Jurnal Penelitian dan Pembelajaran IPA JPPI
Vol. 6, No. 2, 2020, p. 225-240 p-ISSN 2477-1422 e-ISSN 2477-2038

An Analysis of the Scientific Attitudes of Fifth Graders through Guided Discovery Learning

(Received 10 February 2020; Revised 25 November 2020; Accepted 25 November 2020)

Amelia Fahrunisa[1*], Ali Mustadi[2], Restu Waras Toto[3], Pratiwi Pudjiastuti[4]

[1,2,3,4]Department of Basic Education, Faculty of Education,
Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

Corresponding Author: *ameliafahrunisa.2019@student.uny.ac.id

DOI: 10.30870/jppi.v6i2.4704

Abstract

This study is aimed to investigate the effect of guided discovery learning (GDL) on the fifth graders' scientific attitudes. A teaching intervention was planned based on GDL which was then practiced in the two science classes (each class with n = 17) at Public Primary School (PPS). The data were collected through questionnaires and were analyzed by comparing the scores of initial and final scientific attitudes of the control and experimental group using independent-samples T-test and the categorization table. The research results show that GDL positively affected the fifth graders' scientific attitudes. There is a significant difference in the students' final scientific attitudes scores [$t(32) = -3.591; p < 0.05$]. This finding implies that GDL is an alternative learning scheme that can be accommodated to foster students' scientific attitudes. Fostering scientific attitudes builds students' resilience to cope with today's and tomorrow's hoaxes and misconceptions.

Keywords*:* Scientific Attitudes, Fifth Graders, Discovery Learning

INTRODUCTION

Science is one of the subjects in primary school. Students are not only driven to engage in some cognitive-based activities, but also activities to foster their scientific process (Kastner & Knight, 2017; Luk, 2010; Reif, 1998) and attitudes (K. S. Adams & Christenson, 2000; Bidegain & Mujika, 2020; Candrasekaran, 2014; Hungerford, Volk, & Ramsey, 1990; Morales, 2015; Olasehinde & Olatoye, 2014). Teachers have inevitable jobs to create hands-on activities as well as minds-on activities. The students are encouraged to observe, classify, predict, design, and carry out activities such as experiment and demonstration. These activities, however, should ignore any subjective assumptions made by individual or group of students. The students must be able to demonstrate scientific attitudes which prioritize objectivity when they are engaged in a scientific quest either in class or in their daily lives.

The urgency of building students' scientific attitudes (Kurniawan et al., 2019) is also parallel with the latest demand from our society, especially among Indonesians: tackling the hoaxes and misconceptions. There have been hoaxes circulated these days (Idris, 2019) caused by the lack of scientific attitudes among society members. The effects of both issues are pretty devastating to the Indonesian society. Preventive efforts with education to tackle this communal problem Badriyah (2017) should be massively designed, organized, and carried out as early as possible. Educational institutions, especially schools, are the place where young people developing their attitudes. The inculcation of scientific attitudes in primary school will equip students with a set of affective abilities needed to filter all incoming information gathered by students from various sources. Students' well-developed scientific attitudes will increase their resilience against hoaxes and misconceptions. In addition, there have been many studies related to students' scientific attitudes (Kennedy, Latham, & Jacinto, 2016).

Learning process dominated by direct method is an orthodox choice in today's learning paradigm. There have been a vast number of learning models which can be implemented on science (Bamiro, 2014; Grobmann & Wilde, 2019; Lin, 2018) by teachers to improve students' scientific attitudes (Liou, 2020; Noviyanti, Rusdi, & Ristanto, 2019; Secgin & Sungur, 2020)**.** Prior to this study, the study aimed to reveal the effect of Guided Discovery Learning (GDL) on students' scientific attitudes has never been attempted in the fifth graders at PPS (Public Primary School). Based on rows of observations and interviews which targeted some teachers and students in that school, the learning process has primarily been done through expository learning. Teachers have little experience in directing learning process focused in hands-on activities. Therefore, the students' scientific attitudes have not optimally developed yet. An empirical study should be carried out to disclose the effect of GDL towards the fifth graders' scientific attitudes at PPS. The impact of GDL needs to be revealed in order to give teachers recommendation in promoting students' scientific attitudes.

In the context of discovery learning, students explore their learning environments by employing the dominance of students' role within an inductive learning process, doing experiments, collecting data, and generating conclusion (Abruscato & Derosa, 2010; Saab, van Joolingen, & van Hount-Wolters, 2009). Students are required to engage in the process of scientific inquiry through discovery (van Joolingen et al., 2005; van Joolingen, de Jong, & Dimitrakopoulout, 2007). Students' learning activities are more meaningful when students look for and discover knowledge, rather than just being passive receivers of knowledge with discovery learning (Abdisa & Getinet, 2012; Chi, 2009; Hodge, 2007). Therefore, teachers must view themselves as more of a facilitator than a figure that knows everything (Hodge, 2007). Teachers become the part of a learning community where students involve to the material and have possession regarding their individual learning processes. Group activities are usually accommodated in the discovery learning (Reynolds, 2016; Saab et al., 2009) (Reynolds, 2016; Saab et al., 2009). A common learning goal planned in the scope of dyads or small groups gives students opportunity to externalise their ideas (van Boxtel, van der Linden, & Kanselaar, 2000), learn to negotiate with their peers and construct new knowledge (Chan, Burtis, & Bereiter, 1997). Teachers must also realize that guided discovery is actually *not* a group work; it is implemented through group work (Dumitraşcu, 2009). This can be inferred that discovery learning, in fact, does *not* endorse cooperative learning.

Discovery learning is actually derived from the constructivist learning – an active learning process that involves students to build their own knowledge by discovering the targeted information independently (Mayer, 2004). Many studies related to discovery learning lean to focus on specific subjects, especially mathematics, computer skills, science (Honomichi & Chen, 2012), problem solving, and physical/motor skills (Alfieri et al., 2011). The implementation of discovery learning in science must encourage students to make simple observation and make hypotheses and ideas to be tested (Lavine, 2005; Shrager & Klahr, 1983). Teachers must also understand that discovery learning can be positioned on a scale ranging from independent discovery or pure discovery to guided discovery learning and controlled-insightful learning (Zydney et al., 2012). This paper discusses GDL as one of the variations of discovery learning.

GDL, on other hand, is an instructional model in which students are given guidance to accomplish and to discover predetermined outcome (Mukherjee, 2015). The predetermined goal usually requires students to find some general principle by studying specific situations (Mandrin, 2010) GDL demands a plenty use of questions which often focused on learning, exploring, and solving various problems (Scott & Freeman, 2010). Teacher's guidance can be expressed through suggestions, directions, questions, or hints. The guidance from other people who are more competent than students, including teachers, is called *scaffolding* (Westwood, 2008). Discovery-based instruction can be implemented as the effort to make students become more proactive and independent on finding explanation regarding on what they can see, hear, and touch rather than on personal or speculative opinions (Chalmers, 2013). Therefore, GDL gives teachers the opportunity of accommodating hands-on activities. This can be inferred that the presence of hands-on activities in GDL supports one of the learning objectives: developing scientific attitudes.

GDL was chosen to be implemented because discovery learning in its pure configuration was slowly replaced by guided discovery as the failure of pure discovery became apparent (Sweller, Krischner, & Clark, 2007). GDL itself can further be classified into highly guided discovery and minimally guided discovery instruction (Baroody, Purpura, Eiland, & Reid, 2015; Zydney et al., 2012). In this research, the aforementioned dichotomy of GDL was not strictly implemented because the teacher gave guidance if students really needed it. The scheme of GDL in this research was adapted from reference (Bundu, 2006). The stages of GDL are (1) exploration (students explore the objects or events) (2) conceptions invention (students identify, infer, and conclude the patterns as the new knowledge); (3) discovery (the new knowledge is utilised by students to solve new problems). This scheme was chosen because it was more general and more feasible than other proposed arguments regarding the stages of GDL.

Scientific attitudes are a set of attitudes related to a particular opinion, or perspective accepted by individual because of consideration about the physical objects in science (Moore & Sutman, 1970). Teachers must understand that scientific attitudes should not only be assessed to the science but extent (Perwitasari & Djukri, 2018). Scientific attitudes are about the habituation and demonstration of various moral values in doing a scientific quest. Scientific attitudes are completely different from attitudes towards sciences. The attempt to foster students' scientific attitudes through learning will elicit their awareness to become a good person who has characters associated with nobility (Samatowa, 2010). Attitudes towards science are only focused in someone's interest to science, whether she/he likes science or not. This research, however, was merely carried out in the science subject.

Scientific attitudes are crucial competency to be developed because students' scientific mindset, scientific attitudes, and interests are also enhanced and empowered in the instructional process (Bundu, 2006). Jaleel & Philip (2017) clearly states that students who possess better scientific attitude will always keen to acquire new ideas that will surely lead to a better achievement in cognitive area. Moreover, scientific attitudes have the relatively permanent impact on the students. Scientific attitudes are continuously effective and can even be observed after the content of the subject has been delivered or students have forgotten of it (Bundu, 2006). The sub-scientific attitudes in this research were synthesized from reference (de Boo, 2006; Gega, 1966; Harlen & Jelly, 1989). Students' curiosity, critical thinking, cooperation with others, perseverance, creativity and inventiveness, open-mindedness, respect for evidence, and sensitivity to the environment were measured and analyzed. Therefore, this study aims to determine and analyze the effect of the application of guided discovery learning on the scientific attitudes of elementary school students.

METHOD

The research was a quasi-experimental research in form of nonequivalent control group design. The study conducted on first semester in academic year 2019. More details can be described in the following.

Participants

The GDL as teaching intervention was applied into practice in two fifth grade classes. Each class consisted of 17 students from one school in out in PPS in Bantul, Special Region of Yogyakarta, Indonesia. One of the classes was labeled as the control group whereas the other class as the experimental group. The group labeling was randomly established by using lottery so that the assigned label of each group was beyond researcher's intention.

Research instruments

The research instrument in this study was a questionnaire. The questionnaire about students' scientific attitudes was filled out by students before and after GDL intervention.

Procedure

The intervention lasted 3 weeks. The researcher took a role as the science teacher in both classes. During the intervention in the experimental group, students were involved in GDL that consisted of some activities such as assembling learning tools, doing experiments, gathering information from observations towards concrete objects, sharing ideas with peers, and inferring new knowledge. All of the aforementioned activities were carried out via small group learning in which each group contained 3-4 students. The expository learning through small group learning was intentionally implemented in the control group as the benchmark. Indicators of students' scientific attitudes used in this study is explained in Table 1.

Table 1.Indicators of Student's Scientific Attitudes

Dimension	Indicators
Curiosity	Attention to the object being observed
	Enthusiastic about the scientific process
	Attention to the teacher's explanation
Respect for evidence	Objective/honest
Critical thinking	Solve new problems with the understanding that has been obtained
	Don't ignore data even if it's small
Creativity and inventiveness	Use facts to do the worksheet
	Shows different reports with classmates
	Outlining new conclusions from observations
Open-mindedness	Respect other people's opinion
	Receive teacher guidance
Cooperation with others	Active in group discussion
	Interaction with group members
Perseverance	Consistency in conducting inquiry activities
	Checking the steps that have been implemented
	Follow the work instructions as directed by teacher
	Checking the completeness of the contents in worksheet
Sensitivity to the environment	Attention to events around them
	Participation in social activities

Data collection and analysis

The data were collected through questionnaires and were analyzed by comparing the scores of initial and final scientific attitudes of the control and experimental group using independent-samples T test and the categorization table.

Table 2**.** The Categorization of Students' Scientific Attitudes Scores

Score Range	Category
Score < 69.27	Low
69.27 ≤ Score ≤ 89.48	Intermediate
Score > 89.48	High

Based on Table 2, there are three categories of students' scientific attitudes such as low, intermediate, and high.

RESULTS AND DISCUSSION

The effect of GDL intervention on students' scientific attitudes was determined on the base of the scores obtained from scientific attitudes questionnaires. The scores of the students obtained from the scientific attitudes questionnaires before and after the GDL were then determined. The scores of the questionnaires were analyzed using independent sample T test to determine the effect of GDL implementation on students' scientific attitudes and the scores were categorized based on Table 2. The independent-samples T test results regarding the scores are explained in Table 3 and Table 4.

Table 3. The T-Test Result Regarding the Initial Scientific Attitudes from Questionnaires

Class	N	Mean	df	t	p
Control	17	64.29	32	-0.069	0.945
Experimental	17	64.47			

Based on Table 3, there is no significant difference in the students' initial scientific attitudes scores [t(32) = -0.069; p > 0.05). This finding indicated that both groups were equivalent. Prior to the teaching intervention, the mean of the control and experimental was 64.29 and 64.47 respectively.

Table 4. The T Test Result Regarding the Final Scientific Attitudes from Questionnaires

Class	N	Mean	df	t	p
Control	17	64.12	32	32	-3.591
Experimental	17	72.97			

Based on Table 4, there is a significant difference in the students' final scientific attitudes scores [$t(32)= -3.591$; $p < 0.05$]. After the teaching intervention, the control groups' average score slightly dropped to 64.12, whilst the control groups' increased to 72.97. All of the aforementioned findings support the claim that students' scientific attitudes were enhanced after GDL had been implemented.

Scientific attitudes consist of several sub-scientific attitudes. The detailed information concerning each sub-scientific attitude needs to be explained. The comparison of students' sub-scientific attitudes of both groups concerning the initial and final condition is explained in Table 5 and Table 6.

Table 5. The Detailed Information Regarding Control Group's Sub-Scientific Attitudes

Sub-scientific attitudes	Initial Average Scores		Final Average Scores		The Changes of Average Scores
	Scores	Category	Scores	Category	
Curiosity	85.8	Intermediate	83.1	Intermediate	-2.7
Respect for evidence	89.8	High	89.0	Intermediate	-0.8
Critical thinking	76.5	Intermediate	72.8	Intermediate	-3.7
Creativity and inventiveness	72.1	Intermediate	72.3	Intermediate	0.2
Open-mindedness	87.5	Intermediate	86.8	Intermediate	-0.7
Cooperation with others	77.9	Intermediate	81.6	Intermediate	3.7
Perseverance	82.4	Intermediate	81.4	Intermediate	-1
Sensitivity to the environment	77.2	Intermediate	83.5	Intermediate	6.3

Table 6. The Detailed Information Regarding Experimental Group's Sub-Scientific Attitudes

Sub-scientific attitudes	Initial Average Scores		Final Average Scores		The Changes of Average Scores
	Scores	Category	Scores	Category	
Curiosity	92.6	High	94.4	High	1.8
Respect for evidence	92.8	High	96.3	High	3.5
Critical thinking	74.0	Intermediate	88.7	Intermediate	14.7
Creativity and inventiveness	63.2	Low	90.4	High	27.2
Open-mindedness	83.1	Intermediate	92.7	High	9.6
Cooperation with others	89.0	Intermediate	90.1	High	1.1
Perseverance	90.8	High	91.5	High	0.7
Sensitivity to the environment	61.0	Low	87.9	Intermediate	26.9

After examination of the students' sub-scientific attitudes before and after the GDL implementation, it became apparent that students in the experimental group showed better improvement in all of the sub-scientific attitudes than students in the experimental group. Even though there was an increase in students' scientific attitudes before and after GDL was implemented, after the score were analyzed using the independent sample T test it showed that there was no significant effect before GDL was implemented and there was significant effect after GDL was implemented as in Table 3 and Table 4.

The top-three improvements were found in the students' creativity and inventiveness, sensitivity to the environment, and critical thinking. The initial and final scores of these aspects were increased from 63.2 to 90.04 (+27.2), 61.0 to 87.9 (+26.9), and 74.0 to 88.7 (+14.7) respectively. These figures in the compare students' average scores before and after the implementation of GDL.

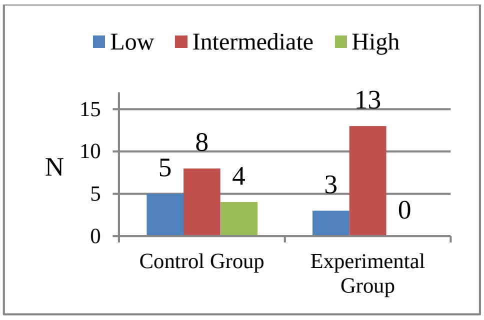

Figure 1. Students' Initial Scientific Attitudes

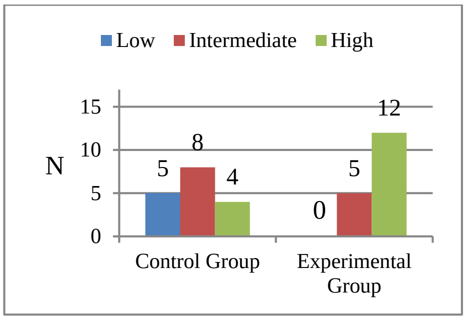

Figure 2. Students' Final Scientific Attitudes

The first stage of GDL is *exploration*. The scientific processes are relevant with the use of GDL because it is based on the assumption that education is process, not a set of facts (Smith, 2012). The implementation of GDL as a learning intervention in experimental group showed that students enthusiastically observed how the simple machines worked by doing simple experiments. Some students asked about the discrepancy between the knowledge which was found in books and their findings. Their excitement also came up because they had not seen almost all of the learning tools which were brought by the teacher. Learning activities that incorporate new things and new activities can "ignite" student's curiosity. This is relevant with the notion that upper-class students in primary school, particularly the fifth graders in this research, have high curiosity and learning enthusiasm (Samatowa, 2010). Smith (2012) clearly states that one of the advantages of GDL is its ability to foster students' scientific attitudes. The other benefits explained by

Lingyi (2010) are GDL's ability in supporting active learning process, through fostering students' curiosity and motivation, to enabling the development of lifelong learning skills.

The exploration was done by observing and manipulating simple machines (e.g. pulleys, inclined planes, wheels and axles, and levers). Teacher told the students not to manipulate the data which were collected from experiments and literature review. In other words, students were strongly prohibited to combine the results of the experiments with their own subjective views. Teacher reinforced them not to afraid of any discrepancy which was later detected in their findings. Students were also not expected to be dependent with other groups or students who were faster and more skilled in doing experiments. Teacher directed the group activities by reinforcing the maximal contribution of the students towards their own group. Abruscato & Derosa (2010) clearly state that student's honesty can be developed by GDL.

After all small groups had finished the experiments; they were obliged to communicate their findings through presentations. Other students were encouraged to pay attention and give constructive feedbacks. Teacher played the role as a moderator and facilitator to give every student the opportunity to participate in the brainstorming activity. Guidance was also given to the students who looked reluctant to articulate what they were going to say. The difference of force measurements and inferences sometimes emerged. This condition caused the teacher to give guidance concerning the correct ways of reacting to others' opinions, critics, and suggestions. This kind of guidance prevented confusion and uncontrolled debate among groups or students. Students who had misconceptions were encouraged to either assimilate or accommodate the true conceptions if theirs were proved wrong (Perwitasari & Djukri, 2018). The brainstorming activity and the students' acceptance of the guidance and true conceptions are two of the indicators regarding students' open-mindedness (Smith, 2012).

The stage number two is *conceptions invention*. Every student, along with peers, processed the data for producing meaningful and applicable knowledge. This finding is in line with the fact that creative pupil tends to combine relevant information in such novel ways (K. Adams, 2007). Students were guided to draw the conclusion by accommodating new knowledge. Students got the euphoria (Campos-Sanchez et al., 2012) of solving problems with knowledge which was semi-independently discovered by them.

Minds-on activities to reveal the principles and examples of simple machines from many sources are the manifestation of creativity. Another manifestation of creativity is group activity to assemble the learning tools. All of the learning tools were set not to ready to be used. Thus, inventiveness and creativity were well-fostered in the implementation of GDL.

In doing so-called experiments, students did the group-based activity such as assembling the learning tools, doing the experiment procedure, organizing the role of each member of the group, concluding the results of the experiments, and discussing the solution of the problems. These activities are quite complex. This caused students to be more cooperative, interactive, and participative to their teammates. During the very first time of learning intervention in the experimental group, students had no adequate skills in assembling and manipulating the experiment tools so they were driven in focusing their participation to help the group members. This was only possible if there was a common goal among group members (van Boxtel et al., 2000). GDL gave students chances to negotiate with their peers in constructing new knowledge (Chan et al., 1997). Science is a participation activity, and if the social aspects to be fully realised, students must have guided discovery activities involving interaction with others (Carin & Sund, 1989). From those findings, we can clearly conclude that GDL supports the inculcation of two sub-scientific attitudes: cooperation with others and sensitivity towards environment (students' social participation as well as sensitivity toward physical objects and events). Table 4 shows that student's cooperation with others (increased 3.7 points) and sensitivity to the environment (increased 6.3 points) have larger increment than the rest of sub-scientific attitudes. These findings are in favor of students' involvement in the cooperative learning which was practiced in both groups. Students of control group's sensitivity to the environment in have smaller score increment than students of experimental group's because they did not experience considerable amount of hands-on activities.

The third stage of GDL is *discovery*. The final conclusion which was produced in this stage helped students to solve various problems by implementing the newly acquired knowledge to several novel problems (Bundu, 2006; W. van Joolingen et al., 2005). Students were elaborated to use simple machines efficiently by maximizing their work principles. The discovery stage obviously depicts the fact that GDL not only does accommodate hands-on activities but also minds-on (thinking) activities. The majority of student successfully solved the problem by implementing the principles of simple machines which had been previously concluded from the experiments. This finding is in accordance with the notion that inquiry training model and GDL are equally effective in developed critical thinking (Smith, 2012). Students' critical thinking as one of the sub-scientific attitudes had been well developed in the implementation of GDL.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the GDL positively affected the fifth graders' scientific attitudes on science at TPPS. Yet, this research was carried out and accomplished with a lot of shortcomings. Future research should be attempted on the bigger population to generate the broader generalization regarding the effect of GDL towards scientific attitudes. This research was only carried out in the limited scope (two classes in a single school) so that the final generalization can exclusively be applied in the corresponding classes and school. Studying human nature using quasi-experimental design is almost inevitable because humans' free-will can still appear even if the researcher sets rules to be obeyed by them.

Indonesia's educational system has given a suitable environment to implement GDL. The use of scientific approach in the Curriculum 2013 in Indonesia is parallel with the implementation of GDL. The relevance between GDL and Curriculum 2013 has been clearly stipulated in the Ministry of Education and Culture Regulation Number 22 in the Year of 2016 about Standardized Learning Process for Primary Schools, Junior High Schools, and Senior High Schools. This regulation recommends the use of inquiry/discovery/problem-based/project-based learning (Ministry of Education and Culture, 2016).

Researchers suggest the implementation of GDL to the instruction. GDL, however, is not the one and only learning intervention which can be used to promoting students' scientific attitudes. There must be further research to reveal the ability of other learning interventions for fostering students' scientific attitudes. Students' scientific attitudes, therefore, must be consistently measured and evaluated in every learning process carried out by teachers. The consistent assessment of scientific attitudes will indirectly strengthen and conduct the inculcation of affective domain. GDL needs to be implemented simultaneously with the use of GDL-based student worksheet as a learning framework. The well-expressed scaffolding in the worksheet will make the scaffolding clearer and more understandable.

Being an objective person is increasingly demanded time by time. Consequently, person attributed with good attitudes is still highly appreciated in today's society. School, a formal institution where young people are trained, can integrate character education within the learning process, not in a separated manner. Teachers must choose the appropriate learning scheme to fulfill this objective.

REFERENCES

Abdisa, G., & Getinet, T 2012, 'The Effect of Guided Discovery on Students' Physics Achievement', *Latin-American Journal of Physics Education*, vol 6, no 4, pp. 530–37.

Abruscato, J., & Derosa, D. A 2010, *Teaching Children Science: A Discovery Approach*, Pearson Education Inc.

Adams, K 2007, *The Source of Innovation and Creativity*, NCEE.

Adams, K. S., & Christenson, S. L 2000, 'Trust and the Family-School Relationship Examination of Parent–Teacher Differences in Elementary and Secondary Grades', *Journal of School Psychology*, vol 38, no 5, pp. 477–97.

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H 2011, 'Does Discovery-Based Instruction Enhance Learning?', *Journal of Educational Psychology*, vol 103, no 1, pp. 1–18.

Badriyah, S 2017, Melawan Hoax Lewat Pendidikan', viewed 20 November 2020, < https://jateng.tribunnews.com/2017/01/19/melawan-hoax-lewat-pendidikan>.

Bamiro, A. O 2014, 'Effects of Guided Discovery and Think-Pair-Share Strategies on Secondary School Students' Achievement in Chemistry'. *SAGE Open*, pp. 1–7.

Baroody, A. J., Purpura, D. J., Eiland, M. D., & Reid, E. E 2015, 'The Impact of Highly and Minimally Guided Discovery Instruction on Promoting The Learning of Reasoning Strategies for Basic Add-1 and Doubles Combinations', *Early Childhood Research Quarterly*, vol *30*, pp. 93–105.

Bidegain, G., & Mujika, J. F. L 2020, 'Exploring the Relationship between Attitudes toward Science and PISA Scientific Performance', *Revista de Psicodidactica (English ed.)*, vol 25, no 1, pp. 1–12.

Bundu, P 2006, *Assessing Scientific Process Skills and Scientific Attitudes in Primary School Science Education*, Department of National Education of Indonesia.

Campos-Sanchez, A., Martin-Piedra, M.-A., Carriel, V., Gonzales-Andrades, M., Garzon, I., Sanchez-Quevedo, M.-C., & Alaminos, M 2012, 'Reception Learning and Self-Discovery Learning in Histology: Students' Perceptions and Their Implications for Assessing the Effectiveness of Different Learning modalities', *Anatomical Sciences Education*, pp. 1–8.

Candrasekaran, S 2014, 'Developing Scientific Attitude, Critical Thinking and Creative Intelligence of Higher Secondary School Biology Students by Applying Synectics Techniques', *International Journal of Humanities and Scial Science Invention*, vol 31, no 6, pp. 1–8.

Carin, A. A., & Sund, R. B 1989, *Teaching Science through Discovery*, Merrill Publishing Company.

Chalmers, A. F. 2013, *What is This Thing Called Science?*, Hackett Publishing Company, Inc.

Chan, C. K., Burtis, J., & Bereiter, C. 1997, 'Knowledge Building As A Mediator of Conflict in Conceptual Change', *Cognition and Instruction*, vol 15, no 1, pp. 1–40.

Chi, M. T. H 2009, 'Active-Constructive-Interactive: A Conceptual Framework for Differentiating Learning Activities', *Topics in Cognitive Science*, vol 1, no 1, pp. 73–105.

de Boo, M 2006, Science in The Early Years' in Harlen. In N. Serret & S. Earle (Ed.), *ASE Guide to Primary Science Education*, ASE.

Dumitraşcu, D 2009, 'Integration of Guided Discovery in the Teaching of Real Analysis', *PRIMUS*, vol 10, no 4, pp. 370–80.

Gega, P. C 1966, *Science in Elementary Education* (Third), John Wiley and Sons.

Grobmann, N., & Wilde, M 2019, 'Experimentation in Biology Lessons: Guided Discovery through Incremental Scaffolds', *International Journal of Science Education*, pp. 1–23.

Harlen, W., & Jelly, S 1989, *Developing Science in the Primary Classroom*, Heinemann.

Hodge, J. K 2007, 'The Top Ten Things I Have Learned about Discovery-Based Teaching', *PRIMUS*, vol 16, no 2.

Honomichi, R. D., & Chen, Z 2012, 'The Role of Guidance in Children's Discovery Learning', *WIREs Cognitive Science*, vol *3*, pp. 615–622.

Hungerford, H. R., Volk, T. L., & Ramsey, J. M 1990, *Science-Technology-Society: Investigating and Evaluating Sts Issues and Solutions : A Worktext for Sts Education*, I Stipes Pub Llc.

Idris, I. K 2019, Studi: Hoaks Rentan Disebar Oleh Mereka yang Tingkat Pendidikan dan Penghasilannya Rendah, Viewed 16 October 2020,<https://nationalgeographic.grid.id/read/131849274/studi-hoaks-rentan-disebar-oleh-mereka-yang-tingkat-pendidikan-dan-penghasilannya-rendah?page=all>

Jaleel, S., & Philip, S 2017, 'A Study on The Relationship Between Scientific Attitude and Achievement in Physics of Secondary School Students', *International Education & Research Journal*, vol 3, no 2, pp. 29–30.

Kastner, S., & Knight, R. T 2017, 'Bringing Kids into the Scientific Review Process', *Neuron*, vol 93, no 1, pp. 12–14.

Kennedy, I. G., Latham, G., & Jacinto, H 2016, *Education Skills for 21st Century Teachers: Voices from a Global Online Educators Forum*, Springer.

Kurniawan, D. A., Astalini, Darmaji, & Melsayanti, R 2019, 'Students’ Attitude towards Natural Sciences', *International Journal of Evaluation and Research in Education*, vol 8, no 2, 455–460.

Lavine, R. A 2005, 'Guided Discovery Learning with Videotaped Case Presentation in Neurobiology', *International Association od Medical Science Educators*, vol 15, no 1, pp 4–7.

Lin, Y.-R 2018, 'The Influences of Contextualized Media on Students’ Science Attitudes, Knowledge, and Argumentation Learning through Online Game-Based Activities', *Journal of Computer Assited Learning*, pp. 1–15.

Lingyi, H 2010, 'Using GPS to design narrative-centered environments for guided discovery learning: “Façade” - a case study of a nonlinear story', *Procedia Social and Behavioral Sciences*, vol *2*, pp. 4032–4037.

Liou, P.-Y 2020, 'Students’ Attitudes Toward Science and Science Achievement: An Analysis of The Differential Effects of Science Instructional Practices, *Journal of Research in Science Teaching*, pp. 1–25.

Luk, R. W. P 2010, 'Understanding Scientific Study via Process Modeling', *Foundations of Science*, vol 15, no 1, pp. 49–78.

Mandrin, P.-A 2010, 'Effect of Similarity-Based Guided Discovery Learning on Conceptual Performance', *School Science and Mathematics*, vol *109*, *no* 3, pp. 133–45.

Mayer, R. E 2004, 'Should There Be a Three-Strikes Rule Against Pure Discovery Learning?', *American Psychologist*, vol 59, no 1, pp. 14-9.

Ministry of Education and Culture 2016, Peraturan Menteri Pendidikan dan Kebudayaan Nomor 22 Tentang Standar Proses Pendidikan Dasar dan Menengah, Ministry of Education and Culture, Jakarta

Moore, R. W., & Sutman, F. X 1970, 'The Development, Field Test and Validation of An Inventory of Scientific Attitudes', *Journal of Research in Science Teaching*, vol 7, no 2, pp. 85–94.

Morales, E. J. D 2015, 'Influence of Culture and Language Sensitive Physics on Science Attitude Enhancement', *Cultural Studies of Science Education*, vol 10, no 4, pp. 1–34.

Mukherjee, A 2015, 'Effective Use of Discovery Learning to Improve Understanding of Factors That Affect Quality', *Journal of Education for Business*, vol 90, no 8, pp. 413–419.

Noviyanti, E., Rusdi, & Ristanto, R. H 2019, 'Guided Discovery Learning Based on Internet and Self Concept: Enhancing Student’s Critical Thinking in Biology', *Indonesiaon Journal of Biology and Education*, vol 2, no 1, pp. 7–14.

Olasehinde, K., & Olatoye, R. A 2014, 'Scientific Attitude, Attitude to Science and Science Achievement of Senior Secondary School Students in Katsina State, Nigeria', *Journal of Educaional and Social Research*, vol 4, no 1, pp. 446–52.

Perwitasari, N., & Djukri, D 2018, 'Developing Thematic Integrated Module Based on Guided Discovery to Improve Critical Thinking and Student Science Attitude', *Jurnal Prima Edukasia*, vol 6, no 1, pp. 44–55.

Reif, F 1998, 'Millikan Lecture 1994: Understanding and Teaching Important Scientific Thought Processes', *American Journal of Physics*, vol 63, pp. 17–32.

Reynolds, R. B 2016, 'Relationships among Tasks, Collaborative Inquiry Processes, Inquiry Resolutions, and Knowledge Outcomes in Adolescents During Guided Discovery-Based Game Design in School', *Journal of Information Science*, pp. 1–24.

Saab, N., van Joolingen, W. R., & van Hount-Wolters, B. H. A. M 2009, 'The Relation of Learners' Motivation with The Process of Collaborative Scientific Discovery Learning. *Educational Studies*, vol 35, no 2, pp. 205–222.

Samatowa, U. 2010, *Pembelajaran IPA SD*, PT Indeks Permata Puri Media.

Scott, J., & Freeman, A 2010, 'Beck's Cognitive Therapy', In N. Kazantzis, M. Reinecke, & A. Freeman (Ed.), *Cognitive and Behavioral Theories in Clinical Practice*, Guilford.

Secgin, T., & Sungur, S 2020, 'Investigating the Science Attitudes of Students from Low Socioeconomic Status Families: The Impact of Problem-Based Learning', *Biochemistry and Molecular Biology Education*, pp. 1–8.

Shrager, J., & Klahr, D 1983, 'Learning in An Instructionless Environment: Observation and Analysis', In *CHI'83 Proceedings*, pp. 226–229, Carnegie Mellon University.

Smith, V. P 2012, *Inquiry Training Model and Guided Discovery Learning for Fostering Critical Thinking and Scientific Attitude*, Vilavath Publication.

Sweller, J., Krischner, P., & Clark, R. E 2007, 'Why Minimally Guided Teaching Techniques Do Not Work: A Reply to Commentaries', *Educational Psychologist*, vol 42, no 2, pp. 115–21.

van Boxtel, C., van der Linden, J., & Kanselaar, G 2000, 'Collaborative Learning Tasks and The Elaboration of Conceptual Knowledge' *Learning and Instructions*, vol 10, pp. 311–30.

van Joolingen, W., Lazonder, A. W., Savelsbergh, E. R., & de Jong, T. 2005, 'Co-Lab: Research and Development of An Online Learning Environment for Collaborative Scientific Discovery Learning', *Computers in Human Behavior*, vol 21, no 4, pp. 671–88.

van Joolingen, W. R., de Jong, T., & Dimitrakopoulout, A. 2007, 'Issues in Computer Supported Inquiry Learning in Science', *Journal of Computer Assited Learning*, vol 23, pp. 111–119.

Westwood, P 2008, *What Teachers Need to Know about Teaching Methods?*, Australian Council for Educational Research, Ltd.

Zydney, J. M., Hai-Jew, S., Renninger, K. A., List, A., Koerber, S., & Farrell, J. M. 2012, 'Scaffolding Discovery Learning Spaces', In *Encyclopedia of the Sciences Learning* pp. 2916–22, Springer.