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Argument-Driven Inquiry Learning Model: A Systematic Review

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Abstract

The learning approach is an important component of education. ADI learning model allows learners to argue actively based on the surrounding observable phenomena in the laboratory. This research aims to review national diversities that represent or contribute to studies by applying the ADI learning model and the research type varieties and characteristics and stages of Argument-Driven Inquiry learning model applied by other researchers; research subjects, the applied content materials for investigation, and the impact of Argument-Driven Inquiry learning model. This research is a systematic literature review (SLR) with published article databases from Scopus, ERIC, and Google Scholar. The applied keywords were "Argument-Driven Inquiry" and "Science Education." The findings showed twenty-three articles were in line with the categories. Then, the analysis and classification could be done for each article. The ADI learning model implementation had been frequently found to improve learners' scientific argumentative skills rather than analytical skills or critical thinking skills. The applied content materials were mostly chemical materials, biology, and rarely found in physics. Most applied research types from the articles were quasi-experimental research. The implication of this research is to provide insight for further reviewing the argument-driven inquiry model (ADI) to improve science learning quality.

Introduction

The learning approach is an important component of education. It is usually categorized based on the demanded targeted objective. Therefore, an appropriate learning approach with the learner characteristics is needed to transmit the learning essence and materials effectively. Researchers have frequently used the Argument-Driven Inquiry model to develop argumentative scientific skills. Scientific argumentative skill is important to promote in Science learning. It makes them reasoning logically, having a clear perception, and having a rational explanation from the received information. Besides that, scientific argumentation skill prepares learners to explain science phenomena in daily life based on science concepts or theory (Osborne, 2010). Probosari et al. (2016) found that educators did not maximally develop learners' argumentative scientific skills completely. Learners should always be involved in the discussion, so their abilities and skills to make decisions concerning scientific problems in daily life.

Many studies discussed the Argument-Driven Inquiry model. It is a model that could be applied to develop and foster argumentative scientific skills (Sampson et al., 2010; Cetin & Eymur, 2017; Hasnunidah; 2013, Erenler & Cetin, 2019; Walker et al., 2016). The Argument-Driven Inquiry model is a new model underlying the roles of argumentation and inquiry for scientific education (Walker et al., 2012). ADI model is the oriented-learning model on inquiry syntax. Walker et al. (2016) found that ADI allowed learners to improve their attitudes toward science and skills to argue significantly, design, investigate, analyze, interpret data, and write scientifically during General Chemical Laboratory course II. Scientists who work in scientific activity know better how physics law is applied to determine the experiment results when serial observation data (Gerspacher, 2018). They invented something by promoting serial confirmation stages. They interpreted the findings, discussed the findings, and debated scientifically. Scientific discussion and debate mostly occurred in several phenomena or evidence. Then, different parties proposed theories to explain phenomena or evidence (Dauphin & Cramer, 2018). Walker et al. (2019) explain that scientists clarify, develop the model, rebuttal the evidence, and evaluate the information when developing new scientific knowledge. Therefore, scientists conduct several stages, as reflected in argument-driven inquiry syntax. It is strengthened by Demircioglu and Ucar (2015). They claimed that ADI could establish a more active learning atmosphere by inviting learners to participate in the learning process. It is important because investigating science teaching will contribute to science process skill development in a laboratory.

ADI learning model allows learners to argue actively based on the surrounding observable phenomena in the laboratory. Learning with the ADI model improves learners' science process skill, scientific - argumentative writing skill, and argument quality (Osborne et al., 2004; Sampson et al., 2013; Sampson et al., 2011; Sampson et al., 2012; Chen et al., 2016). Erduran and Jimenez (2008) found that the other five dimensions would also be improved during science learning by developing argumentation. They were such as 1) cognitive and metacognitive process based on the performance characteristics of experts as a role model for students, 2) critical thinking and communicative competence development, 3) science literacy achievement, learners' bravery improvement to share an opinion and write an argument in scientific language, 4) scientific, cultural pattern habituation and epistemic criterion development in knowledge clarification, and 5) scientific reasoning development, especially in choosing the compatible theories and scientific attitude determination based on rationality criteria. Cetin and Eymur (2017) proved that ADI provided an opportunity for learners to engage with scientific severe presentation practices, such as preparing, presenting, and revising their presentation. Thus, learners were facilitated to develop scientific presenting skills. Erenler and Cetin (2019) state that ADI covers reflective argumentation and a structured-peer review process that influence the monitoring strategy. This process allows pre-service teachers to pay attention to the strength and weeks of their investigation by comparing their works with the other investigations.

ADI learning model is a relatively new matter to apply. Thus, some information and developments are still limited. Therefore, a systematic review of it is needed. This systematic review only reviewed articles published from 2015-2020. This research aims to review national diversities that represent or contribute to studies by applying the ADI learning model and the research type varieties and 2) characteristics and stages of Argument-Driven Inquiry learning model applied by other researchers; research subjects, the applied content materials for investigation, and the impact of Argument-Driven Inquiry learning model.

Method

This research is a systematic literature review with databases from Scopus, ERIC, and Google Scholar. The applied approach was a systemic literature review that was used to identify, evaluate, and interpret specific topics' findings to answer the previous studies' research questions (Kitchenham & Charters, 2007). The literature search was limited for 2015-2020 published years, December 22, 2020. The articles were searched online from databases, such as Scopus, ERIC, and Google Scholar, using keywords of "Argument-Driven Inquiry" and "Science Education." The applied method was the Preferred Reporting Item for Systematic Review and Meta-Analytic (PRISMA) Wahyuningrum et al., 2020). The flowchart of the research stages is shown in Figure 1.

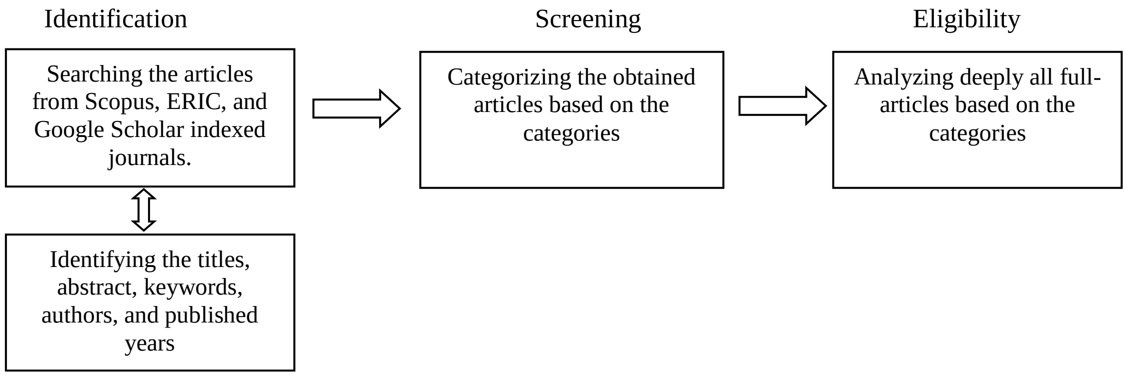

Figure 1. Research Stages

The first stage was identification. The articles were searched by applying the keywords and reviewing the titles, abstracts, search results, and the applied criterion comparisons. The searching results with the applied keywords, "Argument-Driven Inquiry" and "Science Education" in 2015-2020, assisted by software publish or perish, resulted in 263 obtained articles. From the articles, the compatibilities were identified with the keywords, titles, abstracts, and topics taken by the researchers. The applied articles were published articles and indexed by Scopus and ERIC. On the other hand, the articles with review article type, book, book recession, non-science education, and non-English articles were excluded. The articles were then screened based on the authors, publication years, research objectives, the applied instrument, the findings, the discussion, the research implication, the research limitation, and the suggestion for future researchers. This stage was important to determine whether the articles were eligible to be selected, reviewed, and deeply analyzed. After promoting this article process, the included articles based on the topics and could be proceeded to the third stage consisted of 25 articles. The third stage was the eligibility and inclusion of the articles. It required tabulation based on the article criteria with the compatible categories: 1) the findings should deal with Argument-Driven Inquiry (ADI) and scientific argumentation of science; and 2) the obtained articles were original researches and not literature review studies or meta-analysis. From the analysis, twenty-three articles based on the applied categories were obtained. The reason was - two articles, Walker et al. (2019) dan Kim & Hannafin (2016), discussed more learners' argumentation skills. From the findings, twenty-three articles based on the applied categories were analyzed and classified based on 1) the research types, 2) characteristics and ADI model stages, 3) research subjects, 4) the applied material content for research, and 5) ADI model implementation impacts.

Results

The article searches were assisted by software, Publish or Perish, with he applied keywords: "Argument-Driven Inquiry" and "Science Education." Then, the articles were limited only to 2015-2020 published year articles. Further research result identifications were also adjusted to the applied categories and other limitations. From 263 articles, after being analyzed and checked in terms of discussion, only 23 articles met the requirements and were analyzed in the next stage. Here is Table 1, presenting 23 article distributions that were included in full-text analysis about ADI implementation.

Table 1. Included Articles for Analysis Purposes

No	Journals	Years and Publishers	Numbers	Quartile	SJR Index
1.	Chemistry Education Research and Practice	2016, 2018, Ioannina University School of Medicine	2	Q1	0,77
2	Educational Sciences: Theory & Practice	2015, EDAM-Education Consultancy Limited	1	Q4	0,168
3	International Journal of Science Education	2016, Taylor and Francis Ltd.	1	Q1	1,06
4	Journal of Chemical Education	2017, 2018, 2019, 2020, American Chemical Society	4	Q2	0,47
5	Instructional Science	2016, Springer Netherlands	1	Q1	1,27
6	Jurnal Pendidikan IPA Indonesia	2019, Universitas Negeri Semarang (UNNES)	1	Q2	0,45
7	International Journal of Research in Education and Science	2019, 2020, Ismail Sahin	2	Q3	0,19
8	Cakrawala Pendidikan	2019, 2020, Universitas Negeri Yogyakarta	2	Q3	0,21
9	International Journal of Science and Mathematics Education	2018, Springer Netherlands	1	Q1	0,9
10	Journal of Baltic Science Education	2020, Scientific Methodical Center	1	Q2	0,44
11	Journal of University Teaching and Learning Practice	2020, University of Wollongong	1	Q3	0,32
12	Journal of Physics: Conference Series	2018, 2019, 2020, IOP Publishing Ltd.	4	Not yet assigned quartile	0,23
13	AIP Conference Proceedings	2020, American Institute of Physics	3	Not yet assigned a quartile	0,19
14	Asia-Pacific Forum on Science Learning and Teaching	2019, Hong Kong Institute of Education	1	Q3	0,3

Wiyanto (2019) argues that IJSE is a reputable journal in the science field and the most referred journal by researchers. From the article analysis, only one article discussing ADI implementation published by IJSE. The article findings of ADI implementations were published by IOP and AIP, Proceedings, and Indonesian research studies. ADI (Argument-Driven Inquiry) is a model that integrates inquiry and scientific argumentation. ADI model implementation allows researchers to measure, train, and develop learner scientific argumentation skills. According to Sampson et al. (2009), ADI was firstly introduced in 2005. It had the purpose of developing the required inquiry skills, and it involved learners in explaining with scientific reasoning. During the learning, learners had to conduct studies and apply scientific reasoning to analyze, conclude, and develop initial arguments. They then had to share and debate the investigation results with their classmates' peers (Inthaud et al., 2019). In the next stage, learners had to apply scientific reasoning to compose scientific reports. In the last stage, learners were asked to revise the other learners' reports by verifying the scientific reasoning and revised their peers' suggestions about their scientific reasoning (Inthaud et al., 2019; Berland & Reiser, 2009; Enderle et al., 2012). In the Appendix, the author affiliation distribution based on nationality, ADI stages, research types, research subjects, research material content, and ADI implementation impact are shown.

Discussion

Based on the author affiliation distribution, ADI correspondences were mostly from Indonesia with nine article distributions. On the other hand, the second-highest distribution based on author affiliations was from Turkey (5 articles). Then, the subsequent articles consecutively were Thailand (2 articles), Taiwan (2 articles), Malaysia (2 articles), USA (2 articles), and Philippine (an article). The research subject information is stated in Table 2, with various ADI model implementation distribution averages found in SHS, JHS, and science teacher pre-service in elementary school. From the distribution, most researchers were interested in applying ADI to determine the learners' learning outcome, learners' laboratory skills, learners' critical thinking skills, and scientific argument levels. It was stated by Walker et al. (2016) that applied ADI implementation to determine the learners' laboratory skills and learning outcomes. Demircioglu and Ucar (2015) found that ADI implementation for science teacher candidates with Optical Achievement Test instrument (OAT), Argumentative Scale (AS), Science Process Skill Test (SPST), and individual participant reports were more effective than the traditional method to improve science teachers' argument levels.

Sampson et al. (2013) revealed that learning based on social cognitive-learning ADI theory was more effective in developing writing and scientific presentation skills, scientific conceptual understanding, and scientific practice because they presented more authentically in laboratory activities. Cetin and Eymur (2017) revealed the stages of the ADI model, especially in "tentative argument production" and "argument session," to facilitate learners revising their arguments and written presentation. This learning made the learners active to participate in scientific practice, covering social and personal processes. From social perspectives, learning means that learners learn concepts, representations, and practices dealing with science rather than memorizing abstract scientific knowledge. Therefore, learning occurred through collaborative and instructional interaction with other people. The notion that learning science by practicing is very useful in recent studies. Then, the new theory also supports that meaningful science learning occurs when learners actively participate in science (Schewingruber et al., 2007; Tobin, 1990). ADI required learners to practice by paying attention to empirical criteria because they used ideas to interpret science ideas and understand natural phenomena (Grooms et al., 2015). Eymur (2018) also revealed that a science laboratory course should be a place for learners to conduct science and scientific feature rather than a place to learn conceptual understanding. By doing so, the science laboratory course could play a crucial role in creating science-literate students.

From the analysis, a researcher conducted ADI with six-stage, Demircioglu and Ucar (2015) covering; 1) Identification of the Task; 2) Generation of Data; 3) Production of a Tentative Argument; 4) Interactive Argumentation Session; 5) Creation of a Written Investigation Report; 6) The Double-blind Peer Review. Then, it developed with seven-stage ADI, consisting of 1) Identification of task and the research question, 2) Development of a method; collection and analysis of data, 3) Generation of a tentative argument, 4) Argumentation session, 5) Composition of an investigation report, 6) Double-blind group peer review, 7) Revision of investigation reports (Walker et al., 2016; Chen et al., 2016; Eymur, 2018; Siahaan et al., 2019). Several authors used ADI with eight learning steps, including: (1) task identification; (2) data collection; (3) tentative argument production; (4) interactive argument session; (5) reflective discussion; (6) investigation report; (7) report peer-review; and (8) report revision (Cetin & Eymur, 2017; Erenler & Cetin, 2019; Eymur, 2018). In these eight syntaxes, it explains the use of peer-review of the learners' argumentation results to be commented. By Grooms (2020) and Rahayu et al. (2020), the eight-stage was written as an explicit and reflective discussion stage.

Several authors modified ADI stages based on the country and research subject conditions. The seven stages of the MADI learning model (Modified Argument-Driven Inquiry) consisted of 1) Elicitation phase: The teacher leverages existing knowledge of the students; 2) Engagement phase: The teacher guides each group to identify the problem statement and the research question; 3) Exploration phase: The teacher guides the students in the investigation and data collection; 4) Explanation phase: The teacher guides the students in analyzing data and producing tentative arguments; 5) Elaboration phase: The teacher guides the students in engaging in the argumentation session; 6) Evaluation phase: The teacher guides the students in the reflective discussions to evaluate the results of the investigation; 7) Extension phase: The teacher assesses the students' progress based on the investigation report and application in questioning (Ping & Osman, 2019). On the other hand, Chen et al. (2018) revealed that ADI was modified by applying these stages: 1) identifying a focus task from a demonstration or presentation, 2) identifying related research questions, 3) making hypotheses related to the research questions, 4) designing an investigation and procedures, 5) collecting data from hands-on activities, 6) providing evidence-based conclusion, and 7) forming and sharing the group argument and critiquing and refining its explanations and evaluation.

ADI learning model could be combined with Meta-cognitive and environmental learning. Antonio (2020) revealed that combined ADI with 7E stages, also known as MADLE (Metacognitive and Argument-Driven Inquiry Learning Environment) consisted of 1) Elicit (Pre-assessment; 2) Engage (identification of the guiding question); 3) Explore (collection and analysis of data and generation of initial argument); 4) Explain (argumentation session); 5) Elaborate (explicit and reflective discussion); 6) Evaluate (writing argumentation report, retrospective assessment); 7) Extend (reflective writing). Besides that, various modifications, such as Safitri et al. (2020), were also done. They integrated ADI with mind mapping. The applied stages were: 1) identify the task and the guiding question; 2) design a research method to find the answer to the question; 3) collecting data; 4) data analysis and tentative argument session with mid mapping activities; 5) interactive argument session; 6) write an investigation report; 7) double-blind group peer review; 8) revises and conclude with mind mapping activities. Amelia, Budiasih, and Yahmin (2020) applied the ADI model combined with the Scaffolding procedure. The scaffolding procedure was done by using Hannafin and Land (2000) stages. They were: (1) in the data collection and data analysis, conceptual scaffolding and strategic scaffolding was implemented, (2) in the development of tentative argument, metacognitive scaffolding was implemented. (3) in the argumentation section, metacognitive scaffolding was implemented. Various revealed ADI stages showed that ADI implementation was an appropriate solution for science teaching. The material content distribution had not been comprehensively about science concept, chemical material (43.5%), biology material (39.1%), and physics (17.4%).

From ADI learning model researched conducted by many researchers, ADI had impacts such as 1) increasing has written and spoken argumentation level, 2) developing learners with scientific reasoning, 3) improved generic skills, 4) improved conceptual understanding, 5) improved mental models (scientific, synthetic, and initial), 6) improve critical thinking skill, 7) improved science process skill, 8) improved reflective thinking skills, 9) improved engagement in learning science, 10) improved metacognitive awareness, and 11) improved academic achievement. The ADI implementation could be applied in other science concepts. It could be applied or modified with the subject condition or research setting from the literature analysis and the revealed findings.

Conclusion

The findings showed twenty-three articles were in line with the categories. Then, the analysis and classification could be done for each article. The ADI learning model implementation had been frequently found to improve learners' scientific argumentative skills rather than analytical skills or critical thinking skills. The applied content materials were mostly chemical materials, biology, and rarely found in physics. Most applied research types from the articles were quasi-experimental research. The ADI implementation could be applied in other science concepts and could be applied or modified with the subject condition or research setting from the literature analysis and the revealed findings. The implication of this research is to provide insight for further reviewing the argument-driven inquiry model (ADI) to improve science learning quality.

Recommendations

The ADI implementation could be applied in other science concepts. It could be applied or modified with the subject condition or research setting from the literature analysis and the revealed findings. Recommendations to researchers given that the need to make improvements student learning to improve soft skills, especially the ability of scientific argument and skills problems increased with a maximum problem.

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Appendix. Author Affiliation based on Nationalities, Characteristics, and Syntaxes of ADI (Argument-Driven Inquiry), Research Types, Research Subjects, Research Material Content, and ADI Implementation Impact

Author Affiliation based on Nationalities	Characteristics and Stages/Syntaxes of ADI	Research Types	Research Subjects	Research Material Content	ADI Implementation Impact
JP. Walker, V. Sampson, S. Southerland and PJ. Enderle (2016), USA	7 The stages consisted of 1) identification of the task and research question, 2) generation of data, 3) production of a tentative argument, 4) argumentation session, 5) *creation of a written investigation report by individual student, 6) double-blind group peer review, 7) revision of the investigation report*	Comparative research design	The enlisted students in Chemical Laboratory course II in community college in the Southeastern of United States With control group sample n = 76 (male = 39, female = 37), n experimental group of ADI = 81 (male = 45, female = 36).	Acid-Base pH Titration	The findings showed that the average group score applying ADI was higher than those of the control group. On the other hand, gender types did not influence.
Demircioglu. T., Ucar S. (2015), Turkey	Six stages covered; 1) Identification of the Task; 2) Generation of Data; 3) Production of a Tentative Argument; 4) Interactive Argumentation Session; 5) Creation of a Written Investigation Report; 6) The Double-blind Peer Review	quasi-experimental with non-equivalent groups design	Students of the Primary school science teacher department in the Research University of Southern Turkey enlisted in General Physics Laboratory Course II. Forty-one students of experimental group (male = 15, female = 26), control group (male = 8, female = 30).	geometrical optics	The findings showed that ADI implementation effectively improved academic achievement, science teacher candidate's science process skill, and better quality of argumentation found in the experimental group.
Chen, HT., Wang, HH., Lu, YY., Lin, HS., and Hong YR. (2016), Taiwan	Modified ADI model by 1) identifying a focus task from a demonstration or presentation, 2) identifying related research questions, 3) making hypotheses related to the research questions, 4) designing an investigation and procedures, 5) collecting data from hands-on activities, 6) providing evidence-based conclusion, and 7) forming and sharing the group argument and critiquing and refining its explanations and evaluation.	quasi-experimental design	Fourth graders of Elementary School in Southern Taiwan-Kaohsiung city, experimental group = 36, control group = 36	sound, magnetic force, capillarity, light, gravity, and static electricity	The post-test results and learners' argumentation qualities of the experimental group were higher than the control group.
Cetin and Eymur,	ADI includes eight interrelated steps: 1)	exploratory study	Research samples taken from the ninth	Density, periodic	The findings showed that ADI

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(2017), Turkey	identification of task, 2) generation and analysis of data, 3) production of a tentative argument, 4) argumentation session, 5) explicit and reflective discussion, 6) creation of written investigation report, 7) double-blind peer-review of the reports, and 8) revision of the report.		graders = 32, male = 15, female = 17	trends, bond character and molecular polarity, solution, and gas	implementation facilitated learners to Improve their scientific presenting skills and develop writing skills (argumentative structures, argument content, and writing mechanisms).
I. L. L. Ping and K. Osman. (2019). Malaysia	The MADI model is an instructional model with seven phases, and the phases are presented in Figure 1. The seven phases involve the (1) Elicit phase: Eliciting students' prior knowledge; (2) Engage phase: Identifying the problem statement and experimental planning; (3) Explore phase: Partaking in practical work experience where small groups of students have the opportunity to carry out experiments and collect data; (4) Explain phase: Producing tentative claim after data analysis on a subject matter among members of the same group; (5) Elaborate phase: Conducting the argumentation session where groups share their arguments and their explanations and are then critiqued by other group members; (6) Evaluate phase: Conducting a reflective discussion about the inquiry; (7) Extend phase: Carrying out an application in practical assessment or experimental planning.	quantitative approach	22 X graders	Investigating Cells as a Unit of Life	The analysis shows that this module has very good validity based on the rating of experts. Therefore, in the next stage of summative evaluation, a study on the effectiveness of this LAB-MADI module in developing students' argumentation skills, science process skills concerning diffusion and osmosis concepts will be carried out in an actual field study.
Erenler, S. & Cetin, P.S. (2019). Turkey	ADI includes eight interrelated steps: identification of task, generation and analysis of data,	single group pre-posttest design	The study was carried out in Laboratory Application in Science in 2015-	density, solubility, durability, enzymes, and water quality	ADI improved pre-service teachers' metacognition and writing skills

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	production of a tentative argument, argumentation session, explicit and reflective discussion, creation of written investigation report, double-blind peer-review of the reports, and revision of the report		2016 with 50 pre-service teachers comprised the entire class of third-grade students in the elementary science teacher education program (16 male, 34 female).		
Chen, H.-T., Wang, H.-H., Lu, Y.-Y., & Hong, Z.-R. (2018). Taiwan	Modified ADI model by 1) identifying a focus task from a demonstration or presentation, 2) identifying related research questions, 3) making hypotheses related to the research questions, 4) designing an investigation and procedures, 5) collecting data from hands-on activities, 6) providing evidence-based conclusion and 7) forming and sharing the group argument and critiquing and refining its explanations and evaluation.	quasi-experimental mixed methods design	Thirty-two fourth graders (13 boys and 19 girls) were randomly selected to join the experimental group (EG), and the other 36 fourth graders (20 boys and 16 girls) from the same the classroom was also randomly selected as the comparison group (CG) in Southern Taiwan	parachute competition, magnet combat, making 3D glasses, flowering paper, wipe-out pen, boomerang, making pH indicator	The use of MADI interventions as an effective learning strategy to improve the continuity of ELS (engagement in learning science) and performance of argumentation
Seymour, 2018. Turkey	The steps of the ADI instructional model; 1) Identification of task and the research question; 2) Develop a method; collect and analyze data; 3) Generation of a tentative argument; 4) Argumentation session; 5) Open and reflective discussion; 6) Write an investigation report; 7) Double-blind group peer review; 8) Revise investigation reports	pre- / post-test control group design	Forty-five enlisted students in Chemical lesson in SHS, Anatolia, northeast of Turkey.	Chemical equilibrium, physical properties, acid-base titration, density, and the periodic table	ADI provided opportunities for learners to "promote science" to encourage their understanding of science's essence and practice deeply. Thus, their skills could be improved.
Grooms, J. (2020), USA	ADI steps include; 1) Identification of a Task, 2) Generation and analysis of data, 3) Production of the tentative argument, 4) Argumentation the session, 5) Investigation the report, 6) Double-blind peer review, 7) Revision of the report, 8) Explicit and reflective	This study follows a quasi-experimental , pre/postinter vention design, comparing the quality of arguments undergraduat e chemistry students	ADI experimental group (n=73), the control group was taught by scripted inquiry instructional approach (n=79)	For this study, the SSI tasks centred on proposed legislation to add a tax on large soft-drinks to curb obesity and proposed legislation to reduce excessive and restrictive	The findings showed that ADI improved the students' argumentation qualities higher than those taught by scripted inquiry.

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	discussion	generate when supporting a stance on a socio-scientific issue and the nature of students' conceptions of data and evidence after experiencing a scripted inquiry or argument-driven inquiry approach to laboratory instruction		carbon emission limits of power plants	
Rosidin, U., Kadaritna, N., Hasnunidah N. (2019) Indonesia	ADI steps include; 1) Task Identification Stage, 2) Data Collection, 3) Production of Tentative Arguments, 4) Argumentation Session, 5) Compilation of Written Investigation Reports, 6) Review the Report, 7) Revision based on Review Results, 9) Reflective Discussion	*Nonequivalent (Pretest and Posttest) Control Group Design* dan *One-Group Pretest-Posttest Design*.	This research was conducted on eighth-grade students of Public and Private Middle Schools in Bandar Lampung City. we involved 52 students (each experimental and control class was 26 students), he involved 26 students to obtain pretest-posttest data of students' critical thinking skills through the application of the ADI.	Natural Science	The findings showed ADI influenced high and low academic learners' critical thinking skills. This model significantly influenced high academic learners to improve their critical thinking skills effectively.
Eymur (2018), Turkey	Seven ADI stages 1) identification of task and the research The question, 2) Development of a method; collection and analysis of data, 3) Generation of a tentative argument, 4) Argumentation session, 5) Composition of an investigation report, 6) Double-blind group peer review, 7) Revision of investigation reports	a quasi-experimental design with non-equivalent control group design	There were 64 10th grade students from two classes enrolled in this study. The experimental group consisted of 32 students (16 girls and 16 boys), and the comparison group also consisted of 32 students (15 girls and 17 boys) with ages ranging from 15 to 16 years	Reaction rates, characteristics of acids and bases, identification of an unknown based on physical properties, and the quality of dissolution.	No significant differences between the ADI learning model and traditional laboratory instruction toward *self-efficacy* or preferences of the students
Rahayu, S. Bambut KE,	ADI consists of eight learning steps,	Case study	The study involved a high school in	Chemical equilibrium	ADI learning model implementation

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Fajaroh F. (2020) Indonesia	including: (1) task identification; (2) data collection; (3) tentative argument production; (4) interactive argument session; (5) reflective discussion; (6) investigation report; (7) report peer-review; and (8) report revision		Malang city with 64 grade11 students (23 males and 31 females) and as participants who were learning chemical equilibrium in the age range 15 to 17 years old.		could influence students learning motivation and improved their motivation higher than those taught by collaborative-ADI discussion.
Antonio, R. P. (2020) the Philippines	MADLE stages (Metacognitive and Argument-Driven Inquiry Learning Environment), consisting of 1) Elicit (Pre assessment; 2) Engage (identification of the guiding question); 3) Explore (collection and analysis of data and generation of initial argument); 4) Explain (argumentation session); 5) Elaborate (explicit and reflective discussion); 6) Evaluate (writing argumentation report, retrospective assessment); 7) Extend (reflective writing)	mixed-method approach	The study involved third-year Biological Science Education students (n=23) in a state university in the Philippines.	Microbiology	MADLE was more effective in improving learners' reflective thinking skills.
Ping ILL, Halim L., Osman K. (2020) Malaysia	Seven stages of MADI (modified Argument-Driven Inquiry); 1) Elicitation phase: The teacher leverages existing knowledge of the students; 2) Engagement phase: The teacher guides each group to identify the problem statement and the research question; 3) Exploration phase: The teacher guides the students in the investigation and data collection; 4) Explanation phase: The teacher guides the students in analyzing data and producing tentative arguments; 5) Elaboration phase: The teacher guides the students in engaging in the argumentation session; 6) Evaluation	quasi-experimental methodology involving Pre-test Post-test Non-equivalent Control Group design	Tenth graders of the experimental group were taught by the MADI approach (thirty students). Forty-two students were taught by IWA (Inquiry without Argument). Then, forty students of the control group were taught by CON (conventional approach).	Concepts of diffusion and osmosis	The data analysis showed that MADI could significantly improve science process skills and the students' biology concepts.

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	phase: The teacher guides the students in the reflective discussions to evaluate the results of the investigation; 7) Extension phase: The teacher assesses the students' progress based on the investigation report and application in questioning.				
Hasnunidah, N; Susilo, H; Irawati, M; and Suwono H (2020) Indonesia	The learning scenario of the ADI model consisted of designing activities, investigating, debating, writing, and reviewing.	correlational study	The research involved 120 pre-service science teachers (18-19 years old) who took a basic biology course in Teacher Training and Education Faculty, Lampung University. The sample consisted of two classes: biology education and chemistry education.	Basic Biology Concept	The data analysis results consisted of hierarchal regression. It revealed the prospective effects of argumentation and critical thinking skills to support learners' understanding of the basic biological concept. Thus, it could be said that it had a strong correlation between the predictors simultaneously with ADI's obtained criteria than the conventional learning model.
Suliyanah*, R N Fadillah, and U A Deta. (2020) Indonesia	ADI stages: concepts in a group investigation, analyzing skill to connect the data and the concepts (not written clearly and completely)	qualitative descriptive method	Subjects are student grade XI MIPA in SMAN 1 Magetan total of 32 students.	the theory of elasticity	Spoken and written argument improvements measured after ADI implementation Every ADI learning activity, the spoken argumentation skills of students at every level tended to have various patterns.
Safitri, M. A. D., Budiasih, E., & Marfu'ah, S. (2020) Indonesia	Integrating ADI with mind mapping with these stages: 1) identify the task and the guiding question; 2) design a research method to find the answer to the question; 3) collecting data; 4) data analysis and tentative argument session; 5) interactive argument session; 6) write an investigation report; 7) double-blind	Quasi-experiment with 2 x 2 factorial version of non-equivalent control group design	The sample was taken randomly by random cluster sampling with population XII MIPA	Biology	Significant differences between mind-map ADI implementation toward students' critical thinking skills

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	group peer review; 8) revises and conclude. The mind mapping activities were done on the 4th and eighth steps of the syntax ADI learning model.				
Amelia, R., Budiasih, E., & Yahmin. (2020) Indonesia	ADI model was implemented according to the following steps: (1) Identification of the task), (2) data collection and analysis, (3) Production of a tentative argument, (4) Interactive argumentation session, (5) Creation of a written investigation report, (6) Double-blind group peer review, (7) The revision process. ADI-S model was implemented according to the ADI model with the addition of scaffolding. Meanwhile, the Scaffolding procedure adopted the one proposed by Hannafin & Land (2000) including the following steps: (1) in the data collection and data analysis, conceptual scaffolding, and strategic scaffolding was implemented, (2) in the development of tentative argument. Metacognitive scaffolding was implemented. (3) in the argumentation section, metacognitive scaffolding was implemented.	A quasi-experimental design with 2x2 factorial design	This study involved two groups of students from a public senior high school in Malang taking science major in the 2018/2019 academic year. One group was considered the experiment group and consisted of 34 students and was taught using the ADI-S model. Another group was considered as the control group and consisted of 32 students and was conducted using the ADI model	Reaction rate	the findings showed that: (1) ADI model + scaffolding (ADI-S) contributed better SA than ADI implementation, (2) higher SR led to better SA, found in both ADI-S and ADI, (3) no interaction between learning model and SR toward SA of the students.
Priyadi, R., Diantoro, M., Parno, & Taqwa, M. R. A. (2020). Indonesia	No clear information about the applied syntaxes	Quasi experimental design	The eleventh graders of Malang 4 SHS in Indonesia Thirty-three experimental group students, 27 control group students	Heat and temperature	Mental model improvement was found (scientific, synthetic, and initial) of learners taught by ADI
Salsabila, E. R., Wijaya, A. F. C.,	No clear information about the applied syntaxes	Quasi-experimental design,	Seventh graders of JHS in Bandung with 26 persons (12	Global Warming	From the results, Argument-Driven inquiry provided

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Winarno, N., & Hanif, S. (2019) Indonesia		control group pretest-posttest design.	female, 14 female), experimental group students = 26 (13 female, 13 male).		significant impacts on learners' conceptual tasks.
Siahaan, A. T., Liliasari, & Hernani. (2019) Indonesia	The ADI learning model consists of seven stages of learning, namely identifying assignments and asking questions, designing experiments and collecting data, producing tentative arguments, conducting argumentation sessions, making investigative reports, conducting peer reviews, and revising and collecting investigative reports	the quasi-experimental method with the Non-equivalent Pre-Test and Post-Test Control-Group Design	The experimental class (N = 25) used the ADI model and as a comparison is called the control group (N = 25) using a guided inquiry model	the topic solubility product constant	The findings showed that the ADI model was influential in developing their science generic skills and conceptual understanding, except on the sub-indicator. The conceptual understanding was not different from the guided inquiry.
Inthaud, K., Bongkotphet, T., & Chindaruksa, S. (2019) Thailand	ADI steps include; 1) Identification of a Task, 2) Generation and analysis of data, 3) Production of the tentative argument, 4) Argumentation the session, 5) Investigation the report, 6) Double-blind peer review, 7) Revision of the report, 8) Explicit and reflective discussion	Action research	24 learners on the eleventh science program (1 female, 23 male)	Cahaya	Scientific learners' reasoning improved after being taught by ADI
Songsil, W., Pongsophon, P., Boonsoong, B., & Clarke, A. (2019) Thailand	rADI states consisted of; 1) Determining students' prior knowledge; 2) Data and research activities in the group; 3) Free exchange of scientific explanation; 4) Presenting socio-scientific issues; 5) Data/Research activities in groups 2; 6) Make tentative claims about SSI as a group; 7) Engaging in argumentation as a class; 8) The creation of a written investigation report by groups of students; 9) Engaging in peer review and revising group reports.	Comparative research	The participants comprised of 155 Grade 10 Thai students who studied in a high school located in Bangkok, Thailand	Life and environment	Findings of rADI model implementation showed the model was useful to improve learners' scientific argumentation skill outside of science class.