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Digital 3D book and Ausubel theory: increasing the mathematical understanding in a linear system with two variable

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Abstract. The purpose of this study is to develop a valid and practical digital 3D books based on the mathematical understanding of a linear system with two variables. This study uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model. Data were collected through semi-structured interviews, practicality tests, and validity questionnaires. The research samples were nine students and five mathematicians. The results of this study indicate that the use of digital 3D books is valid with a percentage of 92% and practicality with a percentage of 91.67%. In short, 3D books can be used in the learning process on a linear system of material with two variables and are easy to use for students. Teachers can facilitate the use of 3D books in mathematics learning classes, and students can also use this independently in learning.

Keywords: 3D book, Ausubel's theory, mathematical understanding

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INTRODUCTION

Mathematics is one of the studies which supports the development of science and technology. Besides, mathematics is also a science which has specifically compared another science discipline that must focus on authentic mathematical and students' ability to study (Sundayana, 2016). One of the abilities that students' must be had on Permendiknas 2006 is to comprehend the mathematical concept, explain between the concepts of mathematics, and apply the concept of logarithm flexibly, accurately, efficiently, and appropriately in solving problem.

The ability of mathematical understanding is the strength that must be considered during the learning process, especially to get meaningful mathematics knowledge (Hendriana, 2017). Meaningful learning based on Ausubel is learning new process or information which is connected with the concepts and information that has been in the structure of students' cognitive. The learning process will run well if the students focus on conception. Therefore, new information can adapt to a cognitive structure. Moreover, learning can be more meaningful if the students have an understanding. The importance of having a comprehension for students is identified by Santrock (Hendriana, 2017) that comprehends the concept is the key to learning. Otherwise, mathematical understanding is an important basis for thinking in solving mathematical and real-life problems (Harisman, et al., 2018; Bakar et al., 2019; Hidayat, et al., 2019). If the students already have a good ability in mathematical understanding, then the learning process will be run well. Good mathematics learning is the learning that is supported by many factors; one of the factors is the appropriate teaching material. Sumantri (2015) explained that the material is the sources of learning in the form of concept, principle, definition, cluster or context, data or fact, process, value, ability, and skill.

Ahmadi and Amri (2014) stated that if various materials are provided, students will be interested in the learning process. Students will get many chances to learn individually and reduce dependence on teacher attendance. The appropriate material will help the students understand mathematics easily during the learning process. Based on the class observation, the material that used is not interesting and appropriate, and then students have less

understanding of Linear Systems with Two Variables (LSTV). Also, based on interview with one of the mathematics' teacher and some of eighth-grade students at junior high school in Indonesia clarified that the material used by teacher is a book from the government and various sources from other authors, while the teaching materials used by students is a printed teaching material from the government loaned to the school and not each student has it. They are teaching material that will be made in the material LSTV is expected to improve students' mathematical understanding abilities by using Ausubel learning theory that makes students associate new knowledge with existing concepts, which is expected to improve their mathematical understanding ability in the material LSTV. Besides that, the use of technology these days is very important for the learning process.

The development of science and technology requires teachers to use technology, especially computers, in learning. Technology-related research in learning has been done that show success (Pramuditya, Noto, & Syaefullah, 2018). Thus, digital teaching materials using 3D Page flip software are expected to be more interesting and increase student enthusiasm. With this digital teaching material designed, students are expected to be more enthusiastic in learning mathematics because various kinds of media can attract students' attention; students are expected to be more enthusiastic in learning mathematics because various kinds of media can attract students' attention. This was also done by Adjizah, Rozak, and Pramuditya (2019) those digital teaching materials on the material LSTV based on mathematical communication skills displaying several pictures, learning videos that contain problem-solving using methods that explained and integrated interactive tests that provide feedback following the answers given. Another research by Indariani, Ayni, Pramuditya, & Noto (2019) using 3D Professional page flip to increase mathematics ability which is done in seventh-grade students at Junior High School in Indonesia is suitable used for mathematic learning and develop mathematics ability is better with the students who did not get its material.

Maryam, Masykur & Andriani (2019) had a result mathematic e-book that open-ended in a linear system with two variable 8th grade who have implemented e-book did run well and students are more interested learning mathematic using an e-book, so the e-book is valid, practical and effective increase the students' learning result. Furthermore, research had done by Juneri, Rozak and Pramuditya (2019) the digital material that has a base communication ability will be tested for 15 students 9th grade Junior High School as five students who have high cognitive ability, five students who have medium cognitive ability and five students who have low cognitive ability get results that female students who have high cognitive lack of the interest of digital material than male students who have high cognitive ability. In conclusion, based on the research, the material development using 3D Books that had done is several research that has linear system with two variables that have not Ausubel theory and has not mathematical understanding.

According to Ausubel, students will learn well if instructional content is previously defined and then presented properly and appropriately to students (advance organizers) (Al Tamimi, 2017), students are directed to the material to be learned through related concepts (Kelada, 2008). This is in accordance with the 3D book which provides three kinds of benefits: (1) provides a conceptual framework for material to be studied digitally, (2) functions as a bridge that connects what is being studied and what will be studied digitally, (3) can help students to understand learning materials more easily. The presentation of 3D books is also related to the Ausubel theory which includes the elaboration of concepts which are stages of learning from general to specific; includes superordinate learning which is the learning phase of linking concepts that have been learned to a broader concept, and integrative adjustment which is a learning phase that links two or more concepts to build new concepts. Digital presentation of material (3D books) can provide a more meaningful understanding, especially on abstract concepts in mathematics learning. Based on the explanation above, the research question is how to design the digital 3D Book using Ausubel theory in linear system with two variables based on the ability of mathematical understanding valid and practical?

METHODS

This research use ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development models. According to Sugiyono (2017), R&D can be defined as researching, creating, producing, and testing product validity. The subjects in this study were eighth-grade students of Indonesian Junior High School. The data collection instruments in this study were test questions according to the ability of understanding indicators related to the material system of two-variable linear equations, interview guidelines given to students and mathematics teachers to determine the need for teaching materials so that the teaching materials were made under student character, curriculum and teaching materials at school. Then the teaching material validation sheet is used to measure how valid the teaching material has been made. The validation grid of teaching material is presented in the following table.

Table 1. *Digital teaching material validation grid*

Instrument	Aspect
Digital Teaching Material Validation Sheet	1. Relevance 2. Accuracy 3. Completeness of Serving 4. Conformity of the Presentation with Student-Centered Learning Demands 5. Linguistic 6. Ausubel Learning Theory 7. Mathematical Understanding Ability 8. Visual Communication Display 9. Software Utilization 10. Relevance

[Source: Modified from Akbar (2013) and Kemendiknas (2010)]

Besides, the practicality sheet of teaching materials is used to find out the practicality of teaching materials from user validation, i.e., students who have used teaching materials on the material system of two-variable linear equations using Ausubel learning theory. The practicality grid of teaching material is presented in the following table.

Table 2. *Grid practices of digital teaching materials*

Instrument	Aspect
Practicality Sheet Digital Teaching Materials	1. Ease of Use 2. Time efficiency 3. The benefits

[Source: modified from Hamdunah (2015)]

Data processing techniques in the form of validation of teaching material analysis conducted by lecturers and teachers as validation experts. In addition to validation analysis, practicality analysis is also carried out by students as users of teaching materials. The percentage of validity level is determined by the formula (Akbar, 2013) as follows.

$$P = \frac{\sum(\text{validation score in every validator})}{N} \times 100\%$$

Information:

P: Percentage score

N: Maximum score

The validation criteria for teaching materials are presented in the form of a table as follows.

Table 3. *Teaching material validation criteria*

Validity Criteria	Validity Level
$85{,}01\% < v \leq 100{,}00\%$	Very valid, or can be used without revision.
$70{,}01\% < v \leq 85{,}00\%$	It is quite valid, or can be used but needs a little revision.
$50{,}01\% < v \leq 70{,}00\%$	Invalid, it is recommended not to use it because it needs a major revision.
$00{,}00\% < v \leq 50{,}00\%$	Invalid, or may not be used.

[Source: Akbar (2013)]

Then to determine the level of practicality of teaching materials, the formula used is (Akbar, 2013) as follows.

$$\mathrm{P} = \frac{\sum(\text{Practicality score in every practicality})}{\mathrm{N}} \times 100\%$$

Information:

P: Percentage score

N: Maximum score

The practicality criteria for teaching materials are presented in tabular form as follows.

Table 4. *Categories of practicality assessment tools*

Score %	Category
$80 < P \leq 100$	Very practical
$60 < P \leq 80$	Practical
$40 < P \leq 60$	Practical enough
$20 < P \leq 40$	Not Practical
$P \leq 20$	Not practical

Source: (Hamdunah, 2015)

RESULTS

The researcher had done a test about the linear system with two variables, which had a mathematical understanding and interviewed some of the students to know the learning difficulties and the material that had used in a linear system with two variable. The researcher also had interviewed the mathematics' teacher to know what the material and curriculum were used. These are the analysis that needed in this research:

a) Students character analysis

Character is on the personal individual that comes from scientifically through processing in kindness repeatedly that would be realized in thinking and applying in their attitude and action (Zahro, Serevina & Astra 2017). To create the material, it must be known as students' character to adjust the material that would be used for them. Based on the interviewing result, the researcher had done two mathematics' teachers and some of the seventh-grade students as known that there were difficulties in learning linear systems with two variables.

Students prefer to memorize the form than the concept because many forms that must be memorized even students did not know how to do with its form. Students also confused when the example and questions were different, students less attention and patients during doing the exercise and students always depended on the teachers as one of the sources during learning activity until students could not do individually to do the exercise as students comprehend. Besides that, a student is less motivated because the teachers only explained by using a whiteboard that was only written the form.

Another students' difficulties teacher explained the difficulties in explaining linear system with two variable because there were many students' characteristics was also challenging to make sure all students were comprehend, the comprehension of algebra for grade VII was also less and causing students hard to understand the linear system with two variable such as

changing the question from the text to mathematics model. Agreed with Farida (2015) that students were fault changing the information that was given in the mathematics model because students did not pay attention what the purpose of the question, in order the teacher more focusing on comprehension and students can easily use the right information. In this case, the ability of mathematical understanding in a linear system with two variables needs to get more attention.

b) Curriculum analysis

Curriculum analysis was found by the interview result between two mathematics' teachers. Curriculum analysis was done in order for the material that created appropriate with the curriculum. Besides that, curriculum analysis was used in school as the guidance to classify KD and explained the indicators. In the result of interviewing that the curriculum which Indonesia Junior High School used was curriculum 2013. Competence which was used in syllabus Junior High School has explained the system in a linear system with two variables and the solving which was connected in a contextual problem. Curriculum 2013 created students' centered during learning that focused on observing, thinking out, asking, trying, and communicating.

According to Sinambela (2017), the learning process caused by the implementation of curriculum 2013 is the learning, not teachers' centered but students' centered, and it was causing learning process which was more interactive. Curriculum 2013 also must be a learning process that had the active activity and observed and the teachers can be a facilitator in the learning process who can create students can solve all the contextual problems and real. Based on the interviewing, one of the mathematics teachers explained that curriculum 2013 was better than the previous curriculum, but the consequence for the mathematics questions was getting difficult than the previous one. In reality, there were difficulties in explaining because the students must be active, but it was not like the expectation. So according to one of the mathematics teachers in Indonesian Junior High School, a curriculum that was used as same as the government standard was KTSP to curriculum 2013. Looked by the question level was higher because using HOTS (High Order Thinking Skills) so that curriculum 2013 was better and deeper, but the reality students felt difficult because students lack motivation while students must be active than teachers.

c) Material analysis

The material which was used in school was the material such as a book from the government that was borrowed by a school from the students. The material had not already created the students learned individually because students still needed guidance from the teachers to learn the material from the book as like as the problem that must be solved. Students wanted the practical material was not thick and easy to bring anywhere, more interesting because of the colorful picture, material that was easy to understand with many exercises. In Indonesian Junior High School, the use of digital material has not been used because the school only used printed material. However, students were interesting when there were pictures or videos because it was not boring but interesting then students can easily understand. Based on mathematics' teachers in Indonesian Junior High School students described, "Students needed digital material not only printed material."

Pamuditya, Noto, and Purwono (2018) explained that every teacher has their challenge because teachers must know the technology, information, and media then took advantage of the classroom learning process to increase students' creativity. One of the ways to balance the learning process was by comparing the digital and printed material. One of them is to compensate technology, so the commonly used is printed learning materials which can be combined with technology in the form of digital learning materials. The conclusion of this analysis, learning materials that will be designed are digital learning materials that are adjusted with the student's character. The software which can be used to provide an electronic module is 3D Page flip Professional. This material uses curriculum 2013 because the junior high school used it as well. The materials will focus on mathematical comprehension abilities because based on the tests in linear equation two-variables of students are still minus incomprehension.

Furthermore, teachers and students do not use digital learning materials, so with digital learning materials; it can increase students' comprehension abilities in linear equation two-variables.

Phase Design

This step is creating an early product and product design. This early design is done by looking for basic competence which students must achieve related to linear equation two-variables. Basic competence is used to determine learning indicators that students must achieve which is adjusted to mathematical comprehension abilities. Then it arranges explanations materials to digital learning materials which are adjusted to Ausubel's theory. According to Pohan et al. (2014), components of learning activities are suited to competency standards, basic competences, learning indicators, and learning objectives. The materials on student activity sheets are designed regularly and systematically. This design is begun with creating contents of learning materials on Microsoft word and the file saved in PDF. Next, learning materials that saved in PDF are imported into software 3D Page flip Professional to be changed into digital learning materials which can be played on a computer. The function of the software is to show learning materials in a digital mode that can work on a computer with showing some contents, such as texts, animations, images, videos, audios, formative tests, communicating tests, and corrected and created games using certain software (Febrianti et al., 2017). For example, digital learning materials are shown in figure 1.

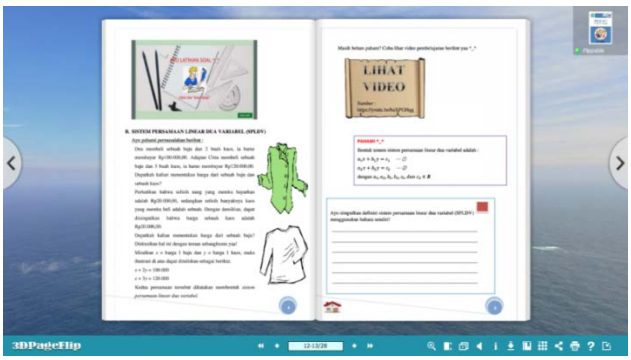

FIGURE 1. *Example of digital learning materials*

This page presents the problems regarding linear equation two-variables, which is equipped with images that support students' comprehension of linear equation two-variables. Besides, there are learning animation videos about the system of two-variables linear equations to students understand more the materials so that learning process is more enjoyable and interactive tests with questions following mathematical comprehension indicators that provide feedback to students, so students can measure their understanding of the materials that they have been learned. The researcher designed learning materials with showing some images, learning videos to support student understanding, questions following mathematical comprehension indicators, and combining interactive tests using inspiring suite application into 3D Page flip Professional. The learning process will be more understandable by students if supported by using teaching media (Putra, 2014). According to Abidin (2017), choosing teaching media as one of the technological learning applications in an initial activity that must be planned, chosen, and decided accurately and designed to solve the learning problems.

Phase Development

The development consists of changing the conventional learning materials into digital learning materials, explaining the results of the validity of digital learning materials and explaining the results of the practicality of digital learning materials. Learning materials that have been designed will be changed in the form of (.exe), after finished, made in the form of (.exe). According to Kurniawati, Desnita, and Siswoyo (2016), stated that file with format EXE has longer time because of the executable file for independent reading, it means that whether 3D

Pageflip Professional is available on laptop or not, so it always can be opened and make users easy to use. Then, doing validity learning materials to five validators to get suggestions and critics to make it better digital learning materials. The validity of learning materials is to produce a book with high validity which is done through validity tests. A validity test can be done by experts, users, and audiences (Akbar, 2013). The result of expert validity as can be seen in Table 5:

From five validators, it gets the result in a percentage of 92%; it means that it was valid or can be used without revisions. The result of each aspect proves it. The aspects are relevancy, accuracy, completeness, suitability, with demand which centered on students, linguistic, learning theory from Ausubel, the ability of mathematical understanding, and the appearance of visual communication on material, and software usage. The aspect of relevancy which validated by five validators, had mean 87.5%. In another words, presenting of digital material was very appropriated, there was the purpose of learning which relevant with the competency that must be mastered by students, the example of exercise and explanation which relevant with the purpose of learning that must be mastered by students, and the exercise was relevant with the purpose of learning objectives that must be mastered by students. In line with Purnomo (2012), he stated that choosing learning materials should consider the principle of relevancy, consistency, and sufficiency.

Table 5. *Result of the validity of learning materials*

Validators	Score of Validators	Max Score of Validity	Persentase validity (%)
1	120		100%
2	103		85.83%
3	103	120	85.83%
4	116		96.67%
5	110		91.67%

The principle of relevancy means learning materials which chosen had relevance with standard competency achievement and basic competency. Accuracy which validated by five validators, had mean 88.33 %. In other words, the criteria of accuracy were valid. It was caused by the materials that presented is appropriate with daily life, core competency, and basic competency on linear equation two-variables. This is in line with Puspita, Sumarni, and Pamelasari (2014), who stated that the criteria of appropriateness, which is in the module which developed were suitability materials with competency standards and basic competency that is divided into the material vastness and material depth. Material accuracy comprises facts, concepts, and illustrations. Materials can support the learning process and it is integrated. The completeness aspect, which validated by five validators, had mean 98.58%. In other words, the criteria of the completeness aspect were valid. It is based on digital learning materials presenting core competencies, basic competencies, learning indicators, and learning objectives. It is also presenting a table of content, references, and summary, instruction the use of teaching materials, the author's information and glossary.

A good teaching book contains competencies that must be mastered, useful, table of content, and references (Akbar, 2013). Appropriate aspect with student-centered learning, which validated by five validators, had mean 87.5%. In other words, the criteria of appropriate aspects with student-centered learning were valid. It is based on digital teaching materials supporting student's curiosity and digging their knowledge. Sinabela (2017) stated that the teacher has to make an effort for students so they can construct concepts and knowledge principals. Learning that is done must be planned first by the teacher, and the teacher is only as facilitator and supervisor. The language aspect which validated by five validators had a mean of 90%. In other words, the criteria of language aspect were valid. This is based on the appropriate use of spelling and appropriate arranging of the grammar of digital teaching materials. In line

with Furqon as cited in Nurdyansyah and Nahdliyah (2018), stated that a good teaching material must meet the criteria, such as legibility, both in terms of language and substance difficulties must be suited with the level of learning ability.

Ausubel learning theory aspect which validated by five validators, had mean 90%. In other words, the criteria of the Ausubel learning theory aspect was valid. This is based on digital teaching materials contain the stages of the Ausubel learning theory. In Ausubel's perspective, to learn optimally in order to students must connect new knowledge (concept and proposition) with what they have known (Dahar, 2011). The mathematical comprehension ability aspect which validated by five validators, had mean 87.5%. In other words, the criteria of mathematical comprehension ability aspects were valid. This is based on digital teaching materials containing indicators of mathematical comprehension ability and the questions in digital teaching materials had been adjusted with indicator mathematical comprehension ability that had been chosen.

Hikmah (2017) stated that student comprehension abilities in the learning process are an important thing to get the aims from learning mathematics. It means a student who had an understanding of the material or a concept would know how students solve the problem related to mathematics. The visual communication aspect that validated by five validators had mean 94.16%. In other word meant the criteria of visual communication aspect was valid. This case was based on presenting of digital material which contained navigation: all of the pages from material was easy to access, letter: text can be read, proportional and the composition of the letter was good, media: the use of media (movie, sound, picture, and animation) in material, media: picture and animation for learning in material clearly and appropriate with the material that presented, color: the color composition in material was appropriate, layout: design of appearance on each page of material was interesting and proportional. This case was on guidance for material development based on ICT which was developed by Directory of Junior high school (2010) was the material assessment based on ICT must be in principle which was on an instrument, it was material substance, learning design, visual communication and the use of the software.

The aspect of software usage, which was valid by five validators, had meant 90%. This case was caused by practice interactivity, and evaluation on digital material had given feedback for the user, the creation of this material utilized supporting software, and the originality there was picture/sound/video and animation thoroughly was made by researcher and if there was picture/ sound/ video and animation which took from another source was listed the name of the source. According to Kurniawati, Desnita, and Siswoyo (2016) that the creation of a learning source with software application expected could increase interest and motivation students' learning, and increasing students' achievement in learning that reached. After the material was valid, I had done practicality test digital material nine students which consist of three students who had a high ability, three students who had a medium ability, and three students who had a low ability. Based on Hamndunah (2015) practicality was the level of the usage from learning equipment, with executing the experiment of material that had valid by validators. The result of the practicality test of digital material, as can be seen in Table 6.

Based on table 6, that the percentage of practicality for students who had high ability was 95.83%, for students who had medium ability was 90,28%, and students who had low ability was 88.89%. From nine users, it was gotten the result practicality with the percentage 91.76% with practical criteria. This case was proven with the result of each aspect. Those aspects were the ease of using the efficiency of time and benefit. The aspect of ease of using that was tested to nine students had mean 86.11%. In other words, it was very practical. Students with high ability had produced value higher that was 91.76% from students who had a medium and low ability that was 83.33%. This caused with the existence of the purpose of using from digital material that could help students to use the material easier, the topic that presented in the material was appropriate with the purpose of learning, the material had used easy language, the material could be played on PC/laptop/another device, and easy to use and operate. Until students who had high ability said that the material understood the concept of material that presented, besides the operation of digital material, was easy.

Table 6. *Result of material practicality*

Ability Classification	User	Score of Practicality	Percentage
	S-1	46	95.83%
High	S-2	47	97.92%
	S-3	45	93.75%
Medium	S-4	44	91.67%
	S-5	44	91.67%
	S-6	42	87.05%
Low	S-7	41	85.42%
	S-8	46	95.83%
	S-9	41	85.42%

DISCUSSION AND CONCLUSIONS

Kurniawan, Suyatna and Suana (2015) said that the interactive module was easy to learn and to be understood because it used daily language. Besides, the level of the operation the use of the product was interesting, easy to use and full of benefit. The aspect of time efficiency, which tested to 9 students, had a mean 88.89%. In other words, that aspect was practical students who had high ability had a value higher that was 95.83% than students with a medium ability that was 87.05% of students with low ability was 83.33%. Students with high ability said that the learning by using digital material was more effective and efficient until students could be faster two get the information about the concept of material that students had learned. By using the module of learning more, be efficient and students could learn with their speed learn (Yerimadesi, et al. 2017) digital was easier and faster to understand. The benefit of the aspect that tested nine students had a mean of 98.33%. In other words, that aspect was very practical.

Students had produced the best score but students who had high ability had a mean 100%, then students with medium ability were 98.33% and students with low ability were 96.67%. Students said that the existence of elements such as picture, video, and animation made the learning process more fun because they could be easier to memorize the information that learned until developed their spirit to learn and adding their knowledge. Diani and Hartati (2018) identified that flipbooks could be presented in electronics that could show interactive simulation with animation, text, video, picture, audio and navigation that made students became more interactive until the learning process more interesting. Based on the research in practicality, the researcher agreed with the result from Suprihatiningsih and Annurwanda (2019) that stated the happened of mathematics module based on a problem that is seen by the ease of usage, readability, content, and language. General assessment from the level of practicality from mathematics module based on a problem by using an observation sheet was very practical, practical, practical enough, less practical and not practical.

From assessment aspect consist of similarity from the assessment aspect that used that was the ease of use. Sari, Amir, Risnawati (2017) in their research, had done a test to a small group, assessment aspect of practicality test there were comprehend from students to the material, students' interest and the usage of the worksheet. This research contains the difference of assessment aspect that was not be used in the aspect of time efficiency and benefit. Based on practicality that was done by using the assessment of practicality and based on the result which relevant had some similarities and also had some differences in this aspect. However, the main in this practicality must be paid attention to the aspect of the ease of usage, readability, content, students' interest, time-efficient, and benefit.

From the explanation above stated that the result of validation from digital material by five validators had produced the highest value, and the result of practicality user by nine students had produced the highest value, so digital material that made by the researcher was valid and practical. Until digital material was appropriate to use in mathematics class.

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