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Guided inquiry-based model on pre-service teachers conceptual understanding of learning invertebrate zoology

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Abstract

The purpose of the current study was to investigate the effects of the guided inquiry-based instructional model (GIBIM) on pre-service biology teachers' conceptual understanding of invertebrate zoology learning. The research study used a quantitative research method. The study used a non-equivalent quasi-experimental pre-test, post-test group design. Three intact classes were assigned into a treatment group-1, treatment group-2, and comparison group. The groups were taught for eight consecutive weeks with a GIBIM and conventional teaching method, respectively. The data were collected with invertebrate zoology conceptual understanding test items and administered pre-test and post-test. The data were analyzed using one-way ANOVA. The study result revealed that there were significant differences between groups in concept understanding of invertebrate zoology learning. The normalized gains of pre-service biology teachers in the treatment groups were also higher than a comparison group. Henceforth, the GIBIM has sound effect on pre-service biology teachers, understanding of invertebrate zoology concepts.

Key words: conceptual understanding; conventional method; guided inquiry; invertebrate zoology; pre-service teachers

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1. Introduction

In the 21st century science learning scenario students can be able to construct their own knowledge when they get opportunity to interact with peers, teachers and environment (Wardyaningrum & Suyanto, 2019). Contrary, in the process of learning biological information without interaction of phenomena is struggling for learners to understand scientific knowledge. Mainly the reasons are due to the nature of the subjects/courses and teachers selection of instructional strategy. The instructional strategy which was discussed later plays significant role for attaining the objectives of biology learning (Shamsudina et al., 2013; Jerrim et al., 2020).

The nature of biology such as; the diversity of organisms, level of organization, fragmentation of concepts and miscellaneous terminologies are largely affects students teaching (Maigoro et al., 2017). Sezek (2013) identified the characteristics features and classifications of animals into appropriate groups are the struggling concept of learning biology/ zoology. Likewise, Maigoro et al. (2017) recognized that the struggling features of invertebrate zoology are including from simple characteristics of porifera to complex echinoderms.

Despite, the characteristics features is challenging to learn and understand, the knowledge of invertebrate zoology has significant contributions to humans and environment. Some of the contributions include connecting producers to consumers, keeping healthy environment, disseminating of seeds, providing as a food sources and decomposing of organic substances (Pereira & Carneiro, 2014; Putra et al., 2014). With is regards, contributions of invertebrate zoology learning are recognized as part of the biology curriculum in schools and institutions in different nations.

Thus, in Ethiopian education system, curriculum of invertebrate zoology is offering in schools and institutions. The invertebrate zoology curriculum at colleges of teacher education designed to offer eight major phyla and some others sub-phyla (Ministry of Education in Ethiopia [MoE], 2007). The frameworks of the course include characteristics of phylum, body structure and function, criteria of classification, hierarchy of invertebrate animals and their roles to humans and environment (MoE, 2007). Hence, study shows that learning invertebrate zoology due to its very nature learners are struggling to understand the concept (Cinici, 2013). So, pre-service biology teachers for effective understanding of invertebrate zoology concepts, interactive frameworks are very needed in the process of learning.

1.1 Theoretical Framework

Pre-service biology teachers' understanding of invertebrate zoology concepts learning with inquiry-based constructivist model was framed for the current study. Thus, among the different forms of inquiry-based model, guided inquiry-based instructional model was used for the study. The phases of guided inquiry-based instructional model include planning, retrieving, processing, creating, sharing, and evaluating (Learning, 2004). The guided inquiry-based instructional model in each phase has been coined with Vygotskian principles such as; proximal zone of development (PDZ), scaffolding, cooperative learning, and social interaction (Vygotsky, 1980).

With this regards, guided inquiry-based instructional model encourages pre-service biology teachers to develop experience of working with their peers collaboratively by focusing on teachers' probing questions and with providing pertinent guidance, and feedbacks in the process of learning (Mwanda et al., 2017; Njoku & Nwagbo, 2020). Therefore, guided inquiry-based instructional model was used to study the conceptual understanding of pre-service biology teachers' in invertebrate zoology learning.

1.2. Related Research

Conceptual Understanding of Pre-service Biology Teachers

Understanding concepts is an important component of science learning in all levels of formal education to learners for applying knowledge in the real-life context (Wardyaningrum & Suyanto, 2019). Also, conceptual understanding requires uses of scientific knowledge in real-life context (Hutahaean et al., 2017; Tan et al., 2020). Ibrahim and Lede (2018) conceptual understanding described as 'commonsense beliefs' of learners on their own learning. Besides, conceptual understanding is the functional understanding of knowledge in the contexts, explaining, distinguishing and connecting ability of learners (Widiyatmoko & Shimizu, 2018). Hence, conceptual understanding is the learners thoughtful about what they grasp and explain in the phenomena of learning.

As a result, conceptual understanding is a useful scientific learning domain of 21st century scenario to provide analytic thinking and problem-solving skills (Jansen & Merwe, 2015; Zenger & Bitzenbauer, 2022). Similarly, Koniceck-Moran and Keeley (2015) argue that science understanding concepts is effective when learners practice in different situations that enabling meaning, building models, formulating principles, and generalizing. Therefore, learners to construct scientific knowledge needs active learning methods such as, inquiry-based model (Hutahaean et al., 2017). So, the guided inquiry-based instructional model is important for pre-service biology teachers to investigate live invertebrate animal specimens from the context (Eunice & Michael, 2016).

Guided Inquiry-Based Instructional Model

The inquiry-based instructional model is a constructivist approach that provides learners opportunity to observe and collect live organisms from the context (Wijanayu et al., 2018). Sezek (2013) agreed that inquiry-based instructional model is useful to motivate students' in the process of learning invertebrate zoology. The reason is because; inquiry-based instructional model is prominently heart and center to develop learners' scientific knowledge (Laksana et al., 2019; Jerrim et al., 2020).

At the start, mostly in the process of using guided inquiry-based instructional model the role of the teacher is facilitating and as well supporting learners to reduce cognitive load and misconceptions (Learning, 2004). Later, the teacher educators are also expected learners to generate procedures and explore solutions to the problems and to draw conclusions following on the probing activities (Jerrim et al., 2020). Studies agreed that relevant guidance of teacher is vital for understanding of scientific knowledge (Almuntasheri et al., 2016), applying of scientific concept in real-life situation (Bunterm et al., 2014), and reducing students' frustration (Hardianti & Kuswanto, 2017).

The guided inquiry-based instructional model includes six phases: planning, retrieving, processing, creating, sharing and evaluating (Learning, 2004). In the planning phase, activities mostly taking place by teachers such as: identifying a topic, posing questions, locating information sources and organizing formats. In the retrieving phase, major activities are belonging to students like developing information, collecting resources and selecting relevant information (Ismail & Elias, 2006).

In the processing phase focus given on investigating of pertinent information, making connections with real-life situation and recording information. While in the creating phase, students are organizing information, generating results and raising discussion tips. Likewise, in the sharing phase, students are proposing products of information, demonstrating and reflecting their findings (Learning, 2004). Lastly, in the evaluating phase the roles of teacher and peers are assessing and providing feedbacks. Hence, these discussed phases of the model were implemented in the process of invertebrate zoology learning with relevant coaching of course instructors.

As a result, research reported that science learning using inquiry-based instructional model promotes students understanding of scientific concepts (Hadjichambis et al., 2015; Nisa et al., 2018; Saputro et al., 2019; Tan et al., 2020). On the other side, Hinneh (2017) argued that conventional method of teaching is inadequate to promote thinking and doing science in practical situation. This aligns with

Ortlieb and Lu (2011) conventional method of teaching is used for students' rote memorization of content knowledge. Therefore, fixing invertebrate zoology learning with lecture dominating approach are causes for several misunderstanding of scientific concepts **(**Widiansyah et al., 2018).

1.3. Purpose of the Study

In Ethiopian education system, policy documents encourage learner-centered strategy for teaching in schools and institutions, however; teacher-centered method is a dominant in the teaching learning process (Alemu et al., 2019; MoE, 2018; Wodaj & Solomon, 2021; Abate et al., 2021). With this fact, students achievements (Daba et al., 2016; Gebremeskel et al., 2018)**,** interests of students to science learning (Sintayehu, 2016), and ability of students connecting learning with real-life situation (MoE, 2018) are low.

Despite the fact, studies reported that the guided inquiry-based instructional model (GIBIM) is effective in science learning and improving outcomes (Ibrahim & Lede, 2018; Nisa et al, 2018). Similarly, study conducted on Ethiopian schools and colleges of teacher education reported that constructivist based instructional model promotes learners concept understanding in science learning (Shishigu et al., 2018; Wodaj & Belay, 2021).

However, researches claimed that when using GIBIM to conduct science learning, learners only received minimal supervision (Scott et al., 2018; Jerrim et al., 2020). By providing adequate scaffolding for orientation of inquiry activities during invertebrate zoology learning, this study attempted to close this gap. Therefore, the objective of this study was to investigate PBTs invertebrate zoology learning with GIBIM at Hossana and Armanich College of Teacher Education in the Southern Nation Nationalities and Peoples Regional States (SNNPRs), Ethiopia.

To address the purpose following research questions were formulated: Is there a significant mean score difference across groups in terms of overall and selected phylum concept understanding of invertebrate zoology learning? Is there a normalized-gain difference between groups in invertebrate zoology concepts learning?

Finally, the study provides a lot of significance on teaching science in general and biology fields' in particular using guided inquiry-based instructional model to encourage pre-service biology teachers' concept understanding. So, teacher educators' using creative pedagogy like GIBIM in classroom practices gives rise to quality and well-organized science/biology curriculum learning.

2. Method

2.1 Research Design

The study was used quantitative research approach because it is helpful to measure the understanding and practices (Cohen et al., 2007). The design of the study was quasi-experimental a non-equivalent pre-test, intervention and post-test group design (Table1). The quasi-experimental design is helpful for implementing intervention without interfering learning situation of the intact groups. Among three intact groups' two were treatment groups and remaining a comparison group. The treatment groups (TG1 and TG2) were instructed using GIBIM with six phases learning model (planning, retrieving, processing, creating, sharing and evaluating). For the replication purpose of the study used treatment group-2. According to Creswell (2012) the aim of replication was to reduce threats of quasi-experiment design and have reliable data for study. In the other side, a comparison group (CG) was instructed with conventional teaching method.

Table1

Quasi-experimental non-equivalent, pretest, intervention, posttest group design

Group	Pretest	Intervention	Posttest
Treatment group1(TG1)	O_1	GIBIM	O_2
Treatment group 2(TG2)*	O_1	GIBIM	O_2
Comparison (CG)	O_1	CMT	O_2

Note. Where O_1=pretest, O_2=Posttest, GIBIM= guided inquiry- based instructional model, CMT=conventional method of teaching, TG2*= the replication group.

2.2 Setting, Sampling Methods and Sample

The research site Hossana College of Teacher Education (HCTE) and Arbaminch College of Teacher Education (AMCTE) are located in SNNPRs. Using purposive sampling method, the two colleges of teacher education were selected to obtain substantial data. The participants of pre-service biology teachers who were listed for invertebrate zoology course in 2020/21 academic year selected using convenient sampling techniques. Among the total of 128 participants 58 were females and 70 were males.

2.3 Data Collecting Instruments

Quantitative instruments were used to collect data. The data was collected using two tiers test items instrument from selected phylum (Rotifer, Annelid, Mollusk and Arthropd) of invertebrate zoology concept test (IZCUT). The aims of the two tiers test items (multiple choice and reasoning) were evaluating pre-service biology teachers (PBTs) understanding of invertebrate zoology concepts. Multiple choice test items were measuring content knowledge of PBTs while reasoning questions were evaluating the abilities of PBTs explaining, interrelating, drawing, summarizing and applying of concepts (Widiyatmoko & Shimizu, 2018).

The invertebrate zoology data collecting concept test items were made by the researchers. The concept test items were prepared following three phases and ten steps of instruments development (Tüysüz, 2009; Mutlu & Sesen, 2015). In Appendix A below test items were allocated based on content specification grid.

2.4 Validation of the Instruments

The face and content validity of intervention training materials and test items instrument were checked by biology teacher educators, colleagues, and experts of curriculum and instruction. The comments and suggestions of professionals were reviewed accordingly. The test items were piloted before using main study in the same population for analyzing and checking reliability of test items. Difficulty index (L) and discrimination power (P) of test items were computed. Based on the analysis results some test items were re-adjusted to keep for final version of study and some others rejected from test items by considering content specification grid. The internal consistency of IZCUT items reliability was checked with Kurd Rechardson-20 alpha coefficient and it was found to be .71.

2.5 Data Collection Procedure

Before starting the intervention a day lasted refreshment workshop on the infused invertebrate zoology curriculum material with GIBIM was given for three course instructors and three laboratory technicians. During training session practical activities about GIBIM infused invertebrate zoology material were emphasized based on KWL strategy. The KWL refers K= "What I Know", W= "What I Want to Know" and L= "What I Learned" (Learning, 2004). Among those instructors, two course instructors were assigned for treatment groups to teach module (invertebrate zoology teaching material) infused with GIBIM. Checklists were also used by both course instructors and PBTs to follow how intervention is carried out.

The intervention was implemented for eight successive weeks, 6 periods per week (including practical session) for 50 minute for each. On the other side, one instructor was also assigned for teaching a comparison group using conventional teaching method. Before intervention, pre-test was administered for all groups. Lastly, after intervention post-test were administered for both (treatments and a comparison) groups.

2.6 Data Analysis

The quantitative data were analyzed with Statistical Package for Social Sciences (SPSS) software version 20. After, checking assumption of parametric statistical test ANOVA was employed to analyze the collected data. The effect size differences of groups were interpreted from the eta value outputs of the data analysis. Moreover, normalized gain (N-gain) of groups' of PBTs invertebrate zoology concept learning was computed using formula and the score category based on the literature (Permana et al., 2019) as presented in Appendix B.

$$\mathrm{N-gain} = \frac{\mathrm{posttest} - \mathrm{pretest}}{\mathrm{maximum\ posttest} - \mathrm{pretest}}$$

Where:

- N-gain: the measure of change obtained in the same invertebrate zoology concept test to gauge understanding of PBTs at the beginning and after intervention,
- Posttest: the average means scores of PBTs after intervention,
- Pretest: the average mean scores of PBTs before intervention,
- Maximum posttest: the highest mean score of individual after intervention.

3. Results

3.1 Pre-test Analysis of Conceptual Understanding

Results of pre-overall invertebrate zoology conceptual understanding test (pre-IZCUT), pre-rotifer test (pre-ROTT), pre-annelid test (pre-ANNT), pre-mollusk test (pre-MOLT) and pre-arthropod test (pre-ARTT) were administered to assess PBTs understanding of invertebrate zoology concept. After checking the assumptions, ANOVA was used to realize if there is a a statistically significant difference between groups. ANOVA result revealed that there was no a statistically significant mean scores difference between groups in pre-IZCUT, pre-ROTT, pre-ANNT, pre-MOLT and pre-ARTT (see Table 2). Therefore, the study groups' concept understandings of invertebrate zoology learning have similar, before intervention.

Table 2

The results of pre-test scores of dependent variables across groups

Dependent Variables	Groups	N	M	SD	F	df	*p**
	TG1	44	24.7	10.0			
Pre-IZCUT	TG2	40	24.0	9.0	*.38*	*2*	*.67*
	CG	44	23.9	9.4			
	TG1	44	29.0	22.2			

Pre-ROTT	TG2	40	26.9	23.2	.09	2	.09
	CG	44	27.3	24.3			
	TG1	44	21.4	18.5			
pre-ANNT	TG2	40	15.9	14.6	1.31	2	.27
	CG	44	17.2	14.9			
	TG1	44	27.3	17.8			
pre-MOLT	TG2	40	18.5	14.8	2.68	2	.07
	CG	44	22.8	18.8			
	TG1	44	24.6	16.7			
pre-ARTT	TG2	40	25.2	18.3	.02	2	.97
	CG	44	24.4	18.3			

3.2 Post-Test Analysis of Conceptual understanding

At the end of intervention post-IZCUT was administered to all groups. The ANOVA was computed to analyze post-IZCUT test. The major assumptions such as; normality of the test and homogeneity of variance were checked and not violated the assumptions to run ANOVA. The descriptive statistics results of mean scores of groups in PBTs post-IZCUT were different across groups (see Table 3).

Table 3

The descriptive statistics analysis results of post-IZCUT across groups

	Groups								
	TG1			TG2			CG		
Variable	N	M	SD	N	M	SD	N	M	SD
Post-IZCUT	44	47.84	8.91	39	43.33	13.04	43	33.72	11.44

After, analysis of the descriptive statistics results, to see if there is statistically significant differences between post-tests mean scores of groups, ANOVA was computed. In Table 4 result of ANOVA showed that there was a statistically significant difference between groups in post-IZCUT mean scores, (F = 17.98, p =.00, η^2= .23). The eta squared (η^2 =.23) value is much larger than typical value Cohen (1988). The eta squared (effect size) 23 % of post-IZCUT mean scores was associated with intervention.

Table 4

ANOVA result comparing groups in terms of post-IZCUT

Source	Type III Sum of Squares	df	F	P	η^2
Post-IZCUT	4500.24	2	17.98	.00	.23

Since, ANOVA result was a statistically significant between groups, to check which group is significant post hoc analysis was articulated. The post hoc analysis result showed that there was a statistical significant difference across groups (Table 5**).** There was a statistical significant difference between TG1 and CG with **(**p=.00) and TG2 and CG (p=.00) but there was no significant difference between, TG1 and TG 2 with (p=.21**)** in post-IZCUT mean scores. The post-IZCUT results were shown that PBTs in treatment group were performed better than PBTs in comparison group.

Table 5

Post hoc multiple comparison test result

Dependent	(I)	(J) Group	Mean	Std.	*P*

variable	Group		Difference (I-J)	Error	
	TG1	TG2	4.5	2.46	.21
Post-IZCUT		CG	14.12*	2.39	.00
	TG2	CG	9.61*	2.47	.00

Similarly, the results of post-ROTT, post-ANNT, post-MOLT, and post-ARTT descriptive statistics were presented in Table 6. The descriptive statistics analysis results of mean scores of all post-test selected invertebrate zoology phylum indicated that PBTs in treatment groups performed better than PBTs in a comparison group.

Table 6

The descriptive statistics analysis results of select phyla across groups

Dependent Variable	Groups								
	TG1			TG2			CG		
	N	M	SD	N	M	SD	N	M	SD
post-ROTT	44	44.41	24.02	39	30.76	23.96	43	15.11	18.20
post-ANNT	44	41.36	17.99	39	31.79	19.31	43	31.63	19.63
post-MOLT	44	49.54	19.04	39	45.12	18.76	43	40.00	21.80
post-ARTT	44	54.16	17.65	39	39.74	21.83	43	32.94	21.35

To check if there is statistically significant difference post-tests mean scores of the selected phylum of invertebrate zoology between groups ANOVA was conducted. The test result of ANOVA revealed that there was a statistically significant difference between groups in post-ROTT, post-ANNT and post- ARTT mean scores, (F= 18.85, p = .00, η^2= .24), (F= 3.71, p = .03, η^2= .06) and (F = 12.39, p = .00, η^2= .17) respectively in Table 7.

The Eta squared (η^2) value is .24, .06 and .17 for post-ROTT, post-ANNT, and post-ARTT respectively showing that 24%, 6% and 17% variance of outcome variables were associated with intervention. The eta squared (η^2) value is much larger than typical value for post-ROTT, medium value for post-ANNT, and larger than typical value for post-ARTT respectively (Cohen, 1988). This showed that the difference between groups in outcome variable was associated with intervention. But there was no a statistically significant difference between post-MOLT of PBTs groups mean scores, (F=2.49, p=.09, η^2=.4).

Table 7

ANOVA result comparing groups in terms of posttest selected phyla

Independent variable	Dependent Variables	Type III Sum of Squares	df	F	*P*	η2
Groups	post-ROTT	18565.94	2	18.85	.00	.24
	post-ANNT	2670.62	2	3.71	.03	.06
	post-MOLT	1983.94	2	2.49	.09	.04
	post-ARTT	10210.04	2	12.39	.00	.17

Then, to see which group is significant, post hoc analyses were conducted. The post hoc analysis result showed that there were statically significant difference between TG1 and TG2 with (p =.02), TG1 and CG with (p=.00) and TG2 and CG with (p=.01) in post-ROTT scores (Appendix 3). Similarly, post hoc analysis result of post-ANNT showed that there were statistically significant mean scores difference between TG1 and CG with (p=.05). But there were no statistically significant difference between, TG1 and TG2 with (p=.06) and TG2 and CG with (p=1) respectively (see Table 8). As well, there were statistically significant difference between TG1 and CG with (*p*= .00) and TG1 and TG2 with (*p*.00) but there was no significant difference between, TG2 and CG with (*p*=.29) respectively in post-ARTTs scores.

Table 8

Post hoc multiple comparison test result of selected phylum of invertebrates

Dependent Variable	(I) Group	(J) Group	Mean difference (I-J)	Std. Error	*P*
post-ROTT	TG1	TG2	13.54*	4.88	.02
		CG	29.20*	4.76	.00
	TG2	CG	15.65*	4.91	.01
Post-ANNT	TG1	TG2	9.568	4.17	.06
		CG	9.73*	4.07	.05
	TG2	CG	.16	4.2	1.00
post-ARTT	TG1	TG2	14.42*	4.46	.00
		CG	21.22*	4.35	.00
	TG2	CG	6.79	4.49	.29

3.3 Normalized gain analysis

After, intervention N-gain results of rotifer, annelid, mollusk, and arthropod concept test were presented in Table 8. In the treatment group phylum Rotifer N-gain category was found “low” whereas in phylum Annelid, Mollusk and Arthropod N-gain category were “moderate” respectively. On the other side, in comparison group phylum Rotifer and Arthropod N-gain category were obtained “low” whilst for phylum Annelid and Mollusk N-gain category were found “moderate” respectively. Lastly, the average N-gain was found “moderate” category for treatment groups whereas “low” for comparison group respectively. Therefore, there were differences in N-gain between treatment and comparison groups. The treatment groups are superior with few exceptions (Table 9).

Table 9

The results of normalized again in select phyla across groups

Dependent	TG1			TG2			CG		
Variable	Mean	N-gain	Category	Mean	N-gain	Category	Mean	N-gain	Category
pre-ROTT	28.98	.25	Low	29.5	.2	Low	27.04	.03	Low
post-ROTT	43.39			37.16			28.83		
pre-ANNT	21.36	.4	moderate	15.14	.34	Moderate	17.96	.33	Moderate
post-ANNT	41.98			30.81			31.94		
pre-MOLT	27.27	.3	moderate	20	.47	Moderate	22.04	.33	Moderate
post-MOLT	49.55			47.16			43.14		
Pre-ARTT	24.62	.5	moderate	26.58	.3	Moderate	24.49	.2	Low
Post-ARTT	54.17			37.39			35.71		
Average		*.4*	*Moderate*		*.3*	*Moderate*		*.22*	*Low*

4. Discussion

In this section the findings of the research questions were discussed below. The first research question was to study overall and selected phylum of conceptual understanding of invertebrate zoology learning between groups of PBTs. The treatment groups were performed better than comparison group. In the meantime, PBTs invertebrate zoology concepts understanding in pre-test results were similar between groups. Then, the rationale of mean scores differences in post-test results between groups were associated with intervention.

Hence, current study findings are consistent with previous research findings that implementing GIBIM improves students' conceptual understanding as compared to conventional methods of teaching (Maknun, 2020; Nurza et al., 2021). According to Hadjichambis et al. (2015) research conducted on effectiveness of inquiry-based model intervention in human reproduction, finding of study revealed that students' conceptual understanding was higher than non-intervention group.

Similarly, Wardyaningrum and Suyanto (2019) reported that learning biology through GIBIM with appropriate materials improves students' conceptual understanding of biology better than the comparison group. Furthermore, study conducted on ecology using field-based inquiry experiences findings of the study reveal that significantly enhanced students' understanding of concepts and their achievement better than a comparison classes (Eunice & Michael, 2016).

Moreover, study conducted on implementation of GIBIM on the topic of invertebrate zoology findings of the study revealed that treatment groups enhanced concept understandings of learners' (Ertando et al., 2019). Hence, findings of the study were shown that GIBIM enhances learners' understanding of invertebrate zoology concepts instead of learning invertebrate zoology concepts than one of teaching from teacher to students. Therefore, invertebrate zoology learning using GIBIM has positively effects on pre-service biology teachers' concept understanding better than conventional method of teaching.

In research question 2 concept mean scores normalized-gain in the groups of invertebrate zoology learning using guided inquiry-based model effective than conventional teaching methods. The previous study findings were consistent with current study findings, for instance Aulia et al. (2017) reported that N-gain was found high category for treatment group whereas medium category for a comparison group. Likewise, study conducted on improving students' conceptual understanding of biology using inquiry based model N-gain was found .62 at 'medium' category for treatment group while N-gain found .38 'low' categories for a comparison group (Wardyaningrum & Suyanto, 2019).

In addition, study conducted on implementation of inquiry instructional model in plant anatomy, the findings revealed that average N-gain shows a significant difference between treatment and comparison groups which favored for the former (Muhibbuddin et al., 2018). Hence, current study findings supported the previous research findings (Bukifan & Yuliati, 2021). Similarly, Widiyatmoko and Shimizu (2018) attested that appropriate selection and implementation of strategy provides learners opportunity to engage and reduce misconceptions. Therefore, PBTs invertebrate zoology learning using GIBIM contributes concept gain more than conventional method of teaching.

Invertebrate animals learning using GIBIM with instructors probing questions, providing appropriate support and feedbacks allowed PBTs for better understanding of concepts. This because curriculum of invertebrate zoology teaching materials infused with GIBIM provides chance for PBTs interacting with phenomena at real-life situation.

5. Conclusion

The findings of the study revealed that overall and selected phylum of invertebrate zoology learning pre-service biology teachers' instructed with guided inquiry-based instructional model more promoted to understand concepts than conventional teaching method. Similarly, the groups of pre-service biology teachers instructed with GIBIM mean scores in normalized-gain were higher than pre-service biology teachers taught with conventional method of teaching. Beside, pre-service biology teachers instructed with GIBIM could be obtained more opportunity to interact with phenomena for understanding concepts during the investigation of the problems. Therefore, the infused invertebrate zoology curriculum material with GIBIM is helpful for PBTs better understanding of concepts.

6. Recommendations

The study recommended that infusion of teaching invertebrate zoology curriculum material with guided inquiry-based instructional model encourages concept understanding of pre-service biology teachers. Hence, the study suggested that curriculum material developer at the colleges of teacher education should be given emphasis for infusing of guided inquiry-based instructional model for quality science teaching.

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APPENDICES

Appendix A

Concept test content specification grid

Selected phylum	Number of items
Rotifer	3,4,18,19
Annelid	1,2,8,16,17
Mollusk	5,6,7,12,20
Arthropod	9,10,11,13,14,15

Appendix B

The N-gain <g> pair of pre and post selected phyla concept test interpretation

<g>	Category
<g> .7	"high gain"
<.7 <g> ≥ .3	"moderate gain"
<g> < .3	"low gain"