

USING OF HEURISTIC JUDGMENT IN CHOOSING ANSWERS OF CONCEPTUAL UNDERSTANDING TEST

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ABSTRACT

This article presents the cognitive load in choosing answers to conceptual understanding test of the human regulatory system. The purpose of this study is to find the influence of cognitive load directly and indirectly on the variables that are identified. The research method used was survey research and analyzed based on the path coefficient with the 8.72 Lisrel program. The population in this study are students of class XI science from three schools in Kabupaten Serang a numbers of 463 students and the sample taken a numbers of 215 students. The results of this study indicate that there is a direct influence of cognitive load on heuristic judgment. The effect directly have a significant positive effect directly, namely cognitive load on working memory, and working memory on heuristic judgment. One hypothesis had a significant indirect effect, namely cognitive load on heuristic judgment through working memory.

Keywords : heuristic judgment, conceptual understanding test.

INTRODUCTION

The conceptual understanding is the success of students in understanding the materials provided by the teacher and students get through various ways of learning. There are various ways that teachers do to measure the success of students' conceptual understanding such as through multiple choice tests (Lau, Lau, Hong, & Usop, 2011), concept maps (Kordaki & Psomos, 2015), inventory (Klymkowsky & Garvin-Doxas, 2008), dan concept of two-tier (Bayrak, 2013).

Two-tier concept understanding test is used and is designed to answer the weaknesses of multiple choice test. Some weaknesses of multiple choice test are guesses, mistakes and misconceptions in the process of choosing test answers (Lau et al., 2011). In the two-tier concept understanding test, students are tested for their consistency in each question so errors and misconceptions from guessing answers can be avoided. This test is a diagnostic test of students' concept understanding in the form of multiple choice with two groups of options in each question, namely the option group of answers and the option group of reasons (Bayrak, 2013; Lin, Yang, & Li, 2016; Sharma & Kaur, 2016; D. Treagust, 1987; D. F. Treagust, 1988; Uyulgan & Akkuzu, 2014). The response patterns of answers formed from this test is conceptual understanding: the correct answer and the right reason. The second pattern misconceptions: choosing the answer without a reason, the wrong answer but the right reason, and the right answer but the wrong reason, and third, not understanding the concept: the answer and the reasons are wrong or the answers and reasons are not choosing.

Integration of concept understanding test with higher order thinking process and designed

with a two-tier concept make difficult for students in providing answers based on student knowledge so students cannot give correct answers if students do not understand the concept fully. Several studies have shown the use of diagnostic tests of conceptual understanding in biological material, including test of understanding of the concept of photosynthesis and plant respiration (D. Treagust, 1987), plant transport system (Ainiyah, Ibrahim, & Hidayat, 2018), cell (Sharma & Kaur, 2016), and base acid (Bayrak, 2013). In this study the material tested to measure students' conceptual understanding is system of human regulation.

Integration of concept understanding test with higher order thinking process can cause difficulties and loads on students' cognitive thinking processes. One of the conditions in which students feel the load of processing information and using high mental effort in themselves is when they face exams or tests (Ackerman & Ellingsen, 2016; Bornstein & Chamberlain, 1970; Gillmor, Poggio, & Embretson, 2015). Test designs that are not easy to answer correctly by students cause pressure on their thinking processes. One of the pressure is cognitive load. (Gillmor et al., 2015). Cognitive load is a load that is felt by students about how complex the task faced or done can cause the load on their cognitive (Astell, 2017; Vogels, Demberg, & Kray, 2018; Wirzberger, Herms, Bijarsari, Eibl, & Rey, 2018). The existence of cognitive load has stimulated student working memory to be limited in its function to remember knowledge.

The limited working memory of students to remember the materials given and to recall other information needed by students in answering exam questions has become one of the causes of wrong answer choices on the material tested. Delaney, Godbole, Holden, & Chang, (2018) shows people with higher working memory are more accurate on given memory tasks than people with lower working memory. The difference in students' working memory abilities causes accuracy and inaccuracy in choosing test answers as a form of task given to students when the test takes place. This inaccuracy occurs because the student's limited working memory stimulates the use of heuristic judgment by students.

Heuristic judgment is a strategy to decide the choices made by students using partial information retrieval and other information that is not related with the material being tested (Ackert, Church, & Tkac, 2010; Dale, 2015). This heuristic judgment provides a way for bias and errors in judgment and decision making or choice (Blumenthal-Barby, 2016). The use of heuristic judgment by students to choose test answers is caused by the presence of cognitive load that stimulates students' working memory to use heuristic judgment in answering the given concept understanding tests.

Research by Allred, Crawford, Duffy, & Smith, (2016) showed participants with high cognitive load and high working memory showed bias tendency more strongly than when under cognitive load and low working memory. Camos & Portrat, (2015) showed increase in cognitive load had an impact on the recall delay. Whitney, Rinehart, & Hinson, (2008) about the role of working memory in making risky decisions showed limited working memory due to high working memory makes people using heuristics to make good decisions with minimal effort. Research by Gana et al., (2010) showed the use of heuristics had a significant influence on risky judgment. Research by Amos & Kahneman, (1973) showed dependence on heuristics leads to systematic bias. Based on this background, this study aims to determine the effect of cognitive load and working memory on heuristic judgment in conceptual understanding test of the human regulatory system. Testing the influence of these variables is analyzed by the path coefficient and its significance through the path analysis model in the

8.72 Lisrel program. The hypothesis in this study is as follows

H1: There is a direct influence of cognitive load on working memory

H2: There is a direct effect of working memory on heuristic judgment

H3: There is an indirect effect of cognitive load on heuristic judgment

METHOD

The research method used was a survey. Survey data were analyzed using path analysis. Path analysis was used to see the effect or causal of exogenous variables on endogenous. This method was analyzed based on path coefficients using the 8.72 lisrel program. This study used a population of students of class XI science from three State Senior High Schools in Serang, Indonesia, total of 465 students. The population was taken based on data obtained from the Indonesian Education Assessment Center about the percentage of absorption of the working mechanism of the human regulatory system at UN 2018. The sampling technique in this study used simple random sampling technique. The use of simple random sampling techniques is used to provide equal opportunities to all available populations. Samples taken amounted to 215 students based on the sampling formula from Slovin with an error rate of 0.05. The research was carried out along May 2019.

Data collection techniques to measure cognitive load, working memory, and heuristic judgment were obtained using a verbal frequency scale questionnaire with five response choices. The instrument used was a modification of the relevant instrument to measure cognitive load variables (Klepsch, Schmitz, & Seufert, 2017; Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013; Novak, Daday, & McDaniel, 2018; Sewell, Boscardin, Young, ten Cate, & O'Sullivan, 2016), working memory (Vallat-Azouvi, Pradat-Diehl, & Azouvi, 2012), dan heuristic judgment (del Campo, Pauser, Steiner, & Vetschera, 2016). Based on the instrument, cognitive load had three aspects measured namely intrinsic cognitive load, extrinsic cognitive load, and extraneous cognitive load. Working memory instruments had three measured aspects, namely storage, attention, and excitation. Heuristic judgment instruments had five measured aspects, namely rational, intuitive, dependence, avoiding, and spontaneous.

The construct validity for all variables in this study was tested by three experts and analyzed using CVR (content validity ratio). Empirical validity and reliability were tested on students of class XI science in three different schools from the research population in Serang with 204 students. Analysis of empirical validity and reliability on cognitive load, working memory, and heuristic judgment were carried out using the lisrel 8.72 program. The value of empirical validity was obtained from factor loading values between latent variables and manifest variables. Reliability values were obtained from each construct measured on each instrument using the reliability construct formula. The criteria for validity testing were factor loading values above 0.05 and construct reliability values above 0.07 (Wijanto, 2008). The testing of this instrument used the CFA one-step model.

Data obtained from the results of the study were analyzed using inferential statistical methods. Inferential statistics are used to infer research data through a series of hypothesis testing. In this research, the 8.72 Lisrel program was used for path analysis and testing of the proposed hypothesis. However, before testing the path analysis, the data are tested for normality and multicollinearity as analysis requirement testing and model match testing is used to see the compatibility of the model with the data. All significance levels used in testing this hypothesis are using alpha 0.05.

DISCUSSION

Analysis Requirement Testing

Analysis requirement testing is used for initial decisions that must be obtained when the research data was used to see the effect of exogenous variables on endogenous based on the theoretical model used. Testing the requirements of this analysis can be tested using lisrel 8.72 by looking at the value of skewness and kurtosis at the output of lisrel 8.72.

Data Normality Testing

The normality testing criteria in table 1, if the z-score skewness and z-score kurtosis are in the range -1.96 to 1.96 or p-values of skewness and Kurtosis > 0.05 so the data is declared normally distributed. Based on the testing results obtained of the cognitive load variable (CL) z-score was in the range of -0.376 to 0.108 and p-value of 0.926 > 0.05, working memory variable (WM) z-score of -1.846 to 0.651 and p-value of 0.147 > 0.05, and z-score of 0.614 to 0.757 and p-value of 0.622 > 0.05 in the heuristic judgment variable (HJ). Because all data from these exogenous variables show values within the range of skewness and kurtosis criteria and were not significant (p-value > 0.05), it can be concluded that the data from these three variables are "normally distributed"

Table 1. Normality of Variables

Test of Univariate Normality for Continuous Variables						
Variable	Skewness		Kurtosis		Skewness and Kurtosis	
	Z-Score	P-Value	Z-Score	P-Value	Chi-Square	P-Value
CL	-0.376	0.707	0.108	0.914	0.153	0.926
WM	-1.846	0.065	0.651	0.515	3.832	0.147
HJ	0.614	0.540	0.757	0.449	0.950	0.622

Note: criteria of normality is range z-score skewness -1.96 until z-score kurtosis 1.96 or p-value > 0.05; CL = Cognitive Load; WM = Working Memory; and HJ = Heuristic Judgment.

Multicollinearity Testing

The testing criteria for multicollinearity shown in table 2, the correlation value between variables is not allowed at 0.9 or more (> 0.9). On the results of the multicollinearity testing, the output value at Lisrel 8.72 about the correlation between variables is smaller than 0.9. The results of this test indicate that there is not multicollinearity between variables.

Table 2. Correlation Matrix of Variables

Correlation Matrix			
	CL	WM	HJ
CL	1.000		
WM	0.411	1.000	
HJ	0.225	0.217	1.000

Note: criteria of normality is range z-score skewness -1.96 until z-score kurtosis 1.96 or p-value > 0.05; CL = Cognitive Load; WM = Working Memory; and HJ = Heuristic Judgment

Model Match Testing

Model match testing obtained from the results of the study by analyzing the statistical values of goodness of fit statistics from the output of the Lisrel program on the analyzed model. The output displayed on the program is shown in table 3.

Table 3. Goodness of Fit Statistics

Parameters of fit	Assumptions of fit (Wijanto, 2008)	Estimate results	Decisions
Chi-square P-value	Value minimum, p-value > 0.05	7.524, (P = 0.0569)	Good
NCP Interval	Value minimum, Narrow interval	2.121, (0.0 ; 16.457)	Good
RMSEA P (close fit)	RMSEA $\leq$ 0.08 P $\geq$ 0.05	RMSEA = 0.0828 P = 0.183	Good
ECVI	Small value, and close to ECVI saturated	ECVI = 0.100 ECVI for S = 0.0939 ECVI for I = 0.311	Good
AIC	Small value, and close to AIC saturated	AIC = 21.378 AIC for S = 20.000 AIC for I = 66.172	Good
CAIC	Small value, and close to CAIC saturated	CAIC = 51.973 CAIC for S = 63.706 CAIC for I = 83.655	Good
NFI	NFI $\geq$ 0.90	NFI = 0.871	Marginal
NNFI	NNFI $\geq$ 0.90	NNFI = 0.827	Marginal
CFI	CFI $\geq$ 0.90	CFI = 0.913	Good
IFI	IFI $\geq$ 0.90	IFI = 0.918	Good
RFI	RFI $\geq$ 0.90	RFI = 0.741	Marginal
CN	CN $\geq$ 200	CN = 323.725	Good
RMR	Standarized RMR RMR $\leq$ 0.05	RMR = 0.0523	Good
GFI	GFI $\geq$ 0.90	GFI = 0.983	Good
AGFI	AGFI $\geq$ 0.90	AGFI = 0.944	Good

Note: Estimate of Models and Decisions.

NCP : Non-centrality Parameter

NNFI : Non-Normed Fit Index

RMR : Root Mean Square residual (RMR)

ECVI : Expected Cross-Validations Index

CFI : Comparative Fit Index

GFI : Goodness of Fit Index

AIC : Akaike Information Criterion (AIC)

IFI : Incremental Fit Index

AGFI : Adjusted Goodness of Fit Index

CAIC : Consistent Akaike Information Criterion (CAIC)

RFI : Relative Fit Index

S & I : Saturated and Independence

NFI : Normed Fit Index

CN : Critical N

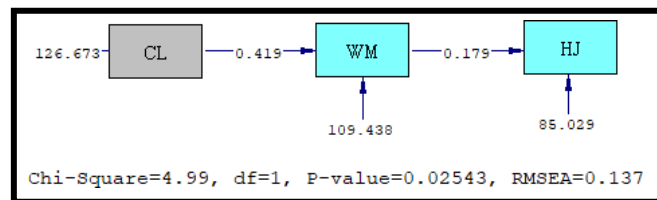
The results of model testing between model and data in the table 3, showed that majority of the testing results have a good match. There were three parameters of model matching at

the marginal level of decision i.e. Normed Fit Index (NFI), Non-Normed Fit Index (NNFI), and Relative Fit Index (RFI). According to Wijanto (2008), Marginal fit had a value in the range of 0.80 to 0.90.

Hypothesis Testing

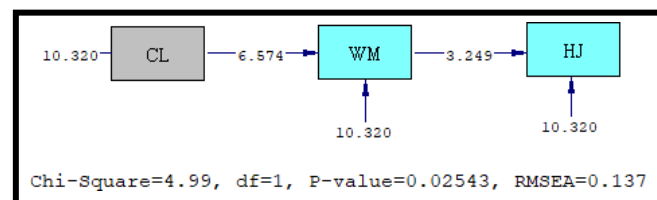
Hypothesis testing is tested to confirm the proposed hypothesis. Test values on each hypothesis can be seen from the value of the path coefficient and the significance value of t. t-value is used to give a decision on the hypothesis if t-value is significant or greater than 1.96 it means that the null hypothesis (H_0) is not equal with zero. This means acceptance of the proposed alternative hypothesis (H_1 s.d H_3). The path coefficient and t values in the model can be seen in Figures 1 and 2.

Figure 1. Coefiecient Path Analyses



Note: Coefficient of path analyses; CL = Cognitive Load; WMC = Working Memory; and HJ = Heuristic Judgment

Figure 2. t-value Path Analyses



Note: t-value of path analyses; CL = Cognitive Load; WMC = Working Memory; and HJ = Heuristic Judgment

Cognitive Load (CL) Directly Influences on the Working Memory (WM)

$WM = 0.414 * CL$, Errorvar = 108.473, $R^2 = 0.167$

(0.0634) (10.511)
6.531 10.320

The testing results, giving a path coefficient value of 0.414 with t-value of 6.531. Because the t-value = 6.531 > 1.96, the path coefficient value is significant. This means cognitive load (CL) directly influences on working memory (WM). R^2 value in this testing showed a value of 0.167, this means 16.7% of the variance of working memory (WM) is explained by the variance of cognitive load (CL).

Cognitive load had a significant effect on working memory. This happens because the load is so high in students' cognitive thinking processes causing the student's working memory to be increasingly limited in performing its functions to recall the material tested. Students' cognitive load will be followed by limitations of working memory or high working memory. Cognitive load was felt to be heavier and increases the limitations of students in remembering the information that is needed. Information stored in short-term memory and in a cognitive load condition will make students forget the memories needed. Based on research

result Camos & Portrat, (2015) showed working memory dependence on cognitive load task and cognitive load has a disturbing effect of students' memory delays. A temporary decrease in the function of working memory to remember the material "human regulatory system" occurs based on the conditions experienced by students when facing an exam task. These conditions are like time pressure, self-regulation, and task difficulties (Kasiri & Mohammad, 2016; Rice, Keller, Trafimow, & Sandry, n.d.; Seufert, 2018).

In the test, students' knowledge is important information because it is related to their understanding of the material being tested. However, the results of these tests cannot fully describe students' understanding if the negative effects of the test cause a cognitive load on students. The concept understanding test as a form of assignment that was imposed on students' cognitive had an unfavorable effect on students' working memory so it needs to be considered various ways to reduce cognitive load in order to improve student memory. There were various results of research that had been done to reduce the cognitive load of students through visualization of task design (Atiyat, 2018), integrating sources of information through practical work (Haslam & Hamilton, 2010), and eyeclosure (Vredeveltdt, Hitch, & Baddeley, 2011). The results of the study provided an overview of the efforts that had been made to reduce the cognitive load of students. Future research need to be considered how the test material, visual test, and test environment can be well designed to reduce the cognitive load on students.

Working Memory (WM) Directly Influences on the Heuristic Judgment (HJ)

The results of testing the effect of working memory on heuristic judgment are as follows.

$$HJ = 0.175 * WM, \quad \text{Errorvar.} = 85.272, \quad R^2 = 0.0445$$

(0.0555)	(8.263)
3.150	10.320

The calculation results of testing the effect of working memory on heuristic judgment shown in Figure 10 giving a coefficient value of 0.175 with t-value of 3.150. Because the t-value = 3.150 > 1.96, the path coefficient is significant. This can be interpreted that working memory (WM) directly affects heuristic judgment (HJ). The value of R^2 in this testing showed value of 0.0445. This means that 4.45% the variance of heuristic judgment (HJ) is explained by the variance of working memory (WM)

The conceptual understanding test that is worked by students with all the difficulties and negative stimuli that are present from the test sheet, provides a decrease in the function of recalling the material understood, not understood and the material partially understood. This set of memories will be more difficult to remember when working memory conditions are limited and the reduction in the connectivity function of the information remembered.

A set of information management occurred in the working memory of the brain haved by students. Information obtained enters the temporary storage space and long-term storage in working memory. Each student has a different working memory, this made working memory affect heuristic judgment. The limited ability of students' working memory will increase the use of heuristic judgment by students. The ability and inability to obtain accurate information in students' working memory processing causing to take actions based on heuristic judgment Based on research result Brunyé, Martis, & Taylor, (2018) showed the load of working memory increases the using heuristics during decision making. These conditions make students tend to use heuristic judgment to determine the choice answers in their tests. Heuristic judgment has the potential of students to make wrong choices and choices that are

not in line with their expectations.

There were two conditions that occur in student working memory where these conditions make students' working memory difficult to recall the information needed. These conditions were related to availability and accessibility. Availability refers to whether information was effectively stored in the memory system and was available at the time of retrieval, or whether the information was not available due to loss of power, damage or loss of certain information due to some form of interference (Cheie, Macleod, Miclea, & Visu-petra, 2016; Smith & Bayen, 2005; Woltz & Was, 2006). Whereas Accessibility refers to whether the information available can be accessed at the time of collection or whether it cannot be accessed due to the lack of appropriate retrieval cues (Dowd, Kiyonaga, Beck, & Egner, 2015; Unsworth, Spillers, & Brewer, 2012).

The availability of information in working memory storage space will be easy to recall if conditions that cause existing information can be suppressed to a minimum. The loss of strength when recalling due to nervousness and the time pressure during the test causes the process of remembering available information cannot be remembered properly. While accessibility has an important role to connect certain cues so that the process of remembering it can be done well. In addition to the two conditions above, it is also necessary to pay attention to the condition of information storage space in working memory, namely short-term and long-term.

Information entered in the long-term storage room will be easy to recall unless there is a mental condition in students that causes the ability to decrease. But it is different in the information stored and entered in the temporary storage room or short-term. This storage room does not last long in students' memories and is easy to forget. Therefore this condition needs special attention. When students try to remember information that is in the storage of short-term memory requires mental and strong enough cues for its success to recall. If this condition is exacerbated by the condition of other disturbances in students, the difficulty in remembering the information needed will fail. The conditions that are not in accordance with the expected are what cause students to look for other cues that are not related to the material being tested. The use of heuristic judgment when the high working memory causes a set of heuristic-based searches is used by students to give decisions or choices based on heuristics.

Cognitive Load (CL) Indirectly Influence on the Heuristic Judgment (HJ)

The result of testing the indirect effect of cognitive load on heuristic judgment was as follows.

Indirect Effects of X on Y

	CL

WM	- -
HJ	0.072
	(0.025)
	2.837

The results of testing the effect of cognitive load on heuristic judgment above gives a coefficient value of 0.072 with t-value of 2.837. Because the t-value = 2.837 > 1.96, the path coefficient is significant. This means that cognitive load has an indirect effect on heuristic judgment (HJ)

There is an indirect effect of cognitive load on heuristic judgment. These results indicate that cognitive load affects heuristic judgment indirectly through working memory. The high

cognitive load on conceptual understanding test of the human regulation system. The cognitive load increasing was affected by the limited working memory ability in recalling the material tested. The inability of working memory to provide accurate information in answering tests caused the high use of heuristic judgment as an alternative to choosing answers to tests of the human regulatory system. Some research results showed the presence of heuristic judgment as a result of cognitive load and working memory (Allred et al., 2016; Blumenthal-Barby, 2016; Langley & Com, 2017)

The presence of a cognitive load on the conceptual understanding test of the human regulatory system did not only lead to the use of heuristic judgment in making judgments or choices. But the presence of cognitive load also affected the duration of judgment made by students. This could be seen from the time given to take the concept understanding test that most students postpone answers and give answers at the end of time. The results of research conducted by Block, Hancock, & Zakay, (2010) provide reinforcement that cognitive load affects the duration of judgment.

CONCLUSION

Hypothesis testing results showed two hypotheses to test the effect directly have a significant positive effect directly, namely cognitive load on working memory, and working memory on heuristic judgment. While one hypothesis had a significant indirect effect, namely cognitive load on heuristic judgment through working memory.

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