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Narrowing the Gap of Science Students' Learning Outcomes Through INSTAD Strategy

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Abstract

This research aimed to examine the strategy effectiveness of the Integrating Inquiry-based learning and Student Teams Achievement Division (INSTAD) compared to other strategies: Inquiry; Student Teams Achievement Division (STAD); and conventional learning, in order to narrow Upper Academic Ability (AA) and Lower Academic Ability (AB) science students' learning outcome gap. As many as 136 research subject, consisting of AA and AB 7th grade students in equal numbers were selected using stratified random sampling from 27 State Junior High Schools in Surakarta, Indonesia. This research employed 4x2 factorial design as a method. Students' learning results were measured with an essay test, then analyzed using Anakova. Findings demonstrate that INSTAD is the optimum strategy to constrict AA and AB students' science grade point average, compared to Inquiry, STAD, and conventional learning.

Keywords*: inquiry, STAD, INSTAD, learning outcomes*

Introduction

A considerable amount of research has established that Indonesian students' grade point average in science is substandard. PISA surveys in different periods indicated that this unsatisfactory learning outcome has been consistently in the lowest 10. In 2015, Indonesian students ranked 62th out of 69 countries, while in 2009, they ranked 60th out of 65 countries. In 2006, Indonesia ranked 50th out of 57 countries, in the period before, in 2003, Indonesia ranked 38th out of 40 countries (OECD, 2015).

The Indonesian government advocate the use of Inquiry strategy in science classes to improve students' academic achievement (Retnawati, Munadi, Arlinwibowo, Wulandari F, & Sulistyaningsih, 2017). Multiple studies confirmed that the Inquiry strategy makes it possible to improve students' outcomes in science (Gillies, Nichols, Burgh, & Haynes, 2012; Ogan-Bekiroğlu & Arslan, 2014; Simsek & Kabapinar, 2010). However, big gaps were persistent when Upper Academic Level (AA) and Lower Academic Level (AB) students' learning outcome is measured. The gap is caused by the homogeneous in-class learning time allocation regardless of their academic ability. As a consequence, students' learning outcomes were varied and categorized into high, moderate, and low. Indeed, varying time allocation for studying science to match their academic ability would lead to a smaller learning outcome gap (Damavandi & Shekari, 2010). It is suggested, then, to conduct scaffolding. Science learning that facilitates scaffolding from AA to AB students has the potential to provide more time without varying in-class time allocation. The scaffolding conducted by AA students delivers AB students to their potential zone, so that the learning outcome gap between them could be diminished (Prayitno, Corebima, Susilo, Zubaidah, & Ramli, 2017).

Integrating Inquiry strategy and STAD (INSTAD) have the potential to decrease the gap between AA and AB science students' grade point averages. The Inquiry strategy implementation without STAD could not demonstrate better outcomes. The STAD is more effective than Inquiry in facilitating scaffolding from AA to AB students. As a cooperative strategy, STAD has been proven effectively able to facilitate scaffolding compared to a non-cooperative strategy. STAD is incompatible for science learning; therefore STAD implementation without Inquiry integration seems less powerful in improving learning outcomes in science classes. The INSTAD strategy comprising both Inquiry – which guarantees optimal empowerment for students' learning outcomes, and STAD – which provides ideal scaffolding from AA to AB students. The INSTAD strategy has the potential to narrow the gap between AA and AB students compared to the Inquiry, STAD, and conventional science learning strategies.

Research Problem

The research problems are the following: (1) Is INSTAD more effective in improving students' learning outcomes in science compared to the Inquiry, STAD, and conventional strategy? (2) To what extent is INSTAD able to narrow students' science learning gap compared to the Inquiry, STAD, and Conventional strategy?

Research Methodology

General Background of Research

This research was conducted with the use of 4x2 factorial design. During the data collection phase, the students were divided into four groups, then each was treated with INSTAD, Inquiry, STAD, and Conventional. Pretest and posttest were conducted before and after science learning treatment for 4 months. Pretest score was used as a covariate controlling the students' pre-determined learning outcome varying factors. Table 1 shows the research design.

Table 1. Research design

Students' Academic Ability	Learning Strategy			
	INSTAD (X1)	Inquiry (X2)	STAD (X3)	Conven-tional (X4)
Upper Academic Ability (Y1)	X1Y1	X2Y1	X3Y1	X4Y1
Upper Academic Ability (Y2)	X2Y2	X2Y2	X3Y2	X4Y2

Research Sample

The population of this research consisted of the 7th grade students from 27 junior high schools in Surakarta Regency, Indonesia. The research sample included 4 upper (AA) and 4 lower (AB) academic ability junior high schools, chosen using stratified random sampling. This academic ability classification was derived from the average national exam score. The AA students sample was selected from the upper academic ability schools, whereas the AB students were selected from the lower academic ability schools. As many as 17 students from each classification per school were chosen, deriving 68 AA and 68 AB students per school, resulting in 136 research subjects in total. The AA and AB students classification was obtained from their elementary school national exam scores.

Instrument and Procedures

Science learning outcomes refer to students' proficiency in concept, principal, law, and science theory enlisted in the learning objectives. The learning outcomes were measured using an essay test. Three experts examined test items used as research instruments, assessing the accuracy of learning objectives and cognitive process dimension to test validity. Expert evaluation results indicated that the test was valid. The reliability was measured by the Cronbach alpha formula specifying a high category of reliability index with the score of 0.81.

The INSTAD class treatment was conducted as follows: (1) the students were divided into AA and AB student groups of 5, (2) the teacher presented problems to the students, (3) the students formulated the problem, constructed hypotheses, designed an experiment, conducted the experiment, and made a conclusion, (4) the students presented their results in class discussion, (5) the students took individual tests, and (6) the teacher calculated the score difference before and after the learning process as the basis for group recognition. The treatment for Inquiry class referred to Pedaste, et. al. (2015), while STAD class treatment referred to Slavin (1980), and the conventional class treatment used variations of seminar. Three experts evaluated the learning steps and learning outcomes prior to the implementation to assess the learning design in treatment classes. The evaluation confirmed the design feasibility. Before the treatment, partner teachers were trained to ensure the consistency of learning strategy implementation during the experiment.

Data Analysis

Data were analyzed with the use of Anakova, with science learning outcomes in form of pretest scores reviewed as a covariate. Kolmogorov Smirnov parametric statistical prerequisite analysis was used for testing data normality, the pretest score was 0.075 and posttest score 0.123, i.e., within the normal category, whereas the Levene homogeneity test concluded that homogeneous variants were at 0.740. The LSD test was further used for the average difference between variables.

Research Results

The results of Anakova test of the students' science learning outcomes after the treatment and academic ability are presented in Table 2.

Table 2. Anakova test results regarding the effect of treatment on science learning outcomes

Source	Sum of Squares	df	Mean Square	F	p
Learning strategy	21352.401	3	7117.467	211.424	.000
Learning strategy*academic	421.525	3	140.508	4.174	.007
a. R Squared = .843 (Adjusted R Squared = .833)					

Table 2 shows that the learning strategy has a significant influence on science learning outcomes (P<0.000). The LSD test results of the learning strategy of science learning outcomes are presented in Table 3.

Table 3. The difference in students' learning outcomes based on the learning strategy

Learning strategy	Pretest	Posttest	Gain	Corrected mean	Notation
Conventional	17.03	43.93	25.97	44.47	a
STAD	28.47	61.21	32.77	60.00	b
Inquiry	18.56	72.90	54.35	73.24	c
INSTAD	18.55	75.77	57.23	76.11	c

Table 3 shows that the learning outcomes of the science students that had been given the INSTAD and Inquiry treatment are similar, but higher than those of the students treated with the STAD and Conventional strategy. The learning outcomes of the students treated with STAD are higher than those of the Conventional treatment groups. Score differences or gain in science learning outcomes from pretest and posttest were highest with INSTAD, followed by the Inquiry STAD, and Conventional learning strategy. This indicated that INSTAD is optimal in improving students' learning outcomes.

Table 2 shows that the learning strategy is significantly interrelated with academic ability in science learning outcomes (P<0.007). The LSD test of learning strategy interaction and academic ability are presented in Table 4.

Table 4. The interrelation of learning strategy and academic ability in science learning outcomes

Learning strategy	Ability	Pretest	Post test	Gain	Corrected mean	Notation
Conventional	Lower	16.177	39.044	22.867	39.758	a
Conventional	Upper	18.456	48.824	30.368	49.180	b
STAD	Lower	14.485	59.118	44.633	60.097	c
STAD	Upper	42.444	63.309	20.865	59.902	c
Inquiry	Lower	16.029	69.044	53.015	69.781	d
INSTAD	Lower	17.279	74.706	57.427	75.247	de
Inquiry	Upper	21.103	76.765	55.662	76.706	e
INSTAD	Upper	19.853	76.838	56.985	76.976	e

Table 4 shows that there are no differences in learning outcomes between the AA and AB science students in the INSTAD group and the AA science students in the Inquiry group. The AA and AB students employing INSTAD and the AA students employing the Inquiry strategy have higher scores than the AB students employing Inquiry, AA and AB STAD group, and AA and AB Conventional group. In addition, the AB science students Inquiry group have higher scores than the AA and AB students treated with the STAD and Conventional strategy. Furthermore, the AA and AB science students treated with STAD have similar learning outcomes. The AA and AB science students treated with STAD have higher scores than the students treated with the Conventional strategy. The AA students treated with the Conventional strategy demonstrate higher scores compared to the AB science students. It could be conclude that INSTAD is the optimum strategy in narrowing the learning outcome gap between the AA and AB science students, compared to the Inquiry, STAD, and Conventional strategies. With regards to the difference or gain of pretest and posttest score in Table 4, the AB students treated with INSTAD and STAD had a bigger gap than the AA students, while the AA students treated with the Inquiry or Conventional strategy had higher pretest posttest differentiation than the AB students. The finding indicated that the AB students' learning outcomes were more improved than those of the AA students' treated with INSTAD and STAD.

Discussion

Tables 2 and 3 show that learning strategy has a significant effect on science learning outcomes. The learning outcomes of the science students treated with INSTAD and Inquiry are similar, but higher compared to the students treated with the STAD and Conventional learning strategy. The students employing STAD have higher scores than those employing the Conventional strategy, whose learning outcomes are the lowest.

INSTAD has characteristics of both the Inquiry and STAD strategies. The Inquiry strategy requires students to use scientific methods in building their knowledge. The problem presentation phase in Inquiry has the potential to cause students' cognitive conflict (Pedaste et. al., 2015). The cognitive imbalance caused by cognitive conflict is marked by a multitude of questions on their minds. In the next phase, students are required to formulate hypotheses and to design a strategy for testing the hypotheses. Inquiry character requires students to construct their knowledge. Students learning by constructing their knowledge have been proven to have higher scores than students memorizing knowledge (Gurses, Gunes, Dalga, & Dogar, 2015; Kwan & Wong, 2015). The students treated with INSTAD were divided into smaller heterogeneous groups to ensure effective scaffolding (Prayitno et al., 2017). Scaffolding on INSTAD was effective because of the combination of teacher and peer tutorials. The characteristics of STAD ensured the sustainability of positive dependency amongst group members. The complementary Inquiry and STAD characteristics in INSTAD resulted in the students' higher academic achievements compared to the STAD and Conventional learning strategies.

Inquiry originates from steps of a scientific method (Pedaste et. al., 2015). The inquiry phase begins with problem presentation. In the next step, students are required to conduct a theoretical investigation to temporarily solve the problem in the form of hypotheses. Then, students design a strategy to test the hypotheses. The phases make students independently find a problem and the solution. In solving problems, students are required to conduct deductive-inductive thinking. Their activity in constructing knowledge and performing deductive-inductive thinking has been proven to improve students' learning outcomes (Arslan, Ilkörücü, & Seden, 2009).

STAD develops group member's positive dependency in the learning process (Slavin, 1980). Peer tutorial on STAD proved more effective than non-cooperative learning (Kyndt et al., 2013). STAD is not specifically designed for science learning. Science learning outcome empowerment on STAD is practiced through the teacher's explanation and group discussion. The teacher explains knowledge through lecture and cooperative group discussion. Each member of the group is responsible for mastering the learning objectives. STAD has less capacity in facilitating students' knowledge construction, hence students' learning outcomes are lower than those of the students employing the INSTAD and Inquiry learning strategies.

Students taught with the use of the Conventional strategy learn by listening to the teacher's explanation, therefore they lack involvement in constructing knowledge during the learning process. On the other hand, students' learning outcomes are better if students independently construct their knowledge rather than listening to the teacher's explanation (Gurses et al., 2015; Kwan & Wong, 2015), as a consequence, the science students employing the Conventional strategy gain the lowest scores.

Table 2 presents how learning strategy interacts with academic ability towards science learning outcomes. The LSD test indicates that: (1) the learning outcomes of the AA and AB science students treated with the Conventional strategy were the lowest compared to those of other groups. The strategy was least effective in narrowing the proficiency gap between the AA and AB students; (2) the learning outcomes of the AA and AB science students treated with STAD were higher compared to those of the students treated with the Conventional strategy, but lower compared to those treated with Inquiry and INSTAD. STAD proved effective in narrowing the learning outcome gap between the AA and AB science students; (3) the learning outcomes of the AA and AB science students treated with Inquiry were higher compared to those of the AA and AB science students treated with the STAD and Conventional strategies, equal to those of the AB science students treated with INSTAD, but lower than those of the AA students treated with INSTAD. The Inquiry strategy was less effective in decreasing the learning outcome gaps between the AA and AB science students; (4) the learning outcomes of the AA and AB science students treated with INSTAD were higher compared to those of the students treated with Conventional and STAD. The learning outcomes of the AB students treated with INSTAD were equal to those of the AA and AB students treated with Inquiry. The learning outcomes of the AA students treated with INSTAD were higher than those of the AB students treated with Inquiry. INSTAD is effective in narrowing the gap between the AA and AB students. These findings prove that Inquiry is optimal in enhancing the AA and AB science students' learning outcomes. The optimum cooperative characteristic has proven to reduce the learning outcome gap between the AA and AB students.

According to mastery learning, if students have varied academic ability and they receive equal learning quality, materials, and time allocation, their scores will vary. This gap could be narrowed if time allocation meets students' needs (Damavandi & Shekari, 2010; Ozden, 2008). Unfortunately, the uniformity of students' in-class learning allocation is inevitable, so students' learning outcome gap is unavoidable. Regarding social constructivism theory, students could enter their zone proximal development (ZPD) if provided with scaffolding by individuals with higher knowledge or mastery, including their friends (Kim & Hannafin, 2011; Royanto, 2012). Peer scaffolding equips students with an arguably apt study time without changing the uniform in-class time allocation.

The students treated with INSTAD and STAD were divided into smaller heterogeneous groups regarding their academic ability. The scaffolding performed by the students treated with STAD and INSTAD was effective as each of the group members was required to master the learning objective. Effective scaffolding pushed the AB science students entering their zone proximal development. In addition, effective scaffolding is effective in providing varied students' learning period without changing in-class uniformed learning time allocation. Furthermore, the scaffolding for the students treated with INSTAD and STAD proved effective in narrowing the AA and AB science students' learning outcomes compared to the treated with the Inquiry and Conventional strategies.

The INSTAD and Inquiry strategies require students to use scientific methods in constructing their knowledge, resulting in higher learning scores compared to students employing STAD and Conventional strategy. The students in the Inquiry class were randomly grouped, so the scaffolding process was less effective, as a result, the AA and AB students had different learning outcomes. As STAD is not originally designed for science learning, although it has the potential to narrow the gap between AA and AB science students, the learning outcomes do not surpass those of students treated with the INSTAD and Inquiry learning strategies. INSTAD has characteristics related to Inquiry and STAD. Students employing INSTAD practice group cooperative inquiry activity, which proves to be able to facilitate effective scaffolding. This explains why INSTAD becomes the optimum strategy in improving science students' learning outcomes, equal to the Inquiry strategy, at the same time narrowing the gap between AA and AB learning outcomes, lacking in the Inquiry and Conventional strategies.

Students employ the Conventional strategy in learning science, by listening to their teacher's explanations. Once in a while, the teacher gives examples and asks questions to students. The Conventional strategy is less effective in facilitating scaffolding, as the teacher tends to give scaffolding to actively involve students during the learning period. The Conventional strategy also has little contribution to facilitating students' knowledge construction; therefore the students' learning outcomes appear to be the lowest among the other learning strategies. This also generates a gap between the AA and AB students' learning outcomes.

Conclusions

The results suggest that compared to the STAD and Conventional strategies the INSTAD and Inquiry learning strategies are the most advantageous strategies in improving students' science learning outcomes. STAD is more productive than the Conventional strategy. In addition, INSTAD and STAD enhance both AA and AB science students' learning outcomes, which the Inquiry and Conventional strategies do not do. It is concluded that INSTAD is the optimum strategy both for improving science learning outcomes and narrowing the learning outcome gap between AA and AB students.

The findings confirm that the gap in students' learning outcomes in science is caused by the use of competitive-based and unscientific-based learning methods.

The unscientific-based teaching method leads to unsatisfactory learning outcomes, while the competitive-based teaching is unable to facilitate scaffolding resulting in a gap of learning outcomes between students. Although the competitive-based learning method has the capability of facilitating scientific-based learning activity, it arguably needs to be integrated into other strategies facilitating effective scaffolding, such as the cooperative learning strategy.

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