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Analysis of TPACK (Technological Pedagogical and Content Knowledge) variables for middle school teachers through surveys in the Pasar Jambi district

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Abstract
This study aims to analyze the influence of TPACK variables on junior high school teachers in Pasar Jambi District. The type of research used is quantitative research with a survey approach via WhatsApp groups and filling out questionnaires via google forms. The data collection technique used a questionnaire and then analyzed using the Structural Equation Model-Partial Least Square (SEM-PLS) method with SmartPLS software. From the results of the analysis, there are 5 out of 12 variable relationships that have a significant effect. Seven variables do not have a considerable impact: CK variables on TCK, CK on TPACK, PCK variables on TPACK, PK variables on PCK, PK variables on TPACK, PK variables to TPK, and TPK variable to TPACK. This shows that pedagogical and content knowledge does not significantly influence the teacher's TPACK ability. This research is expected to improve teacher TPACK competence, especially in technological knowledge, because teacher TPACK abilities are strongly influenced by technological knowledge.

Keywords: TPACK, Structural Equation Model-Partial Least Square (SEM-PLS), TPACK competency.

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I. Introduction

The progress of a nation is largely determined by the progress of the nation's education [1]. Education is a means to advance all areas of human life in Indonesia, including economic, social, technological, security, skills, noble character, welfare, culture, and national glory [2]. Humans need education to improve their standard of living, and educators must meet the needs of students. The needs of students will be fulfilled if the teacher has standards that are the teacher's competence. National education aims to educate the nation's life and develop the Indonesian people. National education goals require the presence of professional teachers.

Professional teachers must continue to develop according to the times, science and technology, and the needs of students [3]–[5]. In meeting the needs of students, teachers must have standards by teacher competency standards. Teacher competence is an ability possessed by a teacher covering aspects of knowledge, skills, thinking processes, self-adjustment, attitudes, and values held in carrying out the profession as a teacher [6]. By government regulation No. 74 of 2008 concerning teachers, the competencies that teachers must possess are (a) pedagogic competence, (b) personal competence, (c) social competence (d) professional competence, especially the development of teachers in the 21st century. 21st-century teachers must have hard and soft skills that can contribute to society in the world of education [7]. Teachers needed in the 21st century

are teachers who have the competency of harmony between technology, pedagogy, and material content. If one component is not fulfilled, it can affect other parts [8]. So that teachers need to master various fields and be proficient in pedagogy, including innovation in teaching and learning, design learning, and utilizing new media and technology in learning [9]. Technology is not only useful for communicating, but technology can play an active role in various fields, one of which is education. Technology is used as a medium or resource to assist learning in education.

Technology is the creation and use of devices, materials, processes, and instruments that assist people in solving issues [10]. Technology has several advantages in education besides being helpful for communication. A system used to support learning to attain the intended outcomes is known as educational technology. The complete process of integrating educational materials to address issues with human learning is covered by educational technology. Learning technologies can aid material visualization and inspire student learning [11]. Consequently, it is crucial to incorporate technology into education.

Technology, Pedagogy, and Content Knowledge (TPACK) is a conceptual framework that demonstrates the fusion of three areas of knowledge that instructors need to be proficient in [1]. Technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) are the three (3) forms of fundamental knowledge that makeup TPACK. Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK) Framework are the new knowledge that results from the synthesis of the three (3) core knowledge [12].

According to ref [12], in the TPACK framework model in Figure 1, there are three components of teacher knowledge: subject matter, pedagogy, and technology. This model has an equally important interaction, namely the interaction between bodies of knowledge expressed as PCK, TCK, TPK, and TPACK. TPACK has the advantage of being: TPACK understands not only technology, content, and pedagogy separately but also as an emerging form that understands how these forms of knowledge interact. TPACK refers to an understanding of how to represent concepts with the help of technology, pedagogical techniques that constructively use technology to teach content, knowledge of making complex concepts easy to learn and how technology can help students learn, and knowledge of how technology can be used to build existing knowledge [13].

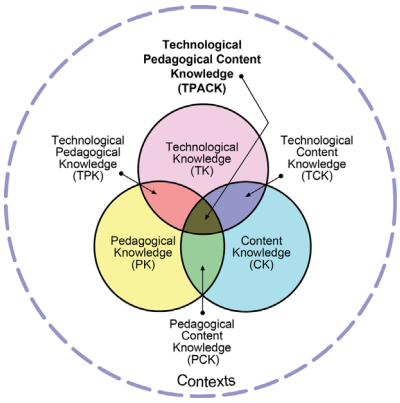

Figure 1. TPACK Framework

Based on a literature study, namely research conducted by Ref. [8] where in his research the PCK component can be influenced by the CK and PK components by 79.4%, the TCK component can be influenced by the CK component and the TK component by 61.5%, the TPK component can be influenced by the TK and PK components by 65.6%. Lastly, the PK, CK, Kindergarten, TCK, PCK, and TPK to TPACK are 81.2%. The difference with the research the researchers conducted was in the research object; the research object above was students, while the writer was a junior high school teacher. The second difference lies in the scope of the research. The above research was conducted at a university, while the author conducted research at a junior high school.

The problem that the researcher found when conducting observations at SMPs in Pasar Jambi District through interviews with several teachers was that they still found problems with Technological Knowledge, Pedagogical Knowledge, and Content Knowledge, where not all teachers understood the three these essential components there are still many teachers who have not utilized technology to facilitate teaching, teachers still

use old methods of teaching such as the lecture method which makes students bored and sleepy, the age factor also influences such as teachers who are old do not understand how to use learning technology such as virtual practicum, Microsoft PowerPoint, and google classroom.

Based on the description above, in this study, an analysis of TPACK abilities was carried out, and which components affected the TPACK ability of Middle School Teachers in Pasar Jambi district. This study aims to analyze the teacher's TPACK variable in junior high schools throughout Pasar Jambi district.

II. Methods

This research is quantitative research with a survey approach. The quantitative method is a research method in which the data involves many numbers. The research design used is survey research. Survey research collects information from a sample by asking through a questionnaire or interview so that later it describes various aspects of the population and uses a questionnaire as a collection tool [8].

The research was carried out at junior high schools throughout Pasar Jambi District. The research was conducted from June 6 to June 18, 2022. The population in this study were all SMP teachers in Pasar Jambi District, Jambi, totaling 114 teachers. The sampling technique in this study is non-probability with total sampling. Total sampling, namely the sampling method, takes all population members as respondents or samples [14]. The data collection technique used in this study using a questionnaire. The questionnaire is a list that contains questions that must be answered or done by students who want to be investigated, also called respondents [15]. The instrument used in this study was adapted from Susanti's research [16]. The teacher's TPACK instrument uses a Likert scale of 5, namely Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The research questionnaire consisted of 20 items, namely the TK component consisting of 3 items, CK consisting of 3 items, PK consisting of 4 items, TCK consisting of 2 items, PCK consists of 2 items, TPK consists of 1 item, and TPACK consists of 5 items.

The first research stage carried out by the researcher is to determine the research theme, then determine the problem or research problem, then make a research design starting from theory, concept, variables, and research scale, then arrange instruments according to predetermined variables, then determine sampling techniques, then test the validity of the instrument. After the instrument is valid, the researcher determines the school to be studied. After coordination with the school, the researcher distributes the TPACK questionnaire to the school, then collects data from the questionnaire that has been distributed. The researcher enters the data into Microsoft Excel to facilitate data processing. After that, the researcher conducts data analysis using SmartPLS software. After the data is analyzed, then the data is described/explained to make conclusions. The last research stage is to make conclusions from the results of the analysis and description of the data.

The validity test in the research questionnaire was carried out to determine whether the research instrument items were valid [17]. Validity is an index that shows the extent to which an instrument measures what needs to be measured [18]. In validating the TPACK instrument, researchers collaborated with Nova Susanti's research, where the results of her research contained 20 valid items. The validity test was analyzed using SmartPLS. According to Ref. [19], in evaluating measurement models, loading factor values, Composite Reliability (CR), and Average Extrack Variance (AVE) are used to validate the instrument. The recommended value of the loading factor is > 0.5, Composite Reliability (CR) > 0.7, and Average Extrack Variance (AVE) > 0.5.

To analyze the 114 completed questionnaires, the data analysis and testing techniques used in this study were Structural Equation Model-Partial Least Square (SEM-PLS). Structural Equation Model SEM analysis technique is a correlation regression analysis technique that aims to examine the relationships between variables in a model, both between indicators and constructs or relationships between constructs. Several terms used in PLS are different from other statistical processing such as SPSS.

III. Results and discussion

Data Description

This research has been carried out in junior high schools throughout the Pasar Jambi District. This research was carried out from June 6 to June 18, 2022. The total number of samples was 114. The data obtained in this study are shown in Table 1.

Table 1. TPACK Questionnaire Data for teachers in SMPs in Pasar Jambi District

Intervals	Category	Frequency	%	Mean
20 - 36	Strongly Disagree	0	0	
37 - 52	Don't agree	0	0	
53 - 68	Neutral	12	10.5	79.5877
69 - 84	Agree	79	69.3	
85 - 100	Strongly agree	23	20.2	
Total		**144**	**100**	

Based on Table 1 above, the percentage in the Strongly Disagree category is 0%, in the Disagree category with a percentage of 0%, in the Neutral category with a percentage of 10.5%, in the Agree category with a percentage of 69.3%, in the Strongly Agree category with a percentage of 20.3%. The overall average value is 77.5877. The lowest percentage is in the Strongly Disagree and Disagree category, and the highest is in the Agree category, with a percentage of 69.3%.

The total sample size was 114 consisting of 52 teachers at SMP Negeri 1 Jambi City, 43 teachers at SMP Negeri 2 Jambi City, and 19 teachers at SMP Muhammadiyah 1 Jambi City, with 79 female teachers and 35 male teachers. Collecting research data using a questionnaire. The questionnaire in this study used a Likert scale. This research questionnaire discusses the teacher's TPACK, which consists of 7 components of the TPACK framework. This research questionnaire consists of 20 items, namely the TK component consists of 3 items, CK consists of 3 items, PK consists of 4 items, TCK consists of 2 items, PCK consists of 2 items, TPK consists of 1 item, TPACK consists of 5 items.

SmartPLS Data Analytics

Structural Equation Model-Partial Least Square (SEM-PLS), which has only modest requirements for sample size and data quality, was employed in this study's data analysis because it is a powerful multivariate analytic tool [19]. An analysis of the measurement model (outer model), an analysis of the structural model (inner model), and hypothesis testing was completed using the SmartPLS 3.0 software. The TPACK theory's tenets form the foundation of the employed SEM model [20].

1. Assessment of the Measurement Model (Outer Model)

The first stage in the analysis using Partial Least Square is to test the outer model or measurement model. The technique used to analyze the outer model is the PLS algorithm. This study tested the outer model using a convergent validity test and reliability test.

Convergent validity. According to Ref. [21], measures how well theoretical ideas that explain the presence of indicators from the variable test fit with the indicators of variable measurement results. Convergent validity refers to the idea that a construct's indicators should exhibit a strong correlation. Convergent validity can be evaluated using a variety of metrics, including average extracted variance and the value of the outer loading. Outer loading is the first test of the convergent validity test.

A table with a loading factor to display the relationship between indicators and latent variables is called an outer loading table. It is legitimate if the loading factor value is more than 0.7. The PLS Algorithm Report SmartPLS can be used to obtain output for outer loadings. The results of the outer loading calculation are detailed in Table 2.

Based on Table 2 shows that each variable indicator in this study has an outer loading value of > 0.7, and there is no variable indicator whose outer loading value is below <0.7, so all indicators are declared feasible or valid.

The next convergent validity test is to know the Average Variance Extracted (AVE) value (in table 3). The AVE value aims to measure the aim to measure the level of variance of a construct component that is collected from its indicators by adjusting the error rate. The recommended minimum AVE value is 0.50 [21].

Based on Table 3, it is known that the AVE value of all the resulting variables is more than 0.5. Based on the AVE criteria, these results have shown that all of these variables are valid, so the convergent validity test is acceptable.

Table 2. Outer Loading Value

	CK	PCK	PK	TCK	TK	TPACK	TPK
CK1	0.854						
CK2	0.857						
CK3	0.866						
PCK7		0.930					
PCK8		0.923					
PK10			0.848				
PK16			0.839				
PK4			0.708				
PK5			0.835				
TCK3				0.948			
TCK4				0.946			
TK13					0.724		
TK5					0.832		
TK9					0.833		
TPACK10						0.901	
TPACK4						0.892	
TPACK5						0.864	
TPACK7						0.837	
TPACK9						0.878	
TPK7							1.000

Table 3. Average Variance Extracted (AVE) value

Variable	AVE
CK	0.737
PCK	0.858
PK	0.655
TCK	0.897
TK	0.636
TPK	1.000
TPACK	0.765

Reliability Test. Composite Reliability and Cronbach's Alpha are tests carried out to see the reliability of each variable [22]. According to Ref. [23], Composite Reliability measures the actual reliability value of a variable, while Cronbach's Alpha measures the lowest value of the reliability of a variable. Data is reliable if the Composite Reliability value is more than 0.7 and the resulting Cronbach's Alpha value is more than 0.6.

Based on Table 4, all measurement variables meet the required reliability criteria, both Cronbach's Alpha and Composite Reliability. All variables have a Cronbach's Alpha value of more than 0.6 and Composite Reliability of more than 0.7. The variables in this study are reliable.

The results of measuring validity and reliability using the Measurement Model or the Measurement Model above show that the data collection tool used in this study is valid and reliable. These results indicate that the research measuring instrument has a good consistency.

Table 4. Cronbach's Alpha Value and Composite Reliability

Variable	Cronbach's Alpha	Composite Reliability
CK	0.823	0.894
PCK	0.834	0.923
PK	0.824	0.883
TCK	0.885	0.945
TK	0.724	0.840
TPK	1.000	1.000
TPACK	0.923	0.942

2 Assessment of the Structural Model (Inner Model)

According to [16], the Structural Model aims to evaluate the relationship between hypothesized latent constructs. The structural model (Inner Model) is submitted by looking at the value of *R*-Square. The second test looks at the significance of the $t_{statistic}$ in the Algorithm Boostrapping report Path Coefficients. The $t_{statistic}$ value is more than the t_{table} and significance ($t_{significance}$ table 5% = 1.98) [24].

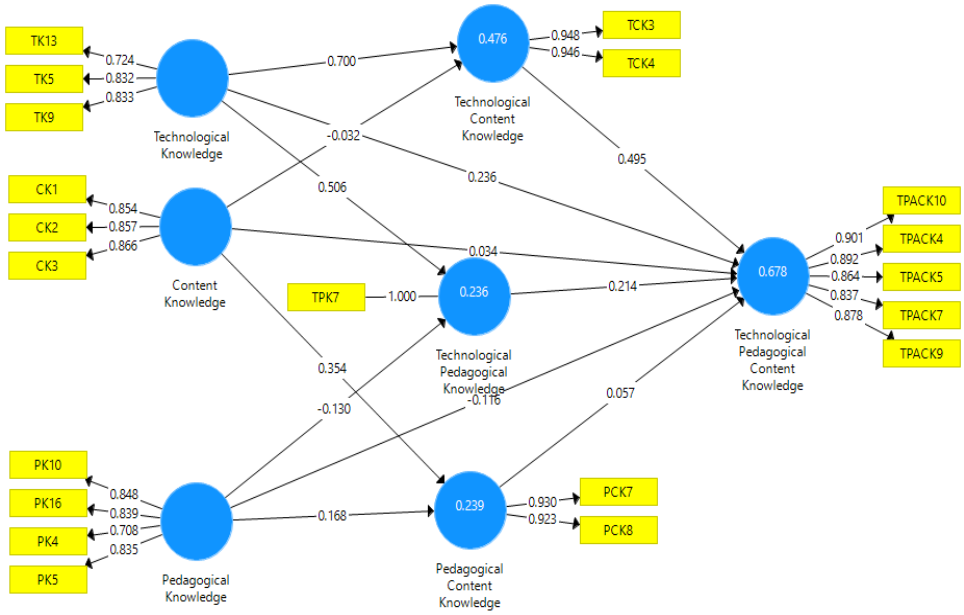

Figure 2. SmartPls Analysis Results Model

3 Analysis of Variant (*R*-Square) or Determination Test

Variant Analysis (*R*-Square) or Determination Test, namely to find out the influence of the variable on the dependent variable, the value of the coefficient of determination can be shown in Table 5.

Table 5. Value of *R* Square

Variable	*R* Square
PCK	0.239
TCK	0.476
TPK	0.236
TPACK	0.678

The *R*-Square values for PCK, TCK, TPK, and TPACK variables are presented in Table 3.5. These values indicate how much of the variance of each construct can be explained by the other constructs in the model. For instance, the *R*-Square value for the PCK construct is 0.239, which means that 23.9% of the variance in PCK can be explained by PK and CK constructs, while the remaining 76.1% is explained by other variables in the model. Similarly, the TCK construct has an *R*-Square value of 0.476, which indicates that 47.6% of the variance in TCK can be explained by TK and CK constructs, while other variables outside the model explained 52.4%. The TPK construct has an *R*-Square value of 0.236, indicating that 23.6% of the variance in TPK can be explained by TK and PK constructs, and other variables outside the model can be explained by 76.4%. Finally, the *R*-Square value for the TPACK construct is 0.678, which means that all the constructs in the model can explain 67.8% of the variance in TPACK, while other variables outside the model explained 32.2%.

Hypothesis Testing

Hypothesis testing in this study was carried out for the significance of the path coefficient values and the $t_{statistics}$ obtained using the bootstrapping procedure. The results of the path coefficient and its value can be seen in Table 6.

Table 6. Path Coefficient Results

	Original Sample (O)	Sample Average (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P Values
CK→ PCK	0.354	0.355	0.103	3.453	0.001
CK→ TCK	-0.032	-0.037	0.067	0.483	0.629
CK→TPACK	0.034	0.029	0.081	0.416	0.678
PCK→TPACK	0.057	0.054	0.083	0.685	0.494
PK→ PCK	0.168	0.173	0.115	1.458	0.146
PK→TPACK	-0.116	-0.110	0.093	1.250	0.212
PK→TPK	-0.130	-0.129	0.101	1.292	0.197
TCK→TPACK	0.495	0.491	0.126	3.920	0.000
TK→TCK	0.700	0.707	0.048	14.657	0.000
TK→TPACK	0.236	0.246	0.089	2.647	0.008
TK→TPK	0.506	0.498	0.094	5.379	0.000
TPK→TPACK	0.214	0.213	0.126	1.699	0.090

Based on table 6 shows that the hypothesis is accepted or rejected by looking at the t-statistical value of the t-table. Of the 12 hypotheses proposed in this study, seven hypotheses about the relationship between variables CK→TCK, CK→TPACK, PCK→TPACK, PK→PCK, PK→TPK, PK→TPACK, and TPK→TPACK are rejected by looking at the higher t-statistic values lower than the t-table value. So the five variable relationships have a significant influence, while the seven relationship variables have no significant effect.

Discussion

CK to PCK. The first hypothesis examines the effect of the CK variable on PCK. The test results show that the path coefficient of CK to PCK is 0.354 with a $t_{statistic}$ of 3.453. These results indicate that the first hypothesis can be accepted because the $t_{statistic}$ is significant, greater than 1.98, and the *p*-value <0.05. Thus, Content Knowledge has a significant influence on Pedagogical Content Knowledge.

CK to TCK. The second hypothesis examines the effect of the CK variable on TCK. However, the test results show that the path coefficient of CK to TCK is -0.032 with a $t_{statistic}$ of 0.483. This shows that the second hypothesis is rejected because the $t_{statistic}$ is insignificant, less than 1.98, and the *p*-value> 0.05. Therefore, CK has no significant influence on TCK.

CK to TPACK. The third hypothesis examines the effect of the CK variable on TPACK. However, the test results show that the path coefficient of CK to TPACK is 0.034 with a $t_{statistic}$ of 0.416. This shows that the third hypothesis is rejected because the $t_{statistic}$ is insignificant, less than 1.98, and the *p*-value> 0.05. Therefore, it can be concluded that CK has little effect on TPACK.

PCK to TPACK. The fourth hypothesis examines the effect of PCK variables on TPACK. However, the test results show that the path coefficient of PCK to TPACK is 0.057 with a $t_{statistic}$ of 0.685. This shows that the fourth hypothesis is rejected because the $t_{statistic}$ is insignificant, less than 1.98, and the *p*-value> 0.05. Therefore, it can be concluded that PCK does not significantly affect TPACK.

PK to PCK. The fifth hypothesis examines the influence of PK variables on PCK. However, the test results show that the path coefficient of PK to PCK is 0.168 with a $t_{statistic}$ of 1.458. This shows that the fifth hypothesis is rejected because the $t_{statistic}$ is insignificant, less than 1.98, and the *p*-value> 0.05. Therefore, PK does not significantly affect PCK.

PK to TPK. The sixth hypothesis examines the effect of the PK variable on TPK. However, the test results show that the path coefficient of PK to TPK is -0.130 with a $t_{statistic}$ of 1.292. This shows that the sixth hypothesis is rejected because the $t_{statistic}$ is insignificant, less than 1.98, and the *p*-value> 0.05. Therefore, PK has no significant effect on TPK.

PK to TPACK. The seventh hypothesis tests the PK variable, which significantly affects TPACK. The test results show that the path coefficient value of PK to TPACK is -0.116, and the $t_{statistic}$ equals 1.250. These results stated that the $t_{statistic}$ was insignificant because it was <1.98 and the *p*-value> 0.05, so the seventh hypothesis was rejected. This proves that PK is not proven to influence TPACK.

TCK to TPACK. The eighth hypothesis tests the TCK variable, which significantly affects TPACK. The test results show that the path coefficient value of TCK to TPACK is 0.495, and the $t_{statistic}$ is 3.920. From these results, it was stated that the $t_{statistic}$ was significant because it was >1.98 and the *p*-value <0.05, so the eighth hypothesis was accepted. This proves that TCK significantly influences TPACK.

TK to TCK. The ninth hypothesis tests the TK variable, which significantly affects TCK. The test results show that the path coefficient value of TK to TCK is 0.700, and the $t_{statistic}$ is 14.657. These results show that the $t_{statistic}$ is significant because it is >1.98 and the *p*-value is <0.05, so the ninth hypothesis is accepted. This proves that TK has a significant influence on TCK.

TK to TPK. The tenth hypothesis tests the TK variable, which significantly affects TPK. The test results show that the path coefficient value of TK to TPK is 0.506, and the $t_{statistic}$ is 5.379. From these results, the $t_{statistic}$ was significant because it was >1.98 and the *p*-value <0.05, so the tenth hypothesis was accepted. This proves that TK has a significant influence on TPK.

TK to TPACK. The eleventh hypothesis tests the TK variable, which significantly affects TPACK. The test results show that the path coefficient value of TK to TPACK is 0.236, and the $t_{statistic}$ is 2.647. From these results, it was stated that the $t_{statistic}$ was significant because it was >1.98 and the *p*-value <0.05, so the eleventh hypothesis was accepted. This proves that TK significantly influences TPACK.

TPK to TPACK. The twelfth hypothesis tests the TPK variable, which significantly affects TPACK. The test results show that the path coefficient value of TPK to TPACK is 0.214, and the $t_{statistic}$ is 1.699. From these results, it was stated that the $t_{statistic}$ was significant because it was <1.98 and the *p*-value was > 0.05, so the twelfth hypothesis was rejected. This proves that TPK does not significantly influence TPACK.

Based on the data from the model hypothesis test, it was found that the TK component had a direct effect on TPACK. The CK and PK components have no immediate impact on TPACK. The results of this study are slightly different from the research conducted by Ref. [8]. The results of his study found that there was a significant effect between PK on TPACK.

IV. Conclusions

Based on data analysis and discussion of the TPACK variable analysis for junior high school teachers through a survey throughout the Pasar Jambi District with the type of Quantitative Research with a survey approach, it can be concluded that there is a significant relationship between the variables in the TPACK instrument. There are 12 relationship variables analyzed. Five of the 12 variables have a significant effect, and seven have no significant impact.

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