program and equipped with color, sound, and music. This media is developed relate to everyday life. An e-book is constructed easily for students. After all, they can be accessed wherever and anytime they want because they can save in emails, smartphones, and computers (Mukminin, 2021). The ebook is an alternative learning resource for students to help them understand the concept of the current material because it is presented in a detailed material coverage accompanied by colorful pictures and equipped with videos that can increase student understanding (Muamar et al., 2021). Instead, the ebook is downloaded on each student's gadget. The duration of the study was on school semester. The result revealed that using the e-book on students' gadgets was a successful way of teaching method (Al-Mashaqbeh & Al Shurman, 2015) especially if the interactive ebook can integrate with any model, methods, and approach to increasing abilities, skills, and intelligence, so it could be an excellent combination to set up better learning. The ebook can be integrated by the learning strategy that is adapted from theory increase the student's intelligence as well.

The first advantage of the e-book is without the use of paper. This is accepted by Government Regulation No. 66 of 2014 concerning environmental health and Law No. 32 of 2009 concerning environmental protection and management to reduce paper use and switch to digital media. Second, it provides action and reaction to students as an interactive medium. Third, accessing devices (gadgets) or smartphones owned by students or PCs provided at schools to read an e-book. Fourth, the menu is linked with a hyperlink so students can go directly to the page they want. It is better if the various media developed are implemented with the right strategies, methods, and models in conveying learning material. Howard Gardner introduced the theory of learning strategy, namely multiple intelligence.

Multiple intelligence is a learner's learning style that includes eight intellectual bits of intelligence called linguistic, audio-spatial, kinesthetic, interpersonal, intrapersonal, logical-mathematical, naturalist, and musical. This agrees with Gardner that the theory of the eight intellectual bits of intelligence is based on the idea that the intellectual abilities measured through the IQ test are limited because the IQ test only emphasizes the ability of logical mathematics and language. The theory of multiple Intelligence provides a useful perspective on the classic problem of education. New perspectives on memory showed that students with "bad memory" may have a bad memory in one or two intelligence. However, everyone has a unique way of solving the problems they face. According to (Kristanto, 2017) intelligence is not only seen from the value one gets. Intelligence is the ability possessed by someone to see a problem, then solve the problem or create an idea or solution that can be useful for others. The intelligence of each student needs to be facilitated by educators. Learning strategy based on multiple intelligence theory can involve all potential that own by students and improve academic potential by being optimal (Kristanto, 2017). Armstrong in (Diana & Paidi, 2019) said that give a test could help students retain what they have learned, it seems to be one of the most pressing education issues unresolved.

Therefore, teachers need to integrate various kinds of multiple intelligence skills in each learning activity so that students can compete in the modernization era of the 21st century (Adi, 2016). Each teacher is a compilation of individuals and professionals where professionalism can be the first step in maintaining and improving competence. As a teacher, learning from students and study groups is also vital. Learning and teaching become an interactive place between teachers, students, and whatever the learning material is (Moyles, 2017: 4). The modern era that coexists with this pandemic, allows all current needs to be fulfilled easily using technology and the competencies they have.

This pandemic has had an impact on the education system in Indonesia, where learning activities become online learning. It is difficult to see the growth of students' abilities to reach out while the motivation and learning outcomes of students decrease. This is consistent with the problem raised by Sawitri et al. (2021) that the problems encountered are first, learning is very theoretical and mechanistic. Second, schools have not done enough structuring in the learning environment. Third, students have difficulties learning in certain fields.

According to industrial era 4.0, the younger generation is trained to develop to become competent in their respective fields of expertise to bring a future to the nation and state. Therefore, students must have skills in the 21st century called 4C, namely Communication, Collaboration, Critical thinking skills, and Creative Skills. As educators, must be able to achieve the students' capabilities of this century. This is in line with the objective of the Government of the Republic of Indonesia to educate the entire citizen. One of the actions to educate the nation's life is to improve critical thinking skills and cognitive learning outcomes, especially for students. These two abilities are suggested by Erdem (2020: 9) to develop students' potential. Many schools and institutions persuade new skills to this generation for educational purposes. It means students must

practical underdeveloped skills to grow (Thornhill-Miller et al., 2023).

Cognitive learning outcomes are the results that students are receiving stimuli, storing information, and solve problems. Cognitive aspects based on Bloom's taxonomy consist of six categories of cognitive process dimensions namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and synthesizing (C5) (Muzenmaier & Rubin, 2013; Anderson & Krathwohl, 2014). The demands of the current curriculum expect students to have cognitive skills, and abilities in the real world, have a noble character, and be more active in the learning activity. In learning, the teachers as the main source of knowledge will learn from real problems and be student-oriented so that students can construct their knowledge and seek information actively (Insyasiska et al., 2015). Whereas, Cognitive is a factor that affects creativity quality (Yin et al., 2023) and basic abilities needed to continue high-level abilities, namely critical thinking skills.

Critical thinking skills are abilities that involve analysis and rigor. This ability exists in all students but hasn't been evolving and properly directed. According to Ariyati (2010), based on observations in learning activities, students must memorize and hoard information, less motivated to develop their thinking skills. Therefore, students are capable theoretically but lacking in terms of application. This resulted in critical thinking skills hard to observe progress.

Concerning meeting learning objectives, the main task of a teacher is to increase student learning motivation so that the activity will run effectively (Edma, 2017). Based on the opinion of the biology teacher, cognitive learning outcomes for the criteria of understanding, explaining, analyzing, applying, and evaluating are still low. There was a learning transition process after the pandemic in Yogyakarta. Based on the results of the preliminary test by conducting tests on class XI students of SMA Negeri 1 Ngemplak, it found that critical thinking skills were lacking at 60%. Based on these data, it is urgent to improve critical thinking skills and cognitive learning outcomes to support and develop the intellectual potential that students already have.

Based on the preliminary study, the obstacles to not achieving 4C abilities in the 21st century are caused by several factors, namely short learning time and fewer types of media, so certain learning objectives have not been reached. Therefore, schools need various learning media that contain essential material that is easy and concise to understand to improve students' critical thinking skills and cognitive learning outcomes. One of the designed media is the e-book. Students admit that they have never studied with e-book media from the teacher. Based on this background, the authors conducted research Development of an interactive e-book based on multiple intelligences to Improve Critical Thinking Ability and Cognitive Learning Outcomes on Excretory System.

## Method

### Validated by education experts and teacher

This phase did in two steps, the first step is validated by education experts, and the second step is by a biology teacher. The validation instrument used a Likert scale with 1-4 that accumulated by the formula below. The score should compare to table 1 to determine which suitable categorize from the score.

$$Score = \frac{Average\ score\ per\ aspect}{score\ maximum} x\ 100\% \qquad (1)$$

**Table 1.** Ebook Feasiblity Category

| Percentage (%) | Feasiblity Category |
|---|---|
| 81%-100% | Very Feasible |
| 61%-80% | Feasible |
| 41%-60% | Feasible enough |
| 21%-40% | Less Feasible |
| 0%-20% | No Feasible |

Source: (Nasrudin et al., 2018)

### Practicality Test

The practicality test did by Likert scale questionnaire filled out by the students. This questionnaire consists of 25 points questions. It filled would be converted from qualitative converted to scores based on the table 2.

$$Practicality\ Score = \frac{Average\ score\ per\ aspect}{score\ maximum} x\ 100\% \qquad (2)$$

**Table 2.** Ebook Practicality Category

| Criteria | Percentage (%) |
|---|---|
| Practical | 0%-20% |
| Less Practical | 21%-40% |
| Enough Practical | 41%-60% |
| Practical | 61%-80% |
| Very Practical | 81%-100% |

Source: Riduan in (Sofa & Indana, 2022)

### Multivariate Test

The Research was done and the data was processed by IBM SPSS 24 to analyze multivariate/Manova to know the differences between both classes

### Effect Size/Partial Eta Squared

**Table 3.** Category Number of Effect Size

| Partial Eta Squared | Category |
|---|---|
| x > 0.138 | High |
| 0.60<x <0.138 | Medium |
| 0.01<x<0.60 | Low |

## Result and Discussion

The first step in 4D of this research is to define. Define phases are front-end analysis, students analysis, task analysis, concept analysis, and determining of learning purpose. This phase did to adjusted the development of an ebook that is suitable to students and school learning characteristics. The second phase is design and development. This phase is the process of making the interactive ebook and other complements in the ebook. the ebook through many repairs after getting validated by education experts and reviewed by a biology teacher. An ebook based on *multiple intelligence* of the excretion system, mainly the renal structure and function, formation mechanisms of urine, renal disorder, and factors that affect the formation process of urine. The ebook was developed with a flipbook feature which is accessed online by phone or PC/computer. The ebook has to be installed on Android phones as an application. this ebook has many features. There are using instruction of ebook, an excretion system, quiz, that provides the students with multiple intelligence, evaluation, and the "reminder thunder" button

As you see at figure 1 shows that three phases of feasibility first is done by education experts as validator. The results showed that content eligibility (A) is 63 %, language(B) is 63 %, graphics (C) is 75%, and presentation (D) is 63%. These numbers are categorized as feasible to use with revision terms. The author received and considered every criticism by the validator to repair the ebook to a better version.The second phase is a feasibility test by the biology teacher. An ebook review results showed a score of on the simplicity of use (A) is 96%, operational techniques(B) much as 98%, and accuracy of learning material (C) is showed 84 %. The average of all aspects 92.6% categorized as very feasible. So the ebook can be used as biology learning media on the excretion system.  The simplicity aspect (A) is 77.45 %, the operational technique (B) is 71.25 %, and the benefits (C) is 75.09% which are feasible to use. Students' impressions of this ebook are good. Students like ebook because of their various features that are very suitable for their interest and motivation to learn in class.
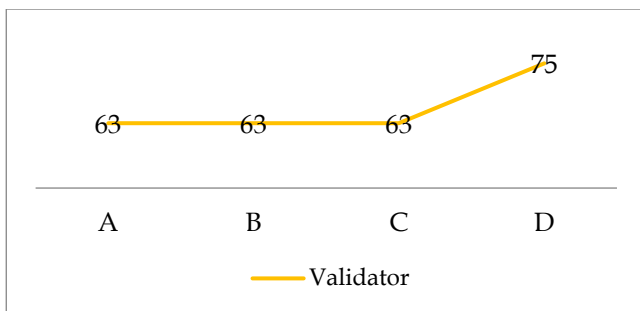


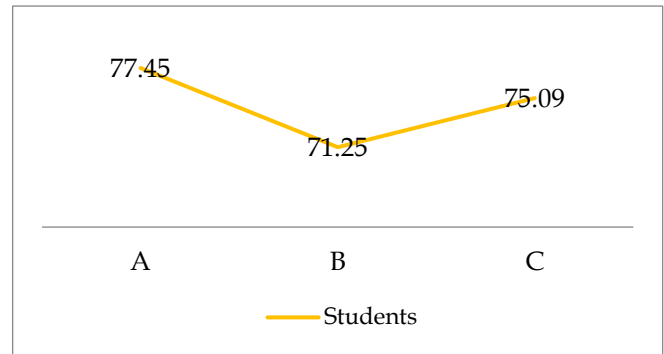**Figure 1.** Results of Feasibility by Validator



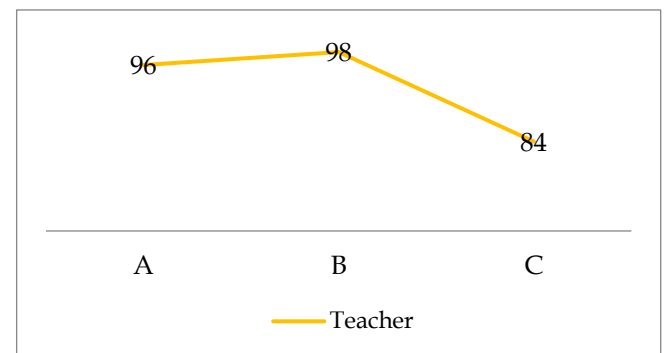**Figure 2.** Results of Feasibility by students



**Figure 3.** Results of Feasibility by teacher

Based on the table 4 shows that the data has normal distribution because the significant value is 0.6 and 0.12 higher than 0.05 and accepted the Ho, which means that the data has a normal distribution. The homogeny test shows that if the significant number is 0.636 higher than 0.05 then Ho is accepted, which means the data is homogenous. The Significant of a multivariate test is 0.003 less than 0.05, which means Ho is rejected. While the research applied, an ebook with multiple intelligence approach theory has an effect on critical thinking and cognitive learning outcomes.

**Table 4.** Hyphotesis test

| Test | Sig. | Description | Hypotesis |
|---|---|---|---|
| Normality Test | 0.6 | Normal | Ho Accepted |
|  | 0.12 | Normal | Ho Accepted |
| Homogenity Test | 0.636 | Homogeny | Ho Accepted |

Table 5 below shows that the Hotelling Trace showed 0.003 means less than 0.05 that Ho Rejected. So, there is a difference between both classes and the effect size that you can see as partial eta squared. This results sustainable with (Budi Santoso et al., 2018)  said that there are different  learning outcomes of using ebook and printed books. The ebook gives 0.449 as a high category of effect on critical thinking and cognitive learning.

**Table 5.** Effect Size

| Effect | | Sig. | Partial Eta Squared |
|---|---|---|---|
| Intercept | Pillai's Trace | .000 | .928 |
| | Wilks' Lambda | .000 | .928 |
| | Hotelling's Trace | .000 | .928 |
| | Roy's Largest Root | .000 | .928 |
| Class | Pillai's Trace | .003 | .449 |
| | Wilks' Lambda | .003 | .449 |
| | Hotelling's Trace | .003 | .449 |
| | Roy's Largest Root | .003 | .449 |

Each improvement is 0.290 for critical thinking and 0.159 for cognitive learning outcomes in table 6. These numbers made ebook influence learning strategy has impact to outcomes high effect of both skills that showed by table 6. This table explain that learning group without ebook only has low effect whether for Critical Thinking abilities (CT) and Cognitive Learning Outcomes (CLO) as much as 0.004 and 0.002. However, the experiments group that using the ebook for their biology learning.

**Table 6.** Effect Size of both Variable

| Source | Dependent | F | Sig | Partial Eta Squared |
|---|---|---|---|---|
| Non-ebook | CT | 917.359 | 0.000 | 0.004 |
| | CLO | 576.795 | 0.000 | 0.002 |
| Using *e-book* | CT | 12.486 | 0.001 | 0.290 |
| | CLO | 0.702 | 0.005 | 0.159 |

Most student in the experiment group has interpersonal intelligence with 38.9%. The rest of the group has 22,2% kinesthetic, each linguistic musical with 8.3%. The percentage of intelligence of visual-spatial shows 13.9%. This ebook is within eighth intelligence and indeed fulfills students' potential. Otherwise, the ebook provides the learning style of students who have one or more intelligence. These statements harmony with (Aljarabah & Mai, 2021) said that MI is a new method to support students' thinking and achievements on their future goals. It helps the sense of strengths and weaknesses in improving crucial educational areas. However, MI could provide a higher catch of the children's abilities and potential success. MI activities regain the students' motivation because of the positive interaction between learner and their classmates, otherwise between the learner, the learning material, and the teacher. MI theory is contrary to the usual way of learning that is less effective in enhancing the abilities of students intellectual.

It shows how MI effect student's outcomes. Another crucial element of this study is when analyzing the moderating variable and comparison models, it was found that intelligence determines that opponents with academic achievement are unidirectional. That is, intelligence is a good predictor of academic achievement, but not vice versa, so the predictive model of intelligence type explains 35% of the variance. Consistent with these results Buckle's research predicted a strength of 26% and found that intelligence is the best predictor of academic success. Academic performance is determined by variables including psychological factors that influence student response to overcome backward, data addressed intelligence as a carrier of success, but also, as this study shows, a positive mindset concerning someone's intelligence and academic ability. A good mindset would be formed in which their academic life takes place, such as friendship, heals, worth, and learning system. Meanwhile suggest ways to implement interventions to increase students' beliefs about their particular subject mastery skills. Research needs to expand the study to limit terms of intelligence (Lozano-Blasco et al., 2022).

The Impact of students' cognitive learning outcomes is the same as (Muamar et al., 2021) that e-books are said to be more effective if as many as 85% of students can achieve cognitive test results reaching KKM with a score of 80. This also shows that MI-based learning has a positive relationship and is directly proportional to cognitive learning outcomes (Arifin & Patahuddin, 2015). Cognitive ability is a stage in receiving information, so MI can assist students in flowing information to be accepted by students. There are nine bits of intelligence, and now there are ten multiple intelligences, then each intelligence has a role in the relationship in the order of neuroscience. This agrees with (Ghraibeh, 2012) that kinesthetic intelligence is embedded in the left hemisphere and is shown in individuals who are able to use gestures expressively. Musical intelligence refers to the right hemisphere of the brain and is the intelligence that first emerges at the age of 3. The right side of the brain is responsible for spatial and visual memory operations, while the left part of the brain supports verbal abilities. However, the maximum domination of intelligence in the human brain cannot be determined because there is no further research. Intelligence has a correlation with cognitive functions. The cognitive load of each potential solution is considered when choosing how to respond to a given situation. This implies that people who have the cognitive ability are more likely to choose the option associated with greater cognitive load because they recognize lying as an option they can implement easily (Wawer et al., 2023).

This ebook improves critical thinking effectively in harmony (Sofa & Indana, 2022) that the ebook MI train the critical thinking. This agrees with Mohsenishad and Hashamdar (2020) that critical thinkers are willing to think, explore, analyze, and think visionary. Multiple

intelligences have the advantage of targeting more students who seek different ways of learning and discipline. Each type of intelligence/intelligence only occurs in specific parts of the brain, therefore, with one or more modules/books that are specifically addressed, it is easier to enter the mental space in the brain. Different learning environments can access information and increase motivation. This MI is applied to ensure students can make connections between information.

MI which is dominant in interpersonal followed by intrapersonal and musical helps learning, supports students with an optimum learning environment through referred learning media, and helps reach the full potential of the talent department. MI can save students from developmental failures such as lack of confidence, feeling unable to learn, and social rejection which will later hinder the development of other potentials. MI needs to be given to students who have abilities that help in solving problems (Aljarabah & Mai, 2021). Ways of thinking and MI are related. Intellect depends on genes or early education or a combination of both. In this case, thinking is the ability to exercise intellectually through experience-based activities. Teaching thinking helps students discover how to use their multiple intelligences. Linguistic, kinesthetic, intrapersonal, interpersonal, logical-mathematical, and natural indirectly influence thinking patterns through critical thinking skills (Ahmed & Mai, 2021).

Cognitive learning outcomes have a positive and directly proportional relationship. It means that these two abilities are closely related, then if one of them highly increases, the other will also be high. It can be shown by the significant value of $0.000 < 0.05$, which means that there is a relationship with the Pearson coefficient of 0.299. According to (Youllanda et al., 2020), two variables have a relationship, which means that critical thinking skills can improve students' cognitive abilities. Every increase of one unit of critical thinking ability contributes 35.9% - 36.9% to cognitive learning outcomes. In this event, it means that if the cognitive learning outcomes are good, the analytical, evaluation and critical abilities will also be better. Because when individuals critically process information, it will involve complex mentality, higher-order thinking, formulating solutions, making decisions, and drawing conclusions (Nur Hayati, 2019). According to Guilford (Daruwati, 2020) thinking critically is a necessity puts forward intellectuality, and acts as a reinforcer in learning meanwhile including character and cognition. The core cognitive abilities in critical thinking are interpretation, analysis, evaluation, and inference. The relationship between critical thinking skills and learning outcomes is very closely related. A critical thinker can find and deal with problems both inside and outside of learning.

## Conclusion

The multiple intelligence-based interactive ebooks with a mean number of three phases are 80% that feasible to use in learning on the excretory system. Regarding the validity test, the ebook used in class gave a high number of 0.290 for critical thinking and 0.159 for cognitive learning outcomes on improving students' abilities.

### Author Contribution
This research article carried by three authors. Preface and method, Heru Nurcahyo; research, validation, data analysis, writing, Renny Septiana; review- writing and editing, Evy Yulianti. The authors have checked the draft and state for publish to any platform.

### Conflict of interest
In the progress, there is an issue with the design-development phase. Determine every variable and ensure indicators of instrument sustainability with development research. When focusing on media development, design the media that has never been applied before based on real-life education. Use the method and approach of both groups (experiment and control) to observe the effect of media. This interest to avoid the bias of the results.

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