EFFECT OF GUIDED INQUIRY BASED INSTRUCTIONAL MODEL ON SCIENCE PROCESS SKILLS OF PRE-SERVICE BIOLOGY TEACHERS IN LEARNING INVERTEBRATE ZOOLOGY

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Abstract. The process of science learning in the Ethiopian education system is rhetorical rather than centered on transferring and memorizing of factual content knowledge. The purpose of the current study was to investigate the effects of guided inquiry-based instructional model on the science process skills of pre-service biology teachers (PBTs) invertebrate zoology learning. Research method was a mixed method approach. Design of the research was a quasi-experimental pre-test-intervention-post-test design. The research was conducted on two purposively selected colleges of teacher education and three classes, which were assigned two treatment groups and the remaining comparison group. The treatment and comparison groups were taught invertebrate zoology for eight consecutive weeks with a guided inquiry-based instructional model and a conventional method of instruction, respectively. A science process skills test was used to collect quantitative data which was then administered as a pre-test and post-test to Second Year PBTs. Qualitative data was also collected through observation using a rubric during the intervention of invertebrate zoology learning.

The data were analyzed using one-way ANOVA and MANOVA. The results of study revealed that there was a significant difference between groups, which was favored for treatment groups. The qualitative data finding of the study supports quantitative data findings in many aspects of science process skills. Conclusions were drawn based on results and discussions.

Keywords: guided inquiry-based instructional model, science process skills, basic and integrated science process skills, invertebrate zoology learning

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Introduction

In teaching-learning process, instructional strategy plays a key role in ensuring high-quality science education. The instructional strategy enables students to participate and share responsibility in their learning on multiple levels, including mental, physical and social (Ganyaupfu, 2013; Ongowo, 2017). In this regard, teachers' selection of instructional strategies in the classroom has a significant role in students' ability to achieve objectives of science teaching (Barzegar et al., 2012). Therefore, choosing appropriate instructional strategies in theories of learning has an effect on the process of learning. One of these major learning theories is social constructivism.

Vygotsky is widely credited with developing the theory of social constructivism, which articulated methods by which knowledge is constructed rather than found by the human mind. He claimed that "direct teaching of concepts is impossible and would not yield fruitful results (1980)." Hence, concepts are socially constructed in the context to connect with students' real-life situations (Mwanda et al., 2017; Kazeni et al., 2018). As a result, the social constructionist approach allows students to participate in learning and construct their own knowledge. In this regard, learners have responsibility in a constructivist instructional framework for providing creative learning settings, fully engaging their ideas, and obtaining important feedback (Molefe et al., 2016). Thus, active-based instructional strategies such as the inquiry method of teaching play a great role for students' learning process of science (science process skills).

Currently, the science education curriculum recognizes science process skills (SPS) as a component of science learning (Zeidan & Jayosi, 2015; Prayitno et al., 2017; Shahali et al., 2017) and as part of the national science curriculum at all levels (Shahali et al., 2017). It is reasonable that teacher education programs in Ethiopia, as in other nations, place a strong emphasis on science learning frames. The Ministry of Education in Ethiopia [MoE] states that all teachers require competence in knowledge; science process skills, and attitude. Accordingly, the purpose of school science in Ethiopian education is "to help children to achieve knowledge, skills, and attitudes essential for solving real-life problems (MoE, 2018)." Based on this statement, researchers may conclude that the goal of science learning includes SPS rather than students receiving factual knowledge. The reason is that Ethiopian science education curriculum proscribes use of SPS rather than promoting memorization of factual knowledge (Asgedom, 2009; MoE, 2018).

Therefore, the current study focused on SPS learning of invertebrate zoology framework of guided inquiry-based instructional model (Learning, 2004) and is supported by Vygotsky's social constructivist theory (1980). The guided inquiry-based instructional model (GIBIM) enables learners to learn SPS and apply scientific information in real-life situations (Zion & Mendelovici, 2012). The idea of Vygotsky focused on students constructing knowledge through peer interaction with reasonable instructor assistance (Mwanda et al., 2017). This occurs when Vygotskian principles like Proximal Zone of Development (ZPD), scaffolding, social interaction, and cooperative learning are implemented in the classroom (Hohenshell, 2004). The social constructivist approach encourages active participation of students' investigations and interaction with peer-supported learning (Kazeni et al., 2018). As a result, inquiry-based learning is a constructivist based approach important for achieving SPS in invertebrate zoology learning.

Literature review

Inquiry-based learning is a center for facilitating and applying the process of science learning (Jerrim et al., 2020) and plays a significant role in science education, mainly in how students learn and the pedagogical strategy used by teachers (Ergül et al., 2011). As a result, an inquiry-based strategy is an important method of instruction for motivating student SPS learning (Damopolii et al., 2018; Tan et al., 2020).

Moreover, a form of inquiry such as GIBIM is important for teachers to reduce the cognitive load and misconceptions of students during the orientation of the inquiry activity and inquiry dimension (Jerrim et al., 2020). The benefit of relevant scaffolding can be valuable for assimilating or accommodating conceptions (Almuntasheri et al., 2016), understanding scientific knowledge (Bunterm et al., 2014), and lessening frustration with the process of science learning (Hardianti & Kuswanto, 2017). As a result, GIBIM is useful for providing learners with appropriate activities and for analyzing the existing knowledge and relating it to new concepts. There is an argument about the effectiveness of inquiry-based classrooms (Almuntasheri et al., 2016) and which and how inquiry models are used in scientific classrooms (Bunterm et al., 2014). The researchers acknowledged issues that were raised by scholars, but GIBIM is helpful to understand the process of science learning when students receive reasonable inquiry orientation and inquiry dimension (Hardianti & Kuswanto, 2017). Therefore, instructional model mostly designed by classroom teachers for attaining science learning have positive or negative effects on student outcomes.

Apparently, GIBIM is important for developing a deep understanding of science concepts in the process of learning. Henceforth, teachers' and students' involvement play an active role in achieving issues in each lesson. For this study, a six-phase inquiry model was used to address the issues of SPS in invertebrate zoology learning. These are planning, retrieving, processing, creating, sharing, and evaluating.[1)] The planning phase includes identifying topic areas, posing questions, locating information sources and arranging formats. The retrieving phase includes developing information about the planning, locating and collecting resources, and selecting relevant information. The processing phase focused on the investigating of pertinent information and recording, making connections with real-life situation based on designed activities.[1)] In the creating phase, focus is on organizing information, generating products, and thinking about the audience, reviewing and raising discussion tips. The sharing phase includes communicating with classmates, presenting new understandings, demonstrating and reflecting (Ismail et al.,2006). In the evaluating phase, teacher provides an opportunity to assess learners' understanding of SPS learning invertebrate zoology.

SPS is a way of thinking about science, pre-requisite for understanding of scientific knowledge and transferrable skills in science education. Science educators' attention was given to SPS a few decades ago (Abungu et al., 2014; Irwanto et al., 2019). SPS encourages learners' in various ways, such as: to enhance prior knowledge; to solve day- to- day problems; to improve students' performance; and to inspire creativity skills (Abungu et al., 2014). So, it is 21st century practical learning skills to solve learners' problems in everyday life circumstances (Irwanto et al., 2019).

SPS can refer to either basic or integrated science process skills. Both are important at every level of science learning (Rabacal, 2016; Ongowo, 2017). Basic science process skills (BSPS) are a perquisite of advanced skills and an introductory tool for the construction of new knowledge in the inquiry process. BSPS are also essential for developing advanced skills and science concept. The claim is that BSPS serves as a foundation for integrated science process skills and scientific investigation (Ristanto et al., 2017). The common reviewed indicators of BSPS include: Observing and/or comparing, communicating, measuring, classifying, inferring, and predicting (Prayitno et al., 2017; Ongowo, 2017).

Integrated science process skills (ISPS) are terminal skills used by students, teachers and scientists in problem solving and doing experiments. ISPS is higher level of cognitive skills and advanced knowledge (Chabalengula et al., 2012). ISPS is widely used in high school and continues to be used at higher levels of education (Mutlu & Temiz, 2013). The most reviewed indicators of ISPS are identifying variables, formulating hypotheses, experimenting, data interpreting, drawing conclusions, and model constructing (Prayitno et al., 2017; Irwanto et al., 2019).

In Ethiopian teacher education, for particular programs SPS is offered as a course called "Science and Scientific Inquiry" (MoE, 2013). Despite this, there is a struggle in the implicit implementation of SPS rather than the emphasis placed on factual knowledge acquisition (MoE, 2018). Recently, in Ethiopian education system, the solution to this problem began with the active participation and realization of students in the teaching and learning process of science. When, we look at the New Education and Training Policy (MoE, 1994) and the Educational Training Policy and its Implementation (MoE, 2002), efforts were made. However, studies show that lecture dominating teaching is still prominent in the Ethiopian educational system to attain content factual knowledge at all levels (Edessa, 2017; Alemu et al., 2019**;** Wodaj & Belay, 2021).

Due to this fact in the Ethiopian curriculum, learners' achievements in general science education and, in particularly, biology education, have increasingly declined over time. For example, reports of national learning assessment of the baseline research conducted by National Educational Assessment Examination and Agency in Ethiopia (NEAEA, 2014; 2016) in biology for grades 8, 10, and 12 revealed that mean scores were less than 50%, indicating that students did not meet the Ministry of Education's required competencies (MoE, 1994).

To solve such problems nations around the world are looking for effective teaching methods to improve science learning (Jerrim et al., 2022) and encourage students to understand the process of science learning (Hazelkorn et al., 2015). GIBIM improves students' learning and SPS (Ergül et al., 2011; Nurza et al., 2021). As a result, GIBIM is used to create an essential cultural change in how and why science is learnt in institutions (Zion & Mendelovici, 2012). Engida (2002) and MoE (2018) emphasized SPS as a component part of inquiry in Ethiopian institutions. Hence, the present study was conducted in an attempt to bridge the gap between institutionalizing of SPS in Ethiopian curriculum, particularly at CTEs.

The purpose of this study was to investigate the effects of GIBIM on PBTs SPS learning invertebrate zoology at CTEs in Southern Nation Nationalities and Peoples Regional State (SNNPRs).

Research questions

The study attempted to answer the following research questions: (1) is there significance mean score difference in overall SPS of invertebrate zoology learning between groups; (2) is there a significant mean score difference across groups in terms of the level of knowledge developed in basic and integrated science process skills; (3) how does GIBIM help pre-service biology teachers to build SPS of invertebrate zoology learning?

Methodology

A mixed method research was used to address the research problems. The study used a quasi-experimental design with a pre-test, intervention, and post-test group design. The two treatment groups (TG1 and TG2) were planned to apply GIBIM using a six phase inquiry model such as: planning, retrieving, processing, creating, sharing, and evaluating. Among the treatment groups, TG2 was used as a replication. In a quasi-experiment design study, replication is a way to reduce the threat of design being validated (Creswell, 2012). The remaining comparison group (CG) was taught using conventional method of instruction.

The research was carried out at Hossana College of Teachers Education (HCTE) and Arbaminch College of Teachers Education (AMCTE), both of which are located in SNNPRs. The research site was purposively chosen based on teacher preparation experience of CTEs, instructors' qualifications, and distance proximity. A purposive sampling method was also used to select a sample of study year, a sample of a course study, and the intervention groups. The participants of the study were Second-Year Linear PBTs who studied invertebrate zoology course (Biol-221) in regular program 2020/21 academic year. The intact groups were assigned into treatment and comparison group. A total of 128 PBTs (70 males and 58 females) were used as the study sample. Both quantitative and qualitative data collection instruments were employed in the study. A science process skills test (SPST) was used to collect quantitative data. The test items include indicators of BSPS and ISPS were adapted and conceptualized from literature (Zeidan & Jayosi, 2015; Shahali et al., 2017). The qualitative data was also obtained through observation using rubric in science process skills learning of invertebrate zoology (Chabalengula et al., 2009). The score, rating, and description of SPS were presented in Appendix1.

Face and content validity of intervention materials and instruments were checked by biology teacher experts, language teachers, colleagues, and curriculum and instruction experts. The comments and suggestions of experts were adjusted accordingly. The piloting was employed for item analysis and checking reliability. The items analysis was conducted using difficulty level and discrimination power. The internal consistency of SPST items reliability was checked with Kurd Rechardson-20 alpha coefficient and it was found to be 0.72.

The intervention material was used to train three course instructors and three laboratory technicians. The training was emphasized on implementing of GIBIM for selected phylum of invertebrate zoology learning. An intervention was held for 8 consecutive weeks, 6 periods per week including practical session for 50 minute for each. The treatment groups were instructed using GIBIM. The comparison group was also taught using conventional method of instruction with same amount of time and topics as treatment groups. The pre-test was administered to all groups before intervention. Similarly, observation using a rubric was done during the process of intervention. A completion of intervention post-test was administered for all groups. Statistical Package for Social Sciences (SPSS) software version 20 was used to evaluate quantitative data. After checking the assumption of a statistical test, ANOVA and MANOVA were computed to analyze the data. The interpretation of mean scores for level of knowledge developed in SPST items was used literature (Rabacal, 2016) in Appendix 2.

Results

A pre-test in science process skills test (pre-SPST) which includes basic science process skills test (pre-BSPST) and integrated science process skills test (pre-ISPST) were administered for both treatment and comparison groups to assess skills ability of PBTs invertebrate zoology learning. An ANOVA was used to see if there was a statistically significant difference between groups. The major assumption of ANOVA was check and no serious violation was found. The results of the ANOVA analysis revealed that there was no statistically significant difference between groups (Table 1). So, the result of ANOVA implied that groups have the same level of SPS ability in invertebrate zoology before intervention.

To analyze post-SPST, an ANOVA statistical test was computed to answer research question 1. The assumptions of ANOVA, such as normality of the test and homogeneity of variance were checked. There was no remarkable violation of assumption preceded the run of ANOVA. The mean scores of treatment and comparison groups were different. The mean scores of post-SPST in both treatment groups exceed those in comparison group. However, the mean scores of TG1 were found to be higher than those of other groups in the post-SPST as shown in Table 2.

Table 1. Results of statistical analysis of pre-test scores of groups

Variables	Group	N	M	SD	F	df	*p*
pre-SPST	TG1	44	36.88	11.92	*0.52*	*2*	*0.60*
	TG2	40	35.23	11.3			
	CG	44	38.06	14.48			
pre-BSPST	TG1	44	41.66	2.28	0.27	2	0.77
	TG2	40	42.79	2.42			
	CG	44	40.31	2.31			
pre-ISPST	TG1	44	32.98	14.59	2.84	2	0.06
	TG2	40	41.37	16.75			
	CG	44	36.07	16.97			

Table 2. Descriptive statistics of post-SPST scores of the groups

	Groups								
	TG1			TG2			CG		
Variable	N	M	SD	N	M	SD	N	M	SD
Post-SPST	44	48.33	11.83	39	45.99	11.25	43	37.54	11.68

In addition to descriptive statistics, to evaluate if there is a statistically significant difference between post-SPST mean scores of groups ANOVA was computed. The result of ANOVA showed that there was a statistically significant difference between groups in post-SPST mean scores (F = 9. 78, p <0.001, η^2=0.14) in Table 3. The eta squared (η^2) value is 0.14 for post-SPST revealing that 14% variance of outcome variable was associated with intervention. The eta square (η^2) value is larger than typical value for post-SPST according to Cohen (1988). The difference between groups is associated with intervention.

Hereafter, post hoc analysis was computed to see which groups were significant. The post hoc analysis result showed that there was a statistical significant difference between TG1 and CG with (p=0.00) and TG2 and CG with (p=0.01) in post-SPST in Table 4. But, there was no a statistically significant difference between TG1 (M=48.33) and TG2 (45.99), p=0.62 in post-SPST.

Table 3. ANOVA result in post-SPST

Source	Groups	Type III Sum of Squares	df	Mean Squar e	F	*P*	η2
Post-SPST	Between groups	2629.20	2	1315	9.78	0.00	0.14
	Within groups	16526.25	123	134.4			
	Total	263272.76	126				

Table 4. Post hoc multiple comparison test result

Dependent variable	(I)group	(J)group)	Mean Difference (I-J)	Std. Error	*p**
Post-SPST	TG1	TG2	2.35	2.54	.62
		CG	10.52*	2.48	.00
	TG2	CG	-8.18*	2.56	.01

To analyze the level of knowledge developed in PBTs post-BSPST and post-ISPST, MANOVA was conducted in order to answer research question 2. The major assumptions of MANOVA like normality of test, homogeneity of error variance, outliers and others were checked. The descriptive statistics results revealed that there was a mean score difference between groups. The mean scores of post-BSPST in treatment groups were higher than comparison group in Table 5. Likewise, descriptive statistics results in the same Table 5 showed that mean scores of post-ISPST indicated that PBTs in treatment groups performed better than PBTs in comparison group.

Table 5. Descriptive statistics of post-BSPST and post-ISPST tests scores across groups

Variables	Group								
	TG1			TG2			CG		
	N	M	SD	N	M	SD	N	M	SD
Post-BSIST	44	53.08	17.13	39	50.15	18.08	43	44.21	18.08
Post-ISIST	44	44.46	13.13	39	43.58	12.86	43	32.11	12.16

Further, to evaluate if there is a significant difference between groups, MANOVA test was employed. The result showed that there was a statistically significant difference between groups of PBTs in the outcome variables mean scores (F=7.99, *p*= 0.00; Wilks' Lambda =0.81; η2=0.10) in Table 6. The eta squared (η2) value implied that 10% multivariate variance post-test mean scores was linked with intervention. Eta squared (η2) value is larger than typical value based on Cohen (1988).

Table 6. MANOVA result- multivariate test

	Wilks' Lambda	F	Hy. df	Error df	*P*	η2
Treatment groups	0.81	7.99	4.00	244.00	0.00	0.10

The Test Between-Subjects Effects result showed that there was a statistical significant mean difference between groups in post-ISPST (*p*= 0.00, η2=0.19). The Eta squared (η^2) value is 0.19 for post-ISPST depicted that 19% variance of outcome variable was related to intervention. Eta squared (η^2) value is larger than the typical value for post-ISPST based on the Cohen (1988) as presented below in Table 7.

After this, post hoc analysis was computed to see which groups were significant. The post hoc analysis result showed that there was a statistically significant mean difference between TG1 and CG (*p* =0.00) and TG2 and CG (*p*=0.00) in post-ISPST. But, there was no a statistically significant difference in post hoc analysis between TG1 and TG2 (*p*=1) in Table 8.

Table 7. Tests of between subjects effects

Source	Type III Sum of Squares	df	Mean Square	F	*P*	η2
Post-BSPST	1769.83	2	884.92	2.72	.07	.04
Post-ISPST	4046.47	2	2023.24	13.95	.00	.19

Table 8. Post hoc analysis test result

Dependent Variable	(I) Group	(J) Group	Mean difference (I-J)	Std. Error	*P*
post-ISPST	TG1	TG2	2.33	2.56	.63
		CG	10.52*	2.5	.00
	TG 2	CG	8.18*	2.57	.01

Relation to the level of knowledge developed by PBTs in post-BSPST and post-ISPST mean scores interpretations; they are presented in Table 9. The indicators of BSPST, such as post-classifying test level of knowledge developed by PBTs, were different across groups. The level of knowledge developed in treatment groups were found to be medium while in comparison group it was low. In post-communicating test, each group's mean scores were different between groups. The level of knowledge developed for TG1, TG2 and CG was high, medium and low, respectively, in post-communicating test according to the mean scores interpretation. In the post-predicting test mean scores were found to be 2.72, 1.80 and 1.78 for TG1, TG2 and CG, respectively. Thus, interpretation was medium for TG1 and low for other groups. Similarly, indicator post-measuring test and post-inferring test mean scores were obtained medium for treatment groups low for comparison group.

Likewise, level of knowledge developed in post-ISPST indicators mean scores and interpretation across group was shown in Table 9. In the post-identifying variable test, the level of knowledge developed in across groups was not the same. The mean scores of TG1 (M=3.26) was higher than TG2 (M=2.88) and CG (M=1.23). Thus, mean score interpretations were found to be high, medium and low for TG1, TG2 and CG, respectively. Similarly, the level of knowledge developed in post-hypothesis test, post-experimenting test, and post-data interpreting test mean scores were different. The mean scores interpretation for all indicators were found to be medium but low for CG, respectively in post-SPST. Regarding data interpretation in both TG1 and TG2, the level of knowledge developed was medium whereas it was low for CG. To finish, for drawing conclusion, all groups mean scores were obtained as medium, and for constructing model, they were found to be low.

Table 9. The mean scores and interpretation of post-BSPST and post-SPST across groups

	Groups					
Indicators	TG1	Interpretation	TG2	Interpretation	CG	Interpretation
Observing/& comparing	2.95	Medium	2.69	Medium	1.30	Low
Classifying	1.59	Low	1.53	Low	2.03	Medium
Communicating	3.00	High	2.89	Medium	1.54	Low
Measuring	2.96	Medium	2.71	Medium	1.46	Low
Inferring	2.50	Medium	2.11	Medium	1.67	Low
Predicting	2.72	Medium	1.8	Low	1.78	Low
Identifying variables	3.26	High	2.88	Medium	1.23	Low
Hypothesis	2.98	Medium	2.08	Medium	1.94	Low
Experimenting	2.98	Medium	2.72	Medium	1.79	Low
Data interpreting	2.65	Medium	2.99	Medium	1.41	Low
Conclusion	2.65	Medium	2.21	Medium	2.28	Medium
Modeling	1.70	Low	1.84	Low	1.85	Low

To sum up, post-BSPST and post-ISPST mean scores were different across groups. However, the interpretation due to range interval scale (see appendix 2) was medium for TG1 and TG2 whereas low for CG, respectively (Table 10).

Table 10. The summary of level of knowledge developed in post-BSPST and post-ISPST

	Groups					
Types of SPS	TG1	Category	TG2	Category	CG	Category
BSPS	15.75	Medium	13.73	Medium	9.78	Low
ISPS	16.22	Medium	14.72	Medium	10.50	Low

Concerning research question 3, qualitative analysis results on designed activities of SPS observation was evaluated using a rubric. The observation data was gathered only in the treatment groups. The results of BSPS indicators, such as observing and/or comparing, measuring and classifying scores (60%) were found under nearly proficient rating scale (see Table 11 and Appendix 1). Similarly, communicating and predicting indicators of BSPS score (50%) were also obtained in a similar rating. Except for inferring indicator of BSPS others were found score to above (50%) and in the medium category. In the BSPS indicators, average scores (55%) were found under nearly proficient and medium categories. Likewise, in ISPS indicators, a relatively high percentage was found under a nearly proficient rating scale. The indicators, such as data interpreting, experimenting, and conclusion scoring of around (60%) were obtained. As well, in identifying variables and hypothesizing indicators of ISPS ability, PBTs scores (50%) were obtained in the nearly proficient rating scale. The average score (51%) is medium for ISPS (Table 11).

Therefore, qualitative data analyses of SPS rubric revealed a nearly proficient rating. This means PBTs' ability of describing events and phenomena were required nearly proficient and medium. To this end, the qualitative data analysis of science process skills rubric results generally in several indicators was supported the quantitative data analysis of post-SPST.

Table 11. The rating score of BSPS and ISPS (N=83)

Indicators	Novice (%)	Nearly proficient (%)	Proficient (%)	Advanced Proficient (%)
BSPS				
Observing/comparing	15.91	59.09	13.64	11.36
Measuring	20.45	61.36	11.36	6.82
Classifying	18.18	59.09	13.64	9.09
Communicating	40.91	52.27	6.82	0
Inferring	43.18	45.45	6.82	0
Predicting	40.91	50.00	13.64	0
Average	**29.92**	**54.55**	**10.98**	**4.55**
ISPS				
Identifying Variables	40.91	52.73	6.36	0
Hypothesizing	29.55	55.27	15.18	0
Experimenting	25	59.97	15.12	0
Data interpreting	38.64	57.91	2.31	1.5

Conclusion	22.73	60	14.37	3.68
Constructing model	75	20.45	4.55	0
Average	**38.64**	**51.06**	**9.65**	**.08**

Discussion

This section attempts to discuss the study's major findings obtained from data analysis. The first research question was to study overall SPS of invertebrate zoology learning between groups. The result revealed that there was a statistically significant difference between groups. In post-SPST, the treatment groups' mean scores were found to be higher than the comparison group's. Studies indicate that inquiry based instruction offers multifaceted dimensions to performing scientific investigation in SPS (Nurza et al., 2021) and contributes to achieving components of process of science (Prayitno et al., 2017). Nisa et al. (2018) testified that GIBIM has a tremendous effect on learning SPS and engages students in higher-order thinking. Moreover, the constructivist approach offers an opportunity for learners to solve scientific problems and empowers them to construct their own knowledge through the process of science (Shamsudina et al., 2013). In contrast, in science education teacher-directed method of instruction emphasizes the acquisition of factual content knowledge and there is a problem with establishing science process teaching (Shahali et al., 2017).

The current study's findings are similar to previous study on effects of GIBIM for improving students' SPS and critical thinking skills (Nisa et al., 2018). Beside, GIBIM provides opportunity for learners to develop SPS throughout life learning and encouraging independency to play active role and responsibility in various stages (Hardianti & Kuswanto, 2017). Likewise, GIBIM improves acquisition of students SPS, performance in science learning by allowing to solve scientific challenges and empowering to construct knowledge (Nisa et al., 2018). In general, the findings of this study showing that

GIBIM is more successful than conventional method of instruction for developing learners' science process skills.

The second research question was about the level of knowledge developed in BSPS and ISPS between groups. In Table 6 above, MANOVA analysis revealed that there was a significant difference between groups in post-BSPST and post-ISPST. The results in Test Between-Subjects Effects in Table 7 showed that there was a statistical significant mean difference between groups in post-ISPST but not significant in post-BSPST. This is because PBTs may have some experience in ISPS in traditional laboratory work than BSPS. Regarding the mean scores' interpretation, the majority of skills indicators in the treatment groups were medium, but the comparison group was low, except for classifying and conclusion.

The current study findings align with Hastuti et al. (2018) argues that students who are exposed to GIBIM have a higher level of knowledge development in SPS than traditional approaches. Similarly, the findings of the study conducted on "integration of project activity to increase scientific process skill and self-efficacy in zoology of vertebrate teaching and learning" revealed that SPS indicators, such as observing and measuring students have the same level of knowledge among groups (Hernawati et al., 2018). In drawing conclusions and constructing models, these authors' findings agree with current research findings. However, the levels of knowledge developed in both post-test skills differed across rest of the SPS treatment and comparison groups. Accordingly, the current study's findings on BSPS and ISPS knowledge levels correspond to earlier research findings (Aydoğdu, 2015). As a result, the outcomes of this study are consistent with previous research findings, indicating that implementing GIBIM is helpful for improving SPS.

The investigation of how PBTs in practice incorporate indicators of SPS was the third research question. The SPS rubric was used to assess practical implementation of designed activities. PBTs had a favorable attitude toward investigating SPS with active-based education (Molefe et al., 2016; Tan et al., 2020). The majority of skills were attained more than 50% based on rubric rating in both BSPS and ISPS. Mohamad and Ong (2013) stated that learners acquired mastery of SPS abilities at a rate 67% as standard. Thus, the current findings of the obtained SPS were not satisfactory, according to these authors. This meant that the current study's findings were lower than the benchmarks in both BSPS and ISPS. However, according to the interpretation of the scores, the skill level was deemed to be in the medium range (Akani, 2015). This implies that PBTs in the CTEs abilities of SPS, particularly BSPS, will require multiple tries to improve using active-based instruction strategies. To this end, GIBIM is effective for attaining the goal of science education. Finally, the qualitative analysis results of SPS findings were supported the quantitative data analysis findings of post-SPST in many aspects.

Conclusion and recommendation

The findings of this study show that GIBIM in SPS learning invertebrate zoology increases PBTs skill acquisition better than conventional method of instruction. As a result, GIBIM helps PBTs learn SPS in the context with reasonable scaffolding from teacher educators. The PBTs level of knowledge developed in SPS learning invertebrate zoology in treatment groups was found to be medium, whereas comparison group was found to be low. In addition, the ability of PBTs in ISPS was higher than in BSPS. Moreover, the experience of teachers in active-based learning strategies and developments of teaching materials or modules affect the implementation of GIBIM in SPS learning invertebrate zoology. The study suggested that creating awareness of teacher educators to use inquiry-based strategy should be enhanced for SPS learning invertebrate zoology. Finally, curriculum or teaching materials developers should be considered GIBIM for science learning and should emphasize SPS as a major component of science learning.

APPENDICES

Appendix 1. Key to the score, rating and description

SPS	Score	Rating scale	Description
	0	Novice	Unable to describe animals and characters correctly.
	1	N*proficient	Limited description of animals and features in the practical manners.
	2	Proficient	Correctly describing the features of animals.
	3	A* proficient	Correctly descripting of the animals with pertinent examples.

N- nearly,* A*-advance

Appendix 2. The mean score and interpretation of science process skills

SPS Overall		BSPS		ISPS	
Score	Interpretation	Score	Interpretation	Score	Interpretation
22-27	Very High	24.01-30	Very High	20.01-25	Very High
17-21.5	High	18.01-24	High	15.01-20	High
12-16.5	medium	12.01-18	medium	10.01-15	medium
7-11.5	Low	6.01-12	Low	5.01-10	Low
<7	very low	.<6	very low	<5	very low

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NOTES

1. https://files.eric.ed.gov/fulltext/ED491498.pdf

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