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Scientific research hypotheses understanding of the pre-service science teachers at Faculty of Education, Amran University, Yemen

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Preparing pre-service science teachers (PSSTs) with the scientific research skills (SRSs) is an ultimate aim of PSSTs' programs. This study aimed to explore PSSTs' understanding level of SRHs (SRHUL). To this end, an action research (AR) was adopted using a pre-post-test design. In doing so, a multiple choice test which consists of 15 items was developed and conducted on a random sample comprising 120 subjects. Results of the study revealed that participants showed insufficient performance on the test of understanding scientific research hypotheses (SRHUT) for both pre and post-test. Besides, results of t-test showed a significant difference between mean scores of pre-test and post-test. The difference was in favor of post-test. Also, results of one-way ANOVA revealed a non-significant difference between or within mean scores of compared groups. Based on the results of the study, some recommendations were made.

Key words: Pre-service science teachers, scientific research skills, action research.

INTRODUCTION

In the context of the 21st century, possessing SRSs is considered as a main goal of education, that is, science education, which leads to rise in SRSs of citizens who could show the scientific aspects of science in their life (Bökeoğlu and Yılmaz, 2005; Irwanto et al., 2017). SRSs can be known as identifying a problem, formulating hypotheses, gathering and analyzing data, as well as interpreting and discussing the results of analyzing data (Fraenkel and Wallen, 2006; Irwanto et al., 2018). Thus, linking such skills should be paramount in the vision of teacher education (Can and Kaymakci, 2015). Also, engaging teacher students in research-based learning is a vital issue in PSSTs' preparation program in order to carry out such goal, since research-based learning is a key aid in enabling students to develop a deep understanding of SRSs and empowers them to behave as scientists in knowledge acquisition and development (National Research Council, 2007; Can and Kaymakci, 2015).

In addition, SRSs (e.g. formulating SRHs) are the most fundamental underpinnings of teachers' educationprogram (National Research Council, 2007; Irwanto et al., 2018). Involving students in research activities continues to be a critical issue as it will enhance their critical thinking and problem-solving capacities which are compulsory competences for new achievements

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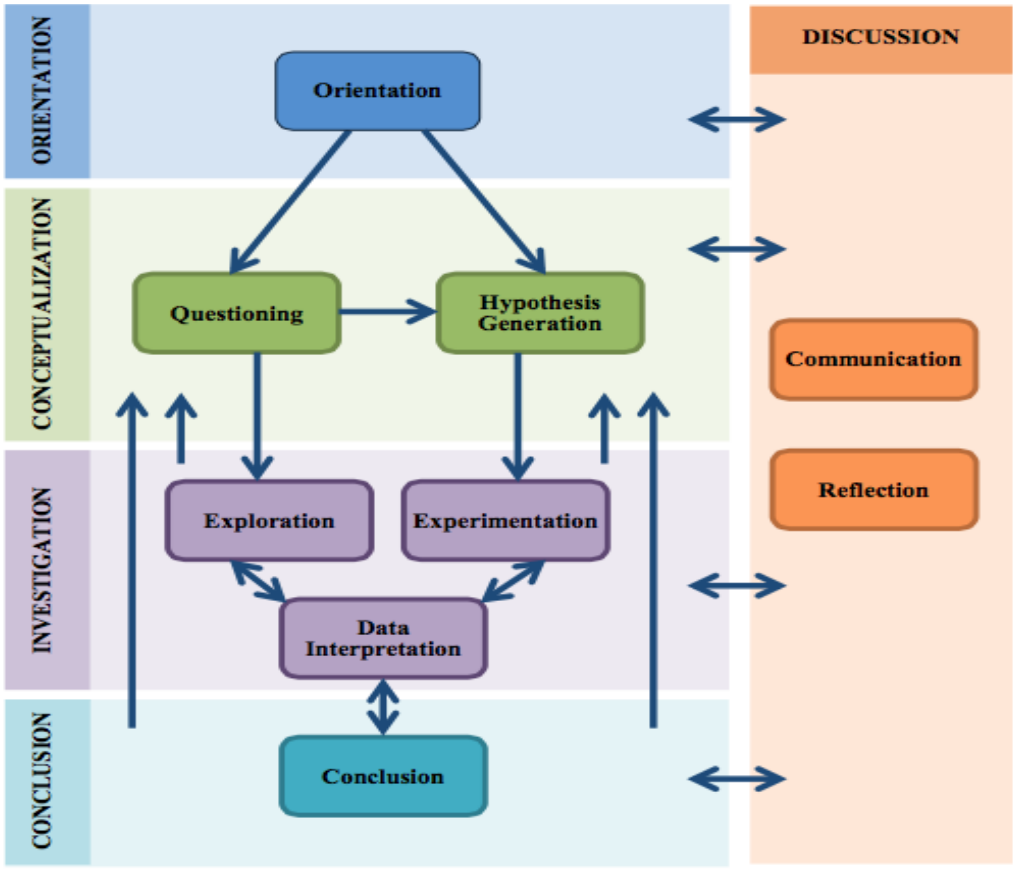

Figure 1. General phases, sub-phases and their relations in doing scientific research.

in education and consequently improve their learning-teaching practice. Thus, SRSs should be considered as an essential goal in students learning as well as a pedagogical method used by teachers (National Research Council, 2007; Irwanto et al., 2017). However, merits of the SRSs cannot be obtained by students unless there are well-qualified teachers who can transfer such skills to their students.

As illustrated in Figure 1, obtaining SRSs requires several practical phases for doing research that PSSTs[1]) should be exposed to. One of these phases involves formulating the hypotheses (Pedaste et al., 2015). Hence, hypotheses formulation is indispensable during scientific research, since it helps the researcher in (1) determining the type of data that will be collected; (2) selecting the instrument/s for collecting data; (3) choosing the suitable means for analyzing data; and (4) organizing such search with others searches (Walliman, 2011; Cohen et al., 2017).

[1] For this study, PSSTs can be defined as the 3rd academic year-students who studied fundamentals of educational research course (FERC) at Faculty of Education-Amran University. In Yemeni universities, PSSTs are prepared to become science secondary school teachers after their graduation (Al-hidabi, 2012). They are exposed to different cultural, professional, and academic courses which FERC is one of the compulsory courses.

SRHs can be defined as tentative statements that explain and describe a solution to a problem that can supposedly occur as results of testing such statements for accepting or rejecting the expected solution to the problem (Fraenkel and Wallen, 2006; Walliman, 2011). Also, hypothesis is a "statistically measurable/testable prediction of a relationship between one or more variables and the problem under study" (Degu and Yigzaw, 2006: 23). Formulating hypotheses, therefore, is one of the most significant components of SRSs. A person who could formulate hypotheses in a good and easy way, is one who is able to create a good conceptual knowledge (Aydoğdu, 2015; Kabir, 2016, Mourougan and Sethuraman, 2017). Thus, teacher students' skill of formulating hypotheses is a key skill for teachers in mastering the conduct of research and teaching SRSs to their students.

Epistemologically, formulating hypotheses belongs to the scientific integrated processes (such as hypothesis formulating, identifying variables, controlling variables, experimenting and interpreting data, etc.) (Yakar, 2014; Aydoğdu, 2015; Paulo and Cruz, 2015). Hypotheses can be expressed in different formulations: as a null or alternative hypotheses. A null hypothesis, H0, refutes the differences or relationships between variables, while the

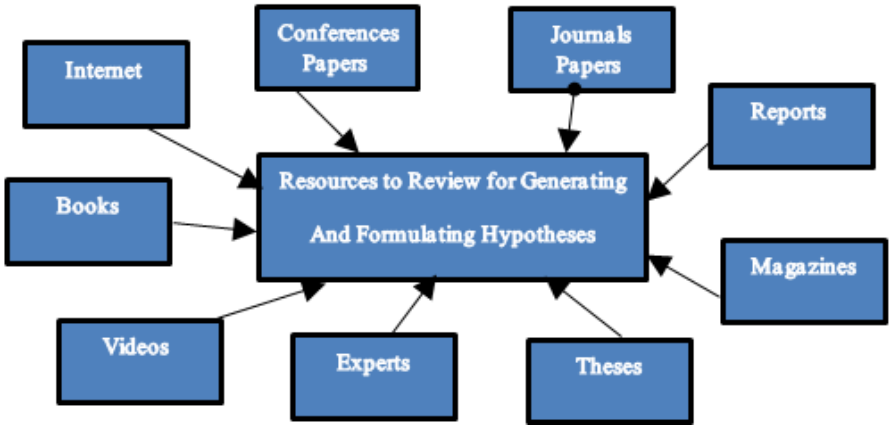

Figure 2. Resources of generating and formulating scientific hypotheses.

alternative one, H1, confirms such differences or relationships (Gay et al., 2009:6). In addition, H1 is examined in two ways: directional and non-directional. While the direction of the variables' difference or relationship is stated in the statement of the directional hypothesis, it is not stated for the non-directional hypothesis (Fraenkel and Wallen, 2006).

In the context of hypothesis formulating, there are many sources can lead to researchers in generating and formulating a good SRH. Figure 1 (i.e. created by the 1st author) illustrates the resources that can help researchers to generate and formulate SRH in a suitable form.

With regard to generating and formulating SRHs, there are many sources that lead a researcher in generating and formulating good SRHs, as illustrated in Figure 2.

A good hypothesis should be (Cohen et al., 2017; Walliman, 2011) in a (1) clear, practical, and testable formulation; (2) way that helps researcher(s) to define and determine operationally research's methods, terms, variables, etc.; (3) way that helps researcher(s) to choose and clear up the suitable search design. Yet, acquisition knowledge and skills of SRHs requires well prepared teachers.

In doing so, teachers, mainly science teachers, should be well-prepared via high quality preparation programs at institutions of teacher's preparation. In Yemen, the task of PSSTs preparation for teaching in secondary school is authorized to faculties of education. They (that is, PSSTs) are exposed to undergraduate programs of the professional preparation (3Ps) in a wide variety of content areas. Thus, PSSTs are expected to be skillful for SRSs via such 3Ps. Responding to this expectation, 3Ps often offer a standalone FERC (Kleiner et al., 2007). In the context of Yemeni 3Ps, every PSST is exposed to FERC which supposedly provides them with sufficient knowledge and skills on SRSs, particularly the skills of SRHs. Nonetheless, engagement in understanding of SRSs, mainly SRHs, is critical to the PSSTs.

Aim and problem statement

As educators of FERC, the researchers noticed that PSSTs often enter FERC in teacher 3Ps with a lack of the research content knowledge and skills that deal with SRHs. Such lack may result in part from a limited research content background. This insufficiency may slow down PSSTs' activities of planning high-level learning experiences for their students as well as the activities of teaching SRSs during their practicum, and also lessen teachers' understanding of inquiry as a valuable method in teaching science for conceptual understanding.

To address this general issue, therefore, FERC was added to the 3Ps that Yemeni PSSTs at the Faculty of Education in Amran University are exposed to, as a compulsory course of the 3Ps. It is foreseen that if PSSTs have taken such course, they will develop their knowledge, attitudes, and skills of SRSs like formulating hypotheses.

In addition, exploration knowledge and hypotheses formulation skills of PSSTs at Faculty of Education in Amran University have not obtained much attention. In this regard, this study could contribute to existing literature on SRHs. In addition, results of the recent study could shed light on the existing 3Ps of PSSTs as regards its focusing on teacher development through scientific research and on teacher development via inquiry. Moreover, results of this study will help the researchers, as educators, in improving their instruction. Thus, this study aimed to explore the PSSTs' SRHUL. Specifically, the study attempted to find out the PSSTs' SRHUL as they progress through studying the CFER. More specifically, this study aimed to answer the following questions:

(1) What is the PSSTs' SRHUL at Faculty of Education-Amran University, Yemen?
(2) Are there any differences between mean scores of the

participants (that is, sample of PSSTs) on the SRHUT referred to the variable of test period (that is, pre and post-test)?
(3) Are there any differences between mean scores of the participants on the SRHUT referred to in the variable of participants' major (that is, chemistry, biology, and physics)?

Research hypotheses

In order to answer the second question, the following hypotheses (that is, null and alternative hypotheses) were put forward:

a. Null hypothesis (H0: μ=0): There are no statistically significant differences between the participants' mean scores on the entire SRHUT and its scales referred to in the test period variable.

b. Alternative hypothesis (H1: μ≠0): There are statistically significant differences between the participants' mean scores on the entire SRHUT and its scales referred to in the test period variable.

2nd a. Null hypothesis (H0: μ=0): There are no statistically significant differences between and within the participants' mean scores on the entire SRHUT and its scales referred to in the major variable (that is, chemistry, biology, and physics).

b. Alternative hypothesis (H1: μ≠0): There are statistically significant differences between and within the participants' mean scores on the entire SRHUT and its scales referred to in the major variable (that is, chemistry, biology, and physics).

LITERATURE REVIEW

Many studies in the field of science education and science teachers' 3Ps (that is, PSSTs' 3Ps) revealed that there is a misunderstanding on knowledge and skills of scientific research mainly SRHs. Though the issue of preparing teacher as a researcher has been globally considered and studied by several researchers in diverse educational researches for different purposes (Kuter, 2013; Özdilek and Bulunuz, 2009; Tuberty et al., 2011; Darus and Saat, 2014; Ural, 2016), it was hardly studied in the context of Yemeni PSSTs' 3Ps at Faculty of Education in Amran University.

As relevant literature explores possessing of research knowledge and skills, certain emphasis such as knowledge about SRHs and its formulation is brought to the fore. Moreover, a considerable amount of research has focused on how to improve such knowledge and skills of different subjects, that is, basic schools, secondary schools, and universities (Özdilek and Bulunuz, 2009; Tuberty et al., 2011; Darus and Saat, 2014; Ural, 2016). Some of those studies used descriptive, quasi-experimental design, while others used pre-post-test to carry out their objectives (Tuberty et al., 2011; Darus and Saat, 2014; Ural, 2016).

Özdem (2009) for instance, conducted a study aimed at exploring PSSTs' argumentation in the context of inquiry-oriented laboratory work. Data of this study were collected through video- and audio-recording and transcribed during the participants' performance of the laboratory tasks. Argumentation schemes developed by Walton (1996) were used for data analysis of this study. Results of Özdem's study showed that PSSTs applied varied premises rather than only observations or reliable sources, to ground their claims or to argue for a case or an action.

Another study conducted by Aydoğdu (2015) aimed to investigate the process skills of Turkish science teachers in terms of some variables. Aydoğdu used science process skills test to collect data. Results of this study revealed that the level of integrated science process skills, formulated by scientific hypothesis, was under the satisfactory level. Also, Aydoğdu (2015) conducted a study aimed at examining PSSTs' skills of formulating hypotheses and identifying variables. To collect data, Aydoğdu used a qualitative approach research (that is, a phenomenological research design). Results of this study showed that participants' skills of formulating hypotheses as well as identifying dependent, independent and control variables accurately were insufficient.

Likewise, a study conducted by Özdilek and Bulunuz (2009) aimed to investigate the effectiveness of a guided inquiry method for science teaching on the elementary PSSTs' self-efficacy beliefs. Özdilek and Bulunuz (2009) conducted a pre-post-test design on a sample that consisted of 101-112nd year-PSSTs of the elementary school who enrolled to a science laboratory course using 'Science Teaching Efficacy Belief Instrument' and focus group interviews for collecting data. Results of this study indicated that the level of subjects' efficacy expectations and outcome expectations on post-test scores were higher than the pre-test scores.

Similarly, Ural (2016) aimed to ascertain: the effect of guide inquiry in doing laboratory experiments on attitudes of the 3rd-year undergraduate Turkish students in science education towards chemistry laboratory; the guide's effect on their anxiety from chemistry laboratory; and the same effect on their academic achievement in chemistry laboratory. To collect data, Ural used a pre-post-test design using Chemistry Laboratory Attitude Scale and Chemistry Laboratory Anxiety Scale as well as semi-attractional interview. Results of Ural's study revealed that there was a significant increase in subjects' attitudes towards chemistry laboratory, their academic achievement, and a significant decrease in their anxiety towards chemistry laboratory.

Also, a study conducted by Yakar (2014) aimed to find

Table 1. Study's population and sample.

Population		Chemistry	Biology	Physics	Total	%
		81	**74**	**72**	**227**	**100**
Sample	Pre-test	40	40	40	120	53
	Post-test	40	40	40	120	

Table 2. Items' distribution of the SRHUT among its sub-scales.

Scale	Items	Total
SRHs' knowledge	1, 2, 3, 4, 5, 6, 9 and 10.	8
SRHs' formulating	7, 8, 11, 12, 13, 14 and 15.	7
-	-	15

out the effectiveness of scientific process skills on a sample selected from PSSTs of Pamukkale University Primary Science Teacher Education Program for four years. To collect data, Yakar used a survey approach.

Results of this study, as regard formulation of scientific hypothesis, indicated that PSSTs at Pamukkale University in Turkey can describe and identify the appropriate hypotheses, decide and test them as well as determine the research variables that deal with the tested hypothesis.

In the context of Yemeni on related literature review, only one study is related to the recent study conducted by Aziz and Zain (2010). This study aimed to compare science process skills in the content of Yemeni physics textbooks for the 10-12th grades. Although the study revealed strengths in the analyzed textbooks' content, it showed a number of integrated science processes have been neglected such as measuring, predicting and hypothesizing processes.

METHODOLOGY

Mixed research methodology is a common scientific research method (Blaxter et al., 2006). Thus, a mixed research approach (that is, descriptive and quantitative research approach) was used to carry out this study. Descriptive research approach was used to answer the 1st question of the study, while pre-test and post-test one-group was used to test its hypotheses. Pre-test and post-test is categorized as an experimental approach, but it is educationally used as a quasi-experimental research approach (Womack, 1997; Walliman, 2011; Ural, 2016).

Due to that, this study does not include a true experiment; therefore it does not belong to the experimental studies. Eight terms should be verified for the true experiment: (1) control group/s; (2) experimental group/s; (3) random sample; (4) equivalence; (5) a tool to measure the independent variable effect on the dependent variable; (6) intervention to the experimental group/s; (7) isolation, control and manipulation of independent variable/s; and (8) non-contamination between the control and experimental groups (Cohen et al., 2007). If one of the previous terms is not seen through the experiment then it is not experiment; it can be looked as a quasi-experiment (Cohen et al., 2007). Thus, this study is a quasi-experimental study.

Data of the study were collected using the pre-post-test one-group design, from a sample that consisted of 120-123rd-year PSSTs at Faculty of Education, Amran University in order to test the study's hypotheses. Moreover, this study belongs to AR (that is, AR is a systematic search procedures conducted by practitioners, teachers or other individuals, in an educational context to collect data about teaching-learning situation in order to improve and develop teaching and learning in such context) (Creswell, 2012; Ali and Akayuure, 2016; Abelardo et al., 2019). Based on the previous definition of AR, AR can be theoretically taken as an incorporation component of the study's overall process.

In addition, AR is flexible; hence it can be used as a separate research approach, or as a part of it (Wiersma, 1985; Womack, 1997). Furthermore, this study can be considered as an AR because it reflects the collaboration of the faculty staff (that is, the authors of the study) in conducting research that will enhance understanding of some issues involving SRHs that was taught to PSSTs by the authors themselves (Ferrance, 2000).

Sampling

Participants in this study were 120 PSSTs university 3rd-year students who studied the FERC at Faculty of Education, Amran University, Yemen. They were randomly selected from a population consisting of 227 PSSTs, that is, 40 participants from three departments (biology, chemistry and physics), as illustrated in Table 1.

Instrumentation

A multiple choice test, that is, SRHUT, was developed by the researchers themselves as an instrument to fulfill this study. Test items were developed and presented on the related literature as well as analysis of the sub-topics related to SRHs. Besides, the test items covered two areas: knowledge and formulating of SRHs (Table 2). SRHUT consisted of 15 items, with each remarked as 1 for the true answer, or zero for the false one. Consequently, the test maximum mark was 15, while the minimum was zero. Test items were developed in terms of document analysis of the literature, and text of student's course that deals with SRHs and their formulation.

For further testing, the SRHUT's applicability, comprehensive validity and reliability were figured out. For validity, it was given to 3 experts (that is psychologists and educationalists) to figure out its content validity. Experts were asked to evaluate the test items in terms of the clarity and accuracy of each item. They were also asked to be free in adding, removing, or modifying any of its items.

Table 3. Participants' responses percentages on SRHUT's items for both pre and post-test.

Item	Test (%)		Scale		Sub-scale
	Pre-test	Post-test	Knowledge	Formulating	
1	51	95	√		Definition of SRH
2	39	54	√		SRH and scientific theory
3	40	88	√		SRH and research problem
4	34	82	√		Sorts of SRHs
5	43	50	√		Standers for a good SRH
6	76	88	√		Sources for the SRH
7	48	87		√	Example for formulating SRH
8	47	93		√	Example for formulating SRH
9	25	38	√		Statistics and SRH
10	14	10	√		Sorts of SRHs' errors
11	12	12		√	Example for formulating SRH
12	3	49		√	Writing directional SRH
13	2	13		√	Writing non-directional SRH
14	3	21		√	Writing null SRH
15	3	20		√	Writing alternative SRH

An entirely consensus (100%) outcome among the experts were taken as a criterion to accept the item. As for the reliability of the test, Cronbach alpha was figured out and found as 0.67 which is an adequate and acceptable coefficient (Taber, 2016).

Subjects were then exposed to SRHTU as a pre-test before teaching them SRHs as a topic, thereafter they were taught during the 2nd semester of the 2019 academic year by the 2nd researcher. Time period for pre-test was 30 min, while that meant for teaching the topic was 2 h. After teaching the topic, subjects were again exposed to the same test as a post-test. Afterwards, their responses on the test were collected to be analyzed and compared with their responses on the pre-test.

Procedures

In this study, eight main procedures were implemented: (1) sampling, that is, choosing the sample of the study from the PSSTs' population; (2) reviewing the available literature; (3) identifying the sub-topics of SRHs; (4) instauration, that is, development of SRHUT; (5) teaching participants SRHs as a topic; (6) collecting data via participants exposed to the pre-post-test on the SRHUT; (7) analyzing data; and (8) interpreting data.

Data analysis

Different statistical tools were applied to analyze the data of the recent study. To answer the study's first question, descriptive statistics (that is, frequencies, and percentages) were conducted. A variety of statistical tools (e.g. T-test, ANOVA, ANCOVA, MANOVA, MANCOVA, etc.) were used to analyze the pre-test and post-test data as an AR (Borg, 1987; Charles, 1988; Womack, 1997; Ural, 2016). Thus, independent sample t-test was used to compare the mean scores' of pre-test and post-test in order to test the first hypothesis of the study as an answer for its second question. In addition, one-way ANOVA was used because the analysis of variance deals with the differences between or among sample means. Moreover, test of Tukey-HSD was used to investigate the homogeneity of the study's groups (Pallant, 2005).

RESULTS

Results of this study were set according to the study's questions and tables used to illustrate its results. According to the 1st question 'What is the PSSTs' UL of SRHs at Faculty of Education, Amran University in Yemen'? Participants' percentages of the responses on the pre-test and post-test were figured out before and after teaching SRHs as a topic. While the percentage of pre-test for all the subjects' items was found as 41.6%, it was 50.6% for the post-test. As shown in Table 3, all pre-test items excluding the 1st and 6th items were less than 50%. On the other hand, the percentage of each of the first eight test items of the post-test was greater than 50%, while the percentage of each of the rest test items was less than 50%.

As illustrated in Table 3, regarding items' percentages of the SRHUT, every item of the test had less than 50% except for 2 items (that is, 1.51 and 6.76%) which belong to knowledge scale of the test. The 1st item dealt with the definition of SRH, while the 6th item dealt with the SRH's sources. On the other hand, 7 out of 15 (47%) of the test items (9, 10, 11, 12, 13, 14, and 15) were found to be less than (50%). All of these items except for 9 and 10 belong to the scale of formulating hypotheses skills, whereas the rest two items belong to the knowledge scale.

In order to answer the study's second question (that is, are there any differences between mean scores of the participants on SRHUT referred to in the variable of test period (that is, pre and post-test)?), a null and alternative hypotheses were put forward and tested. As for the null hypothesis (that is, H0: $\mu=0$), there are no statistically significant differences between participants' mean scores on the entire SRHUT and its scales referred to in the test

Table 4. t-test for comparison of pre and post-test groups on SRHUs' mean scores.

Scale	Group	N	Mean	S. D	T	df	P
SRHUs Knowledge	Pre-test	120	3.24	1.58	-10.45	206.09	0.001
	Post-test		5.05	1.04			
SRHUs Formulating	Pre-test	120	1.12	0.96	-9.12	217.23	0.001
	Post-test		2.54	1.33			
All SRHUT's items	Pre-test	120	4.41	2.03	-12.64	238	0.001
	Post-test		7.60	1.87			

Table 5. One-way ANOVA between and within sample groups the SRHSU.

Domain		Sum of squares	df	Mean square	F	P
Knowledge Domain	Between	4.41	2	2.20	0.84	0.43
	Within	619.49	237	2.61		
Formulating Domain	Between	6.86	2	3.43	1.90	0.15
	Within	427.04	237	1.80		
All SRHs' Items	Between	1.30	2	0.65	0.10	0.90
	Within	1512.70	237	6.38		

period. Results of t-test for independent samples revealed (Table 4) that there are statistically significant differences between participants' mean scores on the entire SRHUT and its scales referred to in the test period variable, since the value of 'P' (0.001) was less than the required cut-off (0.05), and all differences, in all comparisons, were in favor of the post-test. Based on the t-test results, therefore, the null hypothesis dealt with the 2nd question, was rejected and the alternative one was accepted.

As regards the 3rd question "are there any differences between participants' mean scores on the SRHUT referred to in the participants' major variable", the 2nd null hypothesis states that "there are no statistically significant differences between and within the participants' mean scores on the entire SRHUT and its scales referred to in the major variable (that is, chemistry, biology, and physics)". In doing so, one-way ANOVA was used to investigate such differences.

Results of one-way ANOVA, as illustrated in Table 5, indicated that there are no statistically significant differences between and within the groups participants' mean scores on the entire SRHUT and its scales referred to in the major variable, since the value of 'P' for all comparisons between and within groups was greater than the required cut-off (0.05). Consequently, the 2nd null hypothesis was accepted, while the alternative one was rejected.

In addition, Tukey's Honestly Significant Different test (HSD) was used to find out the directions of these differences. Similarly, results of HSD pointed to acceptance of the 2nd null hypothesis and rejection of the alternative one (Table 6), since the value of 'P' for all comparisons between and within groups was greater than (0.05).

DISCUSSION

In general, results of the study revealed that PSSTs' SRHUL on the SRHUT was insufficient, while PSSTs' SRHUL for the post-test was greater than it for the pre-test. This insufficiency may be due to the insufficiency of the knowledge and skills necessary for dealing with SRHs that PSSTs were exposed to either via the preparation program's courses or through their pre-university education (that is, basic and secondary education). Such interpretation can be deducted from a study conducted by Aziz and Zain (2010), which revealed that content of physics textbooks for the 10-12th grade insufficiently included a number of integrated science processes such as hypothesizing process. On the other hand, as regards post-test, results showed that most of the test's items which got a percentage that is over 50% belonged to the scale knowledge of SRHUT. This may be due to lack of attention on SRHs process particularly

Table 6. Results of Tukey's honestly significant different test (HSD).

Group	Scale	Mean difference	Std. error	Mean			P
				Chemistry	Biology	Physics	
Chemistry Biology Physics	Knowledge scale	-0.29	0.26				0.5
Biology Chemistry Physics	Knowledge scale	-0.29	0.26	4.05	4.05	4.34	0.5
Physics Chemistry Biology	Knowledge scale	-0.29	0.26				0.5
Chemistry Biology Physics	Formulating scale	0.175000	0.21				0.69
Biology Chemistry Physics	Formulating scale	0.175000	0.21	2.05	1.88	1.64	0.69
Physics Chemistry Biology	Formulating scale	-0.412500	0.21				0.13
Chemistry Biology Physics	All SRHUT's ıtems	0.18	0.40	6.34	6.03	6.12	0.90
Biology Chemistry Physics	All SRHUT's ıtems	-0.18	0.40	6.34	6.03	6.12	0.90
Physics Chemistry Biology	All SRHUT's ıtems	-0.13	0.40	6.34	6.03	6.12	0.95

formulating hypotheses within the courses' content of PSSTs' preparation program at Faculty of Education in Amran University.

Results of this study are in line with those of Aydoğdu (2015) and Irwanto et al. (2018), but differ from the results of Yakar (2014). While the studies of Aydoğdu (2015) and Irwanto et al. (2018) revealed that participants' skills of formulating hypotheses were insufficient, results of Yakar (2014) study showed that PSSTs could sufficiently describe, identify, formulate SRHs and test them.

As regards the 2nd question's results, t-test outcomes showed that there are statistically significant differences between mean scores on the entire SRHUT and its scales referred to in the variable of test period; and the differences, in all comparisons, were in favor of the post-test. In other words, the mean scores on the entire test and its scales (that is all SRHUT's items, SRHUs Knowledge, and SRHUs Formulating) for post-test were greater than the mean scores of the same test for the pre-test. Obviously, teaching SRHs to PSSTs gave rise to the improvement of participants' achievement on the SRHUT for the post-test. But this improvement is not sufficient particularly with respect to the results of

formulating hypotheses skills. In this context, some studies (Paul, 2015) reported that it is not only students that have a problem dealing with formulating SRHs, but teachers also do.

Conclusion

In the 21st century context, possessing SRSs is considered as a main goal of science education. For this reason, this study was aimed at exploring the PSSTs' SRHUL as well as finding out the differences in their understanding level as they progress through studying CFER. To this end, a validated and reliable instrument (that is, SRHUT) was developed and conducted on a sample of PSSTs before and after studying the topic of SRHs at the Faculty of Education, Amran University. According to the study results, participants showed insufficient performance on the SRHUT, as a result of the pre-test and vice versa in terms of the results of the post-test.

Although a significant difference was found between mean scores of pre-test and post-test, by using t-test, which was in favor of post-test, there were no significant differences between or within mean scores of compared groups, as a result of one-way ANOVA. Results indicated that PSSTs' performance of the post-test on SRHUT was greater than their performance of pre-test because of the teaching of the SRHs topic. The significant differences between or within mean scores of compared groups, as a result of one-way ANOVA was due to the homogeneity of the study's sample.

In a few words, one may conclude from the result of this study that PSSTs have insufficient knowledge and skills on the SRHs. Although the results reveal that participants' achievement on the SRHUT for the post-test was greater than their achievement on the same test for the pre-test, this achievement is still insufficient particularly with respect to the results of formulating hypotheses skills.

RECOMMENDATIONS

Due to the importance of enabling students' acquisition of SRSs, SRSs are universally given an important consideration in science education. Thus, in-service and pre-service science teachers should be well prepared towards providing SRSs. To make this possible, science teachers (PSSTs) should be well prepared in terms of acquisition of SRSs which could not be a reality unless these teachers are exposed to good preparation on SRSs via the preparation programs in the faculties of education. Therefore, evaluation studies on the PSSTs' preparation programs based on the inclusion of SRSs within the programs' contents and activities is recommended.

In addition, as the recent study was limited to SRHs as a topic as well as PSSTs who enrolled in a fundamental scientific research course at the Faculty of Education, Amran University, its results, therefore, could not be generalized to other population or topics. Based on this limitation, it is recommended that similar studies be conducted on different populations and topics of SRSs.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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