Does system thinking.pdf

WORD COUNT 2911
TIME SUBMITTED 07-MAR-2021 11:04AM
PAPER ID 69681056

Does system think in climate change content needs formal operational?

Does system think in climate change content needs formal operational?

M Meilinda[1,2*], N Y Rustaman[1], H Firman[1] and B Tjasyono[3]

[1]Departemen Pendidikan IPA Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia
[2]Departemen Pendidikan Biologi, Universitas Sriwijaya, Jl Raya Palembang Prabumulih Km. 35, Indralaya, Ogan Ilir 30862, Indonesia
[3]Departemen Meteorologi, Institut Teknologi Bandung, Jl. Ganeca No. 10, Lb Siliwangi, Coblong 40132, Indonesia

[*]meilinda@fkip.unsri.ac.id

Abstract. This research aims to know the impact of formal operational in system thinking skills on climate change content through climate change course which is using system approach epistemology. The research design is quasi experiment by comparing groups of students with formal pre-operational and operational on two lectures i.e. human and environment (n=34) and Earth and Space Science (n = 30). Testing the level of students reasoning are using reasoning test TOLT and CCSTI (Climate Change System Thinking Instrument) for testing student system thinking skills. The results showed that the level of students ' reasoning on the lecture of the human and environment affect the system thinking skills especially Indicators III and IV indicators with a value of Cronbach alpha 0.048< 0.005 and 0.008<0.005 Meanwhile the level of reasoning has no effect on student teachers of physical education with the Cronbach alpha value of 0.005 >. Based on the value of Cronbach Alpha obtained, it can be concluded that it was not a formal knowledge which affects the system thinking skills in climate change content but the prerequisites knowledge and post formal operational.

1. Introduction

System thinking or thinking about the systems, becomes a necessity in learning science because the content of science is hierarchical and interconnected [1]. Although they are parts of science but each has different system character. The system in the field of Biology is known as the organization of living systems, in the field of physics known as the solar system, earth systems and particle systems [2], and in the chemical field known as macro, micro and symbol [3].

The inability of system thinking on complex system issues such as climate change can be identified from the inability to link the interrelationship between environmental issues, such a perception that global climate change is caused by the effects of greenhouse gases and ozone holes [4-11]. The greatest impact of the system's inability to think is that people believe that global climate change has no impact on their lives [5].

The complexity of system thinking makes system thinking fall into the category of higher order thinking skills [12,13]. This skill crosses with some other high-level skills [12,13]. As a form of high-level skill, it is assumed that formal operational or formal reasoning will be one of the variables affecting

the skill, especially in the context of climate change which is an abstract and complex material. Formal reasoning or formal operational is needed, so the students are able to relate facts, data, and science products learned in class with a scientific explanation of scientist. In other words, a well reasoning will help students "see" the truth of scientific conception of scientists [14].

Most of the research linking between formal operational to learn achievements, only in term of memorizing facts and concepts, scientific investigations and testing hypotheses and other procedural knowledge. The results show that the level of reasoning is not relevant to the learning achievement. But if the achievement is measured by scientific investigation and testing of hypotheses and other procedural knowledge, then formal operational is highly relevant and a very good predictor of the learning achievement [15-18]. However, there has not been a research found a research that links formal operational with system thinking. This study is important because system thinking is a way to think about complex and coherent systems while formal reasoning is a phase of reasoning which from a single logical system or a linear assumption [19-21]. Thus, a research need to be conducted to see whether formal operational phase impacts on the system thinking skill specially in climate change content?

2. Method

This research uses quasi-experiment method to see the effect of independent variable, i.e. the level of reasoning of the students who have taken climate change course with epistemology system approach to their system thinking skill in climate change content. The student's reasoning level was measured using the instruments Test of Logical Thinking (TOLT) [22] while the system thinking skills in climate change content were measured using Climate Change System Thinking Instrument (CCSTI) developed by Meilinda et al., [23]. Based on the TOTL [22], students who have taken climate change course with epistemology system approach are divided into two groups that have pre-formal operational and those formal operational reasoning. Based on TOLT test result, 24 students who have taken climate change course that embedded with the lectures of human and environment have pre-formal operational reasoning and 9 students have formal operational reasoning. While for the group of students who have attended climate change course that embedded Earth and Space Science lecture, 10 students have pre-formal operational reasoning and 20 people have formal operational reasoning.

3. Result and discussion

To see the difference of system thinking in climate change content at pre-service teacher of Biology and Physic at level of pre-formal and formal operational reasoning, a different test of *n-gain* data is performed. The result of difference means of n-gain in system thinking skill in pre-formal and formal operational reasoning on biology pre-service teacher can be seen in table 1.

Table 1. The result of statistic test of mean n-gain thinks of biology pre-service teacher.

Indicator	Group	*M*	*SD*	*t*	*u*	*p*	*ES*
Total	Formal	0,40111	0,085651	3.022	-	0,005	1,22
	Pre-formal	0,28656	0,101150				
Basic System Thinking	Formal	0,3240	0,141198	-	109,5	0,906	-
	Pre-formal	0,3244	0,175869				
General System Thinking	Formal	0,40311	0,155867	-	67,00	0,074	-
	Pre-formal	0,27624	0,166563				
Cybernetic System Thinking	Formal	0,57778	0,210819	2.117	-	0,042	0,85
	Pre-formal	0,37800	0,252521				
Dynamic	Formal	0,51933	0,114575	2.851	-	0,008	1,23
	Pre-formal	0,32948	0,186437				

Normal: n_{formal}= *9; $n_{pre\text{-}formal}$= 25; M* = Mean; *SD*= Standard Deviasi; *t*= statistik t; *u*= Mann Whitney *p*=Probabilities value; *ES* = *effect size*; * Significant 0,05

On table 1 can be concluded that the reasoning level in the climate change study program with the YSBC learning approach has an impact on the thinking skill of the prospective teacher system from the Biology Education Study on the total data, Indicators III and IV (ES is very high) but not significant in Indicator I and II. The comparison of n-gain data on formal and pre-formal operational groups can be seen in figure 1.

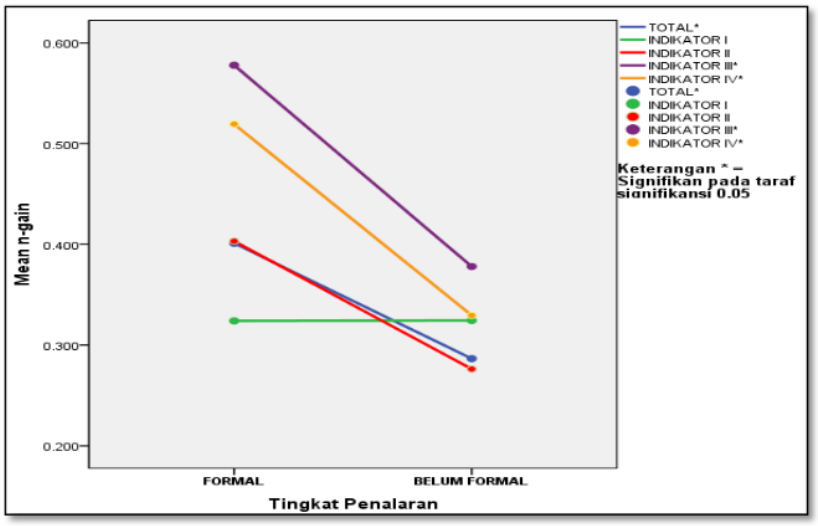

Figure 1. Comparison of mean n-gain in pre-formal and formal operational groups.

Figure 1 shows that the biology pre-service teacher, despite having a mean n-gain not significantly different from the basic system thinking (Indicator I) and generic system thinking (Indicator II), but in the generic system thinking indicator, formal operational group has a higher mean n-gain than pre-formal operational. Meanwhile, on the total data, cybernetic system thinking and dynamic system thinking of n-gain mean are significantly different.

In physics preservice-teacher, the means n-gain in pre-formal and pre-formal operational are normal and homogeneous except in basic system thinking indicator which is not normally distributed but homogeneous can be seen in table 2.

Table 2. The result of the difference test on mean n-gain at physics Pre-Service Physics.

Indicator	Group	*M*	*SD*	*t*	*u*	*p*	*ES*
Total	Formal	0,35555	0,084866	1.579	-	0,126	-
	Pre-formal	0,29900	0,106750				
Basic System Thinking	Formal	0,38790	0,198780	-	71,00	0,197	-
	Pre-formal	0,28670	0,188411				
General System Thinking	Formal	0,37125	0,138904	0,801	-	0,430	-
	Pre-formal	0,32500	0,168325				
Cybernetic System Thinking	Formal	0,29750	0,268757	0,131	-	0,897	-
	Pre-formal	0,28500	0,191558				
Dynamic System Thinking	Formal	0,35105	0,135955	0,809	-	0,425	-
	Pre-formal	0,30840	0,136221				

Note: $n_{formal} = 20$; $n_{pre\text{-}formal} = 10$; *m* = means; *SD*= Standart deviation; *t*= t statistik value; *u*= u Statistic value statistik u; *p*=probabilities; *ES* = *effect size*; * Signifikan 0,05

Table 2 shows that the physic pre-service teachers formal operational in the climate change course with epistemology system approach has no impact on system thinking skills, either on the total data or on each indicator. Comparison of n-gain data in pre-formal and formal operational groups Physic pre-service teacher can be seen in Figure 2.

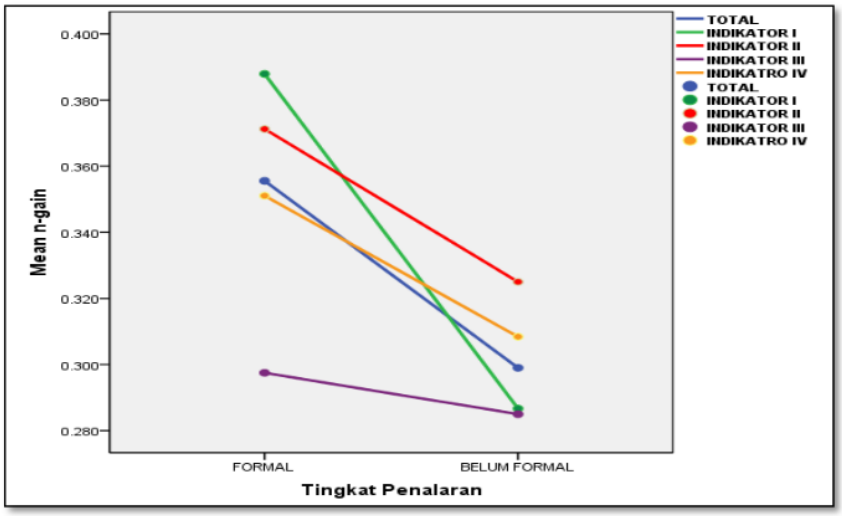

Figure 2. Comparison of mean n-gain in pre-formal and formal operational in physic groups.

In Figure 2, it can be seen that the formal operational group, has the highest n-gain on basic system thinking compared to other indicators, while the pre-formal operational haslowest indicator in basic system thinking. Nevertheless, there is no significant difference between formal and pre-formal operational groups in these indicators.

In biology pre-service teachers, there are significant differences in total data, cybernetic system thinking and dynamic system thinking indicatorbetween pre-formal and formal operational. The significant difference on that reading pattern and modeling system (cybernetic system thinking indicator) and prediction and retrospection (dynamic system thinking indicator) are the indicator that cannot be facilitated by climate change course with epistemology system approach for student with pre-formal operational.

Students with pre-formal operational are able to read simple/linear patterns [24] than reading patterns and modeling in a system as a part of the cybernetic system thinking indicator. Because that indicators are complicated and consist of multilevel pattern [3,25,26] which resembles the modeling diagram. Meanwhile the ability of pre-formal operational pre-service teacher to predict is gained from trial and error [27]. Based on the data, it can be concluded that the role of formal operational is quite dominant in both, cybernetic and dynamic system indicator perform this statement Parmendes an ancient Greek philosopher stated that truth can only be achieved by reasoning, because reasoning helps students make deductive hypotheses, reading patterns and predicting even abduction [28].

Thinking the system is a difficult skill because it's a part of higher order thinking (HOTS) that requires very good reasoning to be able to do it. This fact reinforces the principle of Popper transference [29] which states that what is true according to logic is a truth in science. Because empirical studies in hands on and minds on activities area simply tools for students with pre-formal operational to reach the inductive hypothesis. as for students with formal reasoning, activity in the learning process is a tool to strengthen the conception of owned [28].

On physic pre-service teacher, although means n-gain of formal operational group is higher than then means n-gain of pre-formal operational group but there was no significant difference on total data and each indicator. Prerequisite knowledge that obtained from Earth science and space are able to influence

from pre-formal operational to construct their knowledge so as good as formal operational groups in system thinking.

In the system thinking skill, the value obtained by students does not reach 50% of the perfect score (100%) in both pre-formal operational and formal operational. This is because to understand the system, reasoning is required beyond formal operational i.e. post formal operational [30].

The Post formal is not a full formal operational [31]. Nevertheless, there is an indicator of Post-formal operational that has a relationship with formal operational i.e. analyzing the relationship or interrelation thinking that links the propositions [32]. Indicators of post-formal operational are systematic reasoning, metasystemic reasoning, paradigmatic and cross paradigmatic with each level having a complex sub-hierarchy. This skill has a higher level of formal reasoning [32]. There are three main characters of post-formal operational development, the first character, aware of the relativity and the essence of knowledge that is not absolute. The second character, accepting contradictions as part of reality. The third character, integrates all the contradictions found, in a single unit [27,30]. So, it is natural that until now there has been no single intervention in research that is able to solve students' system thinking skills on all indicators [25, 33].

4. Conclusion

The reasoning level of physics pre-service who follow climate change course program with epistemology system approach with knowledge of prerequisite from science and earth science lecture has no influence on system thinking skill while the level of reasoning of biology pre-service teacher who follow climate change course program with epistemology system approach with knowledge of prerequisite from human and environment lecturing have influence on system thinking skill especially to total data, cybernetic system thinking indicator and dynamics system thinking indicator. So the influence of system thinking not only formal operational but also prerequisite knowledge and post-formal operational.

References

[1] Gharajedaghi J 2011 *Systems Thinking: Managing Chaos and Complexity a platform for designing business architecture* (Burlington, MA: Morgan Kaufmann) p 343
[2] Klir G J 1991 *Facets of Systems Science* (Binghamton, New York: Kluwer academic/Plenum Publisher) p 600
[3] Gilbert J K and Treagust D F 2009 *Int. J. of Sci. Ed.* **31** p 336
[4] Meilinda, Rustaman N Y and Tjasyono 2017 *J. Pendidik. IPA Indones.* **6** p 292
[5] Pruneau D 2011 *Can. Jounal Environ. Educ.* **6** p 121–138
[6] Khalid T 2003 *Environ. Educ. Res.* **9** p 35–50
[7] Daniel B, Stanisstreet and Boyes M E 2004 *Int. J. Environ. Stud.* **61** p 211–222
[8] Leiserowitz A 2006 *J. Clim. Change* **77** p 45–72
[9] Pekel F O and Ã–zay E 2005 *Appl. Environ. Educ. Commun.* **4** p 115–123
[10] Kilinc A, Stanisstreet M and Boyes E 2008 *Int. J. Environ. Sci. Educ. Educ.* **3** p 89–98
[11] Ryghaug M, Holtan S K and Naess R 2011 *Public Underst. Sci.* **20** p 778–795
[12] Richmond B 1993 *Syst. Dyn. Rev.* **9** p 113–133
[13] Zoller U and Nahum T L 2012 *Second International Handbook of Science Education* **1** ed Fraser B J, Tobin K B, McRobbie J C (New York: Springer) p 606
[14] Posner G J, Kenneth S A, Hewson P W and Gertzog W A 1982 *Sci. Educ.* **66** p 211–227
[15] Cohen H D, Hillman D F and Agne R M 1978 *Am. J. Phys.* **46** p 1026–1029
[16] Barnes J 1977 *Philos. Books* **18** p 109–110
[17] Griffiths D H 1976 *Am. J. Phys* **44** p 81–85
[18] Lawson A E *J. Res. Sci. Teach.* **22** p 569–617
[19] Reeese H W and Overton W F 1970 *Life-Span Developmental Psychology*
[20] Bond T G 2005 *Pendul. Sci. Hist. Philos. Educ. Perspect.* p 303–313
[21] Piaget J 1972 *Hum. Dev.* **15** p 1–12

[22] Tobin K and Capie W 1983 The influence of wait-time on classroom learning *Eur. J. Sci. Educ.* **5** p 35–48
[23] Meilinda, Rustaman N Y, Firman H, Tjasyono B T (in press) *Proc. Int Conf in Math. Sci. and Com. Sci. Ed.* (Bandung)
[24] Eilam B and Reisfeld D 2017 *A Curriculum Unit for Promoting Complex System Thinking: The Case of Combined System Dynamics and Agent Based Models for Population Growth* **2** p 39–60
[25] Hahlweg K 1983 *The Evolution of Science: A Systems Approach* (Canada: Western University press) p 220
[26] Levy S T and Wilensky U 2009 *J. Sci. Educ. Technol.* **18** p 224–242
[27] Siegler R S and Richards D D *Dev. Psychol.* **16** p 161
[28] Lawson A E and Thompson L D 1988 *J. Res. Sci. Teach.* **25** p 733–746
[29] Popper K R 1979 *Objective Knowledge an Evolutionary Approach* (UK: Oxford University Press)
[30] Commons M L, Richards F and Kuhn D 1982 *Child Dev.* **53** p 1058
[31] Kallio E 1995 2
[32] Commons M L and Richards F A 2016 *Systematic and Metasystematic Reasoning: A Case for Levels of Reasoning beyond Piaget' s Stage of Formal Operations* Ed Michael L, Commons, Francis A, Richards Kuhn D (New Jersey: Wiley) **53** p 1058–1069

Does system thinking.pdf

ORIGINALITY REPORT

83%

SIMILARITY INDEX

PRIMARY SOURCES

1	M Meilinda, N Y Rustaman, H Firman, B Tjasyono. "Does system think in climate change content needs formal operational?", Journal of Physics: Conference Series, 2019 Crossref	2031 words — 83%
2	ipse.upi.edu Internet	10 words — < 1%

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	ON		