Birlesik Dünya Arastırma BD CENTER Innovasyon ve Yayıncılık Merkezi

Cypriot Journal of Educational Sciences

Volume 17, Issue 3, (2022) 840-858

CJES Cypriot Journal of Educational Sciences

www.cjes.eu

Secondary school students' awareness and practices of science practical work in Saudi Arabia

Fayadh Hamed Alanazi [a*], Jouf University, College of Education, Department of Curriculum and Instruction, Kingdom of Saudi Arabia

Suggested Citation:
Alanazi, F. H. (2022). Secondary school students' awareness and practices of science practical work in Saudi Arabia. *Cypriot Journal of Educational Science*. *17*(3), 840-858 https://doi.org/10.18844/cjes.v17i3.6886

Received from November 10, 2021; revised from January 25, 2022; accepted from March 05, 2022.
Selection and peer review under responsibility of Prof. Dr. Özge Hacifazlioglu, Hasan Kalyoncu University, Turkey

Abstract

The key objective of the present research is to investigate the nature of students' knowledge and practical work in secondary school biology, chemistry, and physics (BCP). Furthermore, comparisons will be made between knowledge and practical work practices in different year groups (Grades 10, 11, and 12). The sample consisted of 438 secondary school students from the first, second, and third years of secondary schools in the Al-Jouf region of north-eastern Saudi Arabia. Additionally, an analytical framework has been applied in the study to assess students' attitudes in the cognitive, affective, and psychomotor domains. A mixed methods approach was adopted for this study, in which questionnaires and interviews were used to collect data. The findings of the research indicated that Saudi students generally displayed positive attitudes towards practical learning in various domains (cognitive, affective, and psychomotor). Nonetheless, significant differences were identified in the psychomotor domain between Grade 10 and Grade 12 students, with Grade 10 showing the most favourable attitudes, followed by Grade 12 and lastly Grade 11. With regard to the cognitive and affective domains, no significant differences were found. Moreover, the findings of the study also showed that a majority of Saudi students understood the importance of practical work in learning science in Saudi secondary schools.

Keywords: Attitudes, Practical work, School science, Secondary school.

[*] Address of correspondence: Fayadh Hamed Alanazi, Jouf University, College of Education, Department of Curriculum and Instruction, Kingdom of Saudi Arabia
Email address: fayad@ju.edu.sa

2. Introduction

Despite being a key component of secondary level science education, students' attitudes towards practical work have been largely under-investigated. In other words, very few studies have solely focussed on exploring students' attitudes towards practical work, and how such attitudes can change as students' progress through their compulsory education (Sharpe & Abrahams, 2020).

Shana and Abulibdeh (2020) suggest that practical work can pique students' interest in science, and promote it as a fascinating subject. For instance, when carrying out chemical experiments, students can see that chemistry is practical and engaging, and not just about rules and theories.

Moreover, Lee and Sulaiman (2018) explain that practical work can enhance students' understanding, skills, experience, and enjoyment in learning science. Thus, developing positive attitudes towards practical work among students plays a significant role in enhancing their academic achievement in science (Hinneh, 2017).

It is the duty of science teachers to help students understand the relationships between theory and the practical phenomena that can be seen in experiments. The first step in achieving this is to identify the problems encountered by students when attempting to make connections between theory and practice. They may also find it difficult to understand the reasons for such relationships (Jokiranta, 2014), which means that they may not base their actions upon scientific ideas or reflection upon the data collection process during practical activities (Monica et al., 2015). Additionally, Lawson (1995) explains that practical work can help students to understand the difference between observation and data presentation.

Learning is a very intricate and multifaceted process. Thus, there are many factors involved in achieving it successfully. Students face academic challenges in classrooms every day (Khalaf, 2014, 2016). One such is the method used by the teacher to deliver lessons in the classroom. The present study focuses on an examination of the importance of combining theoretical and practical work in secondary-level science programmes.

Practical work largely increases students' motivation, interest, and achievement, whilst Lee and Sulaiman (2018) explain that it creates opportunities for students to engage in active learning. Practical work also creates an environment conducive to studying science seriously, and enables students to take control of the learning process whilst also furthering their understanding of the practical work involved. Nonetheless, research carried out by Reid (2003) showed that the science curriculum is significantly restricted by the way in which practical work is performed. Thus, rather than emphasising theories and laws, it frequently confuses students. It is thus crucial to establish the aims and objectives of practical work before starting it. On the other hand, very few studies have investigated students' attitudes towards practical work, and how these attitudes change as students' progress through their learning. Wellington (2005) points out that students must be directly asked questions about their perceptions of practical work in order to truly understand the effects that their attitudes have on science education. The results of this study highlight an urgent need to enhance students' attitudes towards practical science activities in order to encourage more students to continue studying science after secondary education.

Moreover, understanding that the students' attitudes are likely to change throughout the education process is crucial. This has been emphasised by Sharpe (2012); students' awareness and practice of science practical work are largely determined by factors such as age and subject, and it is pivotal to consider this. Despite the importance of science education at the secondary level in Saudi Arabia, very few researchers have explored students' attitudes towards it. The present research focuses predominantly on exploring the affective value of practical work in biology, chemistry, and physics (BCP). Two key areas will be explored in this study: namely the nature of students' knowledge and practical work in secondary school BCP classes, and the differences in knowledge and practical work practice in secondary school BCP between different year groups (grades 10, 11 and 12).

3. Scientific Attitudes and Interests

It has been found that the attitudes of both students and teachers towards learning and teaching science are key to supporting the understanding of scientific concepts, and developing the ability to apply these concepts practically in scientific and daily life. Therefore, it is clear that in order to have professional and effective science teachers, schools need students who have a positive view of learning science.

There has been ongoing research into science education throughout the twentieth century, and its focus has been modified and expanded, as a result of its effect on learning processes. Osborne et al. (2003) state that one subject which has featured prominently in the field of scientific education research is that of analysing students' attitudes towards the study of science. Many researchers have evaluated the importance of developing positive attitudes towards scientists and science, and argue that learning and teaching science are both essential components of science education, and need to be fully investigated (Trumper, 2006).

The attitudes students have towards science are founded on the concepts, views, and emotions which learners associate with science. Osborne et al. (2003) emphasise that attitude is a variable shaped by many factors and features. These researchers undertook a literature review on the topic, and highlighted a key series of factors which determine how individuals respond to science. These factors include the motivation of the student, their perceptions of themselves, the attitudes of their peers, the classroom setting, how students view the science taught in school, and the level of difficulty of the science course. The current research recognises the significance and importance of these obstacles (Alshamrani, 2018; Alshehri & Alabdulkarim, 2016), and acknowledges their impact on the implementation and use of school laboratories in Saudi Arabia. These challenges now need to be considered and addressed by school administrators and teaching staff, in order to enable students to undertake the practical work which will allow them to meet higher academic standards and improve their educational outcomes.

According to Okam and Zakari (2017) affective variables are just as important as cognitive variables in determining student outcomes, their choice of careers, and how they use their free time, in relation to learning chemistry in schools. Students in secondary schools need to develop positive attitudes towards learning biology, chemistry, and physics, and this can be supported by giving them access to laboratory work in the subject at school, if they are to successfully improve their performance.

Literature Review

Abrahams and Saglam (2010) carried out a study to investigate whether any significant changes had occurred to the relative importance of aims and objectives assigned to practical work tasks by science teachers throughout the various secondary school year groups (i.e. for students aged 11–18). These findings indicated that there have not been any significant changes to teachers' opinions of practical work at the Key Stage 3 Level (age 11–14), although significant changes were evident for Key Stages 4 and 5 (age 15–18).

Meanwhile, Sharpe (2012) explored students' attitudes to practical work in biology, chemistry, and physics. The findings indicated that the attitudes of students towards practical science work vary significantly between age groups and the type of science being studied. Typically, students were becoming more aware of the significance of cognitive issues than the affective reasons for enjoying practical work.

Moreover, a study carried out by Alanzi (2014) focussed on identifying the barriers hindering lessons in science education in the upper stages of elementary school in Saudi Arabia. Findings indicated that science teachers are often reluctant to use the laboratory in science teaching. Factors causing this reluctance include the lack of a laboratory manual, and the inability of teachers who are insufficiently trained to conduct the experiment.

Alshehri and Alabdulkareem (2016) carried out a study to investigate the activation of the school laboratories programme in Saudi Arabia. The results indicated that learning materials were lacking and tools for evaluating experiments were not widely available. Additionally, teachers reported only receiving a medium level of support for the programme. With regard to the programme's objectives, the findings indicated a weakness in students' ability to carry out laboratory-based work. In turn, this had a negative effect on their practical scientific skills.

Hinneh (2017) studied students' attitudes towards practical work, and how these attitudes influenced students' achievement in Biology. The study adopted a sequential explanatory mixed methods design, and, to collect data, a 30-item Science Attitude Questionnaire was created. Semi-structured interviews and participant observations were also used. The study found that students found practical science work enjoyable and important, but did not feel motivated to study science further after leaving secondary school.

Moreover, Dagnew and Sitotaw (2019) carried out a study to investigate the impact that practical work in biology lessons had on the academic achievement of ninth-grade students. Their attitudes were examined pre-test and post-test, whilst their achievements were assessed post-test. Four randomly selected students were also interviewed. The research findings showed that experimental teaching impacted students' attitudes and achievements in some biology lessons, whilst a positive relationship was identified between attitude and achievement. Thus, the researcher recommended that secondary school biology teachers incorporate practical work into their lesson plans in order to enhance the academic achievement of their students.

Students' attitudes towards practical work in secondary school physics, biology, and chemistry classes in England were also examined by Sharpe and Abrahams (2020). A total of 607 students from years 7–10 were included in this study, all of whom came from three state secondary schools in England. The research investigated students' attitudes using an established analytical framework incorporating the cognitive, affective, and behavioural domains, whilst a mixed-methods approach to data collection was employed. Thus, data were collected using questionnaires, focus group discussions, and lesson observations. The findings indicated that most students had positive attitudes towards practical work, however these attitudes were not constant. Instead, they were subject to change over time.

The Practice of Science Practical Work in Saudi Arabia

Previous research has highlighted the fact that school laboratories tend to be inadequately used in Saudi Arabia's secondary schools. The Aljabr study (2009) found a number of areas which need to be re-evaluated and improved, including the lack of integration and the complexity of science courses at secondary level, specifically in chemistry, physics, and biology. Additionally, there has been a dearth of clear guidelines on how best to exploit science laboratories within schools. Alharthy (2015) notes that Saudi schools need to tackle a range of issues across every educational level, and points to limited numbers of trained laboratory technicians, overcrowding in classrooms, and short lesson periods which do not offer the time needed to carry out experiments. He also found that the administrators in schools do not successfully encourage their science teachers to make regular use of the laboratory.

According to Alshamrani (2018), female students at secondary school who are studying physics are not generally competent in carrying out scientific experiments. This is due to the lack of essential tools and equipment, the limited amount of time set aside for laboratory experiments on physics courses, and the ever-present risk of experiments becoming dangerous. Alshehri and Alabdulkarim (2016) agree that there are several issues which make it difficult to implement laboratory work for students, and as a result these students do not gain the practical skills they need in the field of science. The study also found that the demand for scientific experiments in school laboratories is weak, particularly among first year secondary pupils. This stage of students' educational journey is, however, an important one, since it precedes the point at which students choose their specialism– whether in natural sciences or humanities – and this choice is influenced by the degree to which they have benefitted from, and enjoyed, their courses.

Alshaya (2011) looks at the issue from a different perspective, and argues that science laboratories in Saudi schools have a positive influence on cognition and developing skills and emotional intelligence. To take one example, in terms of cognitive development, the laboratory plays a part in the teaching and learning of scientific concepts, encourages students to expand their problem-solving abilities, as well as stimulating them to think in new and ground-breaking ways. In terms of skills, the science laboratory supports students in the development of their scientific research abilities, their knowledge of how to analyse data, and their communication and interpersonal skills. Similarly, labs help students to develop a positive view of learning and of their capacity to influence other people, as well as encouraging them to embrace values which underpin science, namely accuracy, honesty, transparency, and validity.

Yager and McCormack (1989) state that it has been determined that traditional methods of teaching science have resulted in students having a negative view of science itself, and of learning it as a subject. Students who have a positive attitude towards science are far more likely to learn it more easily and expand their knowledge of the field. Yager (1996) found that the negative reaction students have towards science is based on the teaching approach: which can consist of the need to memorise scientific facts, the heavy emphasis on tests and grades, and the fact that they are afforded few opportunities to enjoy the subject. It is essential to encourage Saudi students to move away from top-down, teacher-centred learning and move towards student-centred activities, where the students themselves can have an input in designing their own experiments.

Hamdan and Alsalouli (2013) point out that, since the Saudi Arabian Ministry of Education centralised curriculum development, it has followed a top-down strategy, translating both American and British science curricula and textbooks into Arabic. While this approach simplifies the process of devising a curriculum, it also sets up hurdles for curriculum teaching, as a result of other science stakeholders, such as teachers, introducing misinterpretation. The new curriculum also has a student-centred focus, which challenges the traditional approach to teaching in Saudi Arabia (Smith & Abouammob, 2013). Teacher-centred classes can be tedious for students, and impact negatively on the benefits of undertaking practical work. Singer et al. (2006) add that traditional laboratory experimental work limits the number of students who can be involved at any one time, and favours small groups.

4. **Methodology**

This study focussed on exploring the affective value of practical work in biology, chemistry, and physics (BCP). Two key areas of interest were investigated here, namely the nature of students' knowledge and practical work in secondary school BCP science lessons and students' comparative knowledge and practical work in secondary school BCP classes between year groups (years 10, 11, and 12). In this research, the term 'practical work' refers to any science task that requires students to observe or manipulate real-life objects and materials, with no computer-based virtual materials involved (Millar, 2011). A sequential explanatory mixed-methods design was employed in the research to enrich the quantitative results using qualitative data. There are two unique stages involved in mixed methods research, namely a quantitative stage and a qualitative stage (Creswell et al., 2003). A methodological triangulation approach incorporating a scale of attitudes towards practical work (SATPW) and interviews is thus used in this study. The main purpose of using triangulation in this work was to obtain a more profound insight into students' attitudes towards practical work. The two sequential stages carried out in this study are outlined below.

Sample Population

The sample consisted of 438 secondary school students in their first, second, and third years of secondary school in a specific region of north-eastern Saudi Arabia, namely Al-Jouf. To select the sample, simple random sampling was employed. This enabled random schools to be selected from which random classes were then chosen. Subsequently, students were randomly selected from each class. Most participants (362) in the sample were males (83%), and the remainder (76) were females (17%). Altogether, 160 participants were first-year students (37%), whilst 155 were in their second year (35%), and 123 were in their third year (28%). Additionally, 394 participants were students at public schools, whilst just 44 were taught in private schools. During the qualitative stage of the study, 12 students from seven secondary schools were interviewed.

Stage 1: Scale of Attitude towards practical work(SATPW)

During this phase, questionnaires containing items pertaining to knowledge and attitude were distributed to participating students. A total of 438 completed questionnaires were returned. Altogether, 100 items were included in the first item pool, of which 41 were designed to evaluate the affective sub-scale, 23 were intended to assess the cognitive sub-scale, and the remaining 32 measured the psychomotor sub-scale. The first draft of the scale, alongside operational definitions, were given to a panel of 7 jurors for further revision, after which the scale items were narrowed down based on three inclusion criteria, namely clarity, representativeness, and relevance to the construct of interest. The experts used a five-point Likert scale ranging from 5 (very suitable) to 1 (very unsuitable) to assess the items. After the review process, 96 items were retained. The questionnaires were then distributed to students and exploratory factor analysis was performed on their scores for each item.

Validity

Exploratory Factor Analysis (EFA) of the SATPW

To identify a workable factor structure for 70 items in the SATPW, exploratory factor analysis with principal components was performed. In the first SATPW draft, more than 20 items were used for each sub-scale. However, Varimax rotation was performed on the resulting factors to form a simple structure. The following criteria were used to determine how many factors were retained: (a) Kaiser's rule of retaining factors that have eigenvalues higher than 1, (b) factors must be able to explain at least 10% of the total variance extracted, and (c) each factor should include at least three items. The inclusion criterion for retaining factors was that they must have loadings of at least .35. Three factors were yielded during the analysis, which are presented in Table 2. Altogether, 26 items had to be removed, as they failed to meet these criteria. The remaining 24 were kept, and served as the core items of the SATPW. The Kaiser–Meyer–Olkin measure of sampling adequacy was found to be .945, whilst the approximate Chi-Square of Bartlett's Sphericity Test was 7245.113. This suggests that the EFA assumptions were correct.

Table 1. Descriptive statistics of the SATPW, *N*=438

Sub-scales	M (SD)		
	First Year	Second Year	Third Year
Cognitive	29.22 (4.50)	28.95 (4.57)	28.40 (5.51)
Affective	42.17 (6.92)	42.06 (5.96)	40.68 (8.05)
Psychomotor	28.54 (5.23)	28.25 (5.64)	26.86 (6.12)

The descriptive statistics reveal that the scores follow a normal distribution curve.

Table 2. Item-total correlations of the (SATPW), N=438

Item (factor1)	*r***	*Item (factor2)*	*r*	*Item (factor3)*	*r*
15.	.757	92.	.786	53.	.761
10.	.734	96.	.675	55.	.757
9.	.791	94.	.852	54.	.839
14.	.802	93.	.850	43.	.783
16.	.820	95.	.843	52.	.751
8.	.791	85.	.815	63.	.791
3.	.862	89.	.801	64.	.749
4.	.797				
18.	.761				
32.	.781				

Table 2 shows the Item Discrimination Index. Correlation values varied between.675 and .862, which suggests that the items accurately reflect the attitude construct.

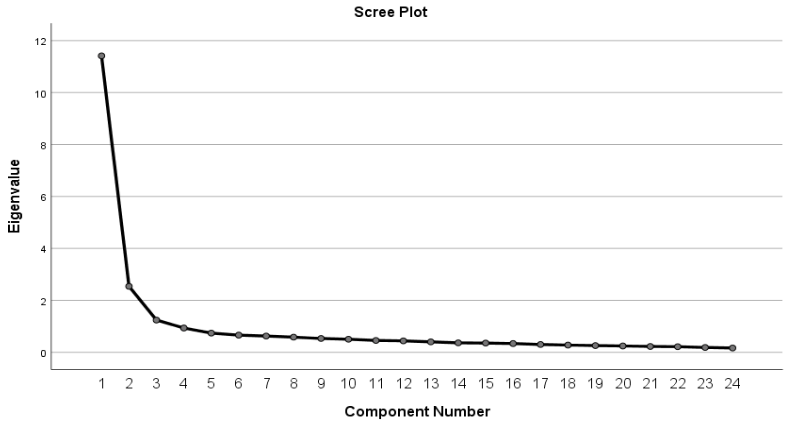

Figure 1. Scree plot of the SATPW

Figure 1 shows the factorial structure of the attitude scale. All three factors were found to have eigenvalues in excess of 1 (the acceptable value), which suggests that the attitude scale is multi-dimensional.

Table 3 Exploratory Factor Analysis of (SATPW) (N=438)

No.	Factor 1	Factor 2	Factor 3	h^2
15.	.795			.743
10.	.764			.677
9.	.762			.663
14.	.748			.635
16.	.742			.660
8.	.719			.623
3.	.715			.582
4.	.689			.539
18.	.688			.583
32.	.681			.592
92.		.822		.746
96.		.813		.699

94.		.803		.739
93.		.765		.710
95.		.748		.673
85.		.679		.610
89.		.501		.415
53.			.722	.730
55.			.699	.607
54.			.676	.657
43.			.669	.591
52.			.638	.592
63.			.546	.596
64.			.503	.530
Eigenvalue	6.317	4.996	3.880	
% Variance	26.321	20.817	16.168	
% Cumulative	26.321	47.138	63.307	

Confirmatory Factor Analysis

To carry out confirmatory factor analysis of the SATPW, Amos Software (version 22) was employed. The scores of the 438 participants for the 24 items were analysed to verify that the attitude construct was multi-dimensional. Moreover, a three-factor model was used to carry out CFA, which provided the following indices: $\chi 2$ /df = 1.89, CFI = .97, TLI = .96, RMSEA = .06 (90%CI = .02; .10) and RMR = .03. When considered collaboratively, these findings suggest that the multi-factor model is very fitting to the data. The factorial loadings of the items varied between .822 and .501, with all items being statistically significant. ($p< .01$) (see Figure 1).

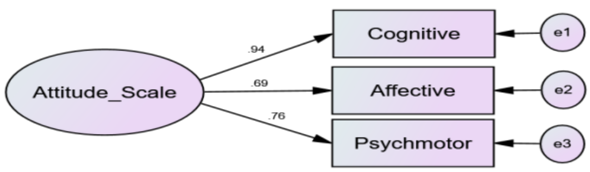

Figure 2. CFA of the ATPWS

Table 4. CFA goodness of fit statistics of the for ATPWS

Model	X^2	*X2/df*	*GFI*	*AGFI*	*NFI*	*CFI*	*TLI*	*RMSEA (90% CI)*
3-factor Model	9.98 (p = .007)	24.99	.985	.955	.983	.986	.979	.09 (.043– .158)

Table 4 reveals that the three-factor model is very fitting for the data. Moreover, the goodness of fit indices (GFI, AGFI, NFI, CFI, and TLI) can be considered acceptable as they are all close to 1 (Khalaf & Abulela, 2021; Khalaf & Al-Said, 2021). However, the root mean square error of approximation was found to be below 1. Thus, it can be confirmed that the attitude scale has a multi-dimensional factorial structure. In turn, these findings confirm the validity of the attitude scale.

Reliability

Cronbach's alpha (α) and McDonald's omega (Ω)were employed to evaluate the SATPW's internal consistency because McDonald's omega is better than alpha at estimating reliability. These findings suggested high reliability (see Table 5)

Table 5. Internal Consistency of the SATPW *N= 438*

Sub-scale	No. of items	Cronbach's alpha α	McDonald's omega Ω
Cognitive	7	.889	.889
Affective	10	.932	.933
Psychomotor	7	.909	.917
Total SATPW	24	.951	.951

Cronbach's alpha (α) varied between .88 and .95 for the three components on the attitude scale, whilst McDonald's omega (Ω) values varied between .89 and 95. This can be seen in Table 5, and suggests that the attitude scale has adequate levels of reliability. Since McDonald's omega is a robust measure of reliability (Khalaf & Abulela, 2021), it was computed along with Cronbach's alpha.

Stage 2: Interviews

After the Scale of Attitudes towards practical work had been carried out, 12 interviews were performed, each of which lasted approximately one hour. The interviews were semi-structured, and involved students in their first, second, and third years of secondary school. Interviews have been defined by Cohen and Manion (1994) as key data collection tools as they generate rich, detailed information and thus they are very suitable for the present study. During interviews, researchers can ask probing questions and ask interviewees to elaborate upon their responses if necessary. Before the real interviews, a pilot interview was performed. This highlighted the need to provide stimuli statements to encourage students to engage in the discussion instead of simply being asked for their opinions about practical work by the researcher. Stimuli questions included: (1) how do you feel about carrying out practical work lessons? (2) Can you provide an example of a specific practical task that they really liked or really disliked? (3) Would you change anything about how practical lessons are carried out?

In order to identify common themes, the researcher read the transcripts of each interview. The themes identified were then categorised and inputted into a Microsoft Word Document to be further analysed.

Member checking was performed in order to ensure that the qualitative component of the study was credible. Interviewees were asked to review the notes and make any corrections if necessary immediately after the interview.

Results

The Cognitive Domain

Table 6 shows that 80–91% of students agreed with the items pertaining to the cognitive domain, whilst this figure was 72–86% for students in the second grade, and 65–84% for those in the third grade. It is thus evident that students from the first, second, and third years understood the cognitive value of practical work when they agreed that 'conducting experiments in the laboratory helps them to develop their problem-solving skills, think practically and interpret results in a logical manner.' Moreover, most second-year students agreed that they could 'describe the steps involved in lab experiments', and most third-grade students reported that 'practical work in the laboratory helps them to understand biology/chemistry/physics'.

Table 6. Frequencies of Items in the Cognitive Domain

Stages / Items	*Year 1* Frequencies of items in the Cognitive sub-scale *N= 160*			*Year 2* Frequencies of items in the Cognitive sub-scale N= *155*			*Year 3* Frequencies of items in the Cognitive sub-scale N= *123*		
	Disagree %)	Neutral (%)	Agree (%)	Disagree (%)	Neutral (%)	Agree (%)	Disagree (%)	Neutral (%)	Agree (%)
Conducting laboratory experiences helps me to develop my problem-solving skills, think practically, and interpret results in a logical manner.	1 (6)	14 (8.8)	145 (90.6)	4 (2.6)	20 (12.9)	131 (84.5)	6 (4.9)	21 (17.1)	96 (78)
Laboratory experiments help me understand biology/chemistry/physics.	9 (5.6)	15 (9.4)	136 (85)	4 (2.6)	30 (19.4)	121 (78)	3 (2.4)	17 (13.8)	103 (83.7)
Laboratory experiments help me develop my creativity.	7(4.4)	26 (16.3)	127 (79.4)	8 (5.2)	22 (14.2)	125 (81)	9 (7.3)	20 (16.3)	94 (76.4)
I like to explain the results obtained from the experiments.	3 (1.9)	15 (9.4)	142 (88.8)	9 (5.8)	7 (11)	129 (82.5)	7 (5.7)	18 (14.6)	98 (79.7)
Lab work enables me to differentiate between measuring instruments and volume.	11 (6.9)	19 (11.9)	120 (81.3)	4 (2.6)	24 (15.5)	127 (81.9)	5 (4.1)	18 (14.6)	80 (65)
I am able to describe the steps involved in laboratory experiments.	7 (4.4)	25 (15.6)	128 (80)	7 (4.5)	24 (15.5)	124 (86.4)	8 (6.5)	30 (24.4)	85 (69.1)
I can easily identify the lab tools.	14 (8.8)	17 (15.6)	129 80.6)	11 (7.1)	32 (20.6)	112 (72)	10 (8.1)	26 (20.1)	87 (75.7)

The Affective Domain

Table 7 shows that between 72% and 90% of first-grade students agreed with the items relating to the affective domain. On the other hand, 69–93% of second-grade students agreed with their items, and 67–81% of third-grade students agreed. Students from all grades thus understood the affective value of practical work, as they reported that they were 'overjoyed when the teacher took them into the laboratory for practical lessons.'

Table 7. Frequencies of items in the Affective domain

Stage / Items	*Year 1* Frequencies of items in the Affective sub-scale *N= 160*			*Year 2* Frequencies of items in the Affective sub-scale N= *155*			*Year 3* Frequencies of items in the Affective sub-scale N= *123*		
	Disagree (%)	Neutral (%)	Agree (%)	Disagree (%)	Neutral (%)	Agree (%)	Disagree (%)	Neutral (%)	Agree (%)
I feel so happy when I am in the lab.	5 (3.1)	17 (10.6)	138 (86.3)	4 (2.6)	24 (15.5)	127 (81.9)	7 (5.7)	23 (18.7)	93 (75.6)
I am overjoyed when the teacher responds to our desires to go into the lab.	9 (5.6)	7 (4.4)	144 (90)	---	11 (7.1)	144 (92.9)	5 (4.1)	18(14.6)	100 (81.3)
I am happy to carry out laboratory experiments with my classmates.	9 (5.6)	23 (14.4)	128 (80)	5 (3.2)	24 (15.5)	126 (81.3)	8 (6.5)	30 (24.4)	85 (69.1)
It makes me happy to carry out scientific experiments in the laboratory.	8 (5)	9 (5.6)	143 (89.3)	11 (7.1)	9 (5.8)	135 (87.1)	4 (3.3)	25 (20.3)	94 (76.4)
I enjoy conducting experiments in the lab with my classmates.	7 (4.4)	21 (13.1)	132 (82.5)	----	21 (13.5)	134 (87.4)	5 (4.1)	22 (17.9)	96 (78)
I really enjoy being in the lab.	5 (3.1)	13 (8.1)	142 (88.8)	2 (1.3)	19 (12.3)	124 (86.4)	6 (4.9)	19 (15.4)	98 (79.7)
I feel happy when we go into the lab.	8 (5)	22 (13.8)	130 (81.3)	7 (1.9)	20 (12.9)	128 (82.2)	6 (4.9)	29 (23.6)	88 (71.5)
I enjoy being in the lab with my classmates.	8 (5)	19 (11.9)	133 (83.1)	5 (3.2)	17 (11.1)	133 (87.3)	6 (4.9)	20 (16.3)	97 (78.9)
I find practical biology, chemistry, and physics classes exciting.	10 (6.3)	14 (8.8)	136 (85)	4 (2.6)	24 (15.5)	127 (81.9)	6 (4.9)	22 (17.9)	95 (77)
I can't wait to go to the science lab.	12 (7.5)	33 (20.6)	115 (71.9)	13 (8.4)	35 (22.6)	107 (69)	7 (5.7)	34 (27.6)	82 (66.7)

The Psychomotor Domain

In Table 8, it can be observed that 72–84% of first-grade students agreed with all the items pertaining to the psychomotor domain, whilst these figures were 72–88% for second-grade students and 63–77% for those in third grade. Thus, the findings presented in the table clearly show that students in the first, second, and third grades all understood the psychomotor value of carrying out practical work, as they all agreed with the statement that they 'did many scientific experiments with their classmates'.

Table 8. Frequencies of items pertaining to the Psychomotor domain

Stages / Items	Year 1 Frequencies of items in the Psychomotor sub-scale *N= 160*			Year 2 Frequencies of items in the Psychomotor sub-scale N= 155			Year 3 Frequencies of items in the Psychomotor sub-scale N= 123		
	Disagree (%)	Neutral (%)	Agree (%)	Disagree (%)	Neutral (%)	Agree (%)	Disagree (%)	Neutral (%)	Agree (%)
I have become highly skilled in carrying out scientific experiments in the laboratory.	9 (5.6)	21 (13.1)	130 (81.3)	6 (3.9)	18 (11.6)	131 (84.5)	15 (12.2)	30 (24.4)	78 (63.4)
I have started to help my teacher when carrying out science experiments in the laboratory.	14 (8.8)	15 (9.4)	131 (81.9)	5 (3.2)	14 (9)	136 (87.8)	6 (4.9)	22 (17.9)	95 (77)
I have conducted many scientific experiments with my classmates in the laboratory.	8 (5)	27 (16.9)	135 (84.4)	11 (8.4)	31 (20)	111 (71.6)	14 (11.4)	25 (20.3)	83 (67.5)
I can identify different laboratory tools just by using my eyes.	10 (6.3)	24 (15)	126 (78.8)	15 (6.5)	25 (16.1)	120 (77.4)	13 (10.6)	25 (20.3)	85 (69.1)
I understand how to perform traditional and technological lab work.	7 (4.4)	24 (15)	129 (80.6)	11 (7.1)	31 (20)	113 (72.9)	15 (12.2)	24 (19.5)	84 (68.3)
I use lab tools with great craftsmanship.	21 (13.1)	24 (15)	115 (71.9)	16 (10.3)	29 (18.7)	115 (73.3)	9 (7.3)	27 (22)	87 (70.7)
The lab has helped me to master a number of skills, including making slides and using an electroscope.	11 (6.9)	21 (13.1)	128 (80)	15 (6.5)	25 (16.1)	120 (77.4)	15 (12.2)	27 (22)	81 (65.9)

Table 9. Multivariate analysis of the differences among the first, second, and third year secondary school students N= 438

Source	Subscales of the ATLWS	Sum of Squares	DF	Mean Square	F	Sig.	Eta Squared
Year Level (1, 2, and 3)	Cognitive	47.662	2	23.831	1.023	.360	.005
	Affective	182.198	2	91.099	1.893	.152	.009
	Psychomotor	215.458	2	107.729	3.389	.035	.015

It is evident from Table 9 that there are statistically significant differences between the attitudes of first-, second-, and third-year students in the psychomotor domain. On the other hand, the differences identified in the cognitive and affective domains are insignificant. An effect size of approximately 0.2 was identified for the psychomotor domain, which is relatively small.

Table 10 Post Hoc Analysis, *N*= 438

ATLWS subscales	Years (Mean)		Mean Difference	Sig.
Cognitive	Year 1*(29.22)*	Year 2 (*28.95)*	.264	.628
		Year 3*(28.40)*	.820	.157
	Year 2	Year 1	-.264	.628
		Year 3	.556	.340
	Year 3	Year 1	-.820	.157
		Year 2	-.556	.340
Affective	Year 1*(42.17)*	Year 2*(42.06)*	.111	.887
		Year 3*(40.68)*	1.486	.075
	Year 2	Year 1	-.111	.887
		Year 3	1.375	.101
	Year 3	Year 1	-1.486	.075
		Year 2	-1.375	.101
Psychomotor	Year 1*(28.54)*	Year 2*(28.25)*	.299	.639
		Year 3 *(28.40)*	1.682*	.013
	Year 2	Year 1	-.299	.639
		Year 3	1.383*	.043
	Year 3	Year 1	-1.682*	.013
		Year 2	-1.383*	.043

The posthoc analysis revealed significant differences between the attitudes of the first- and third-year students in the psychomotor domain, with the former showing more favourable attitudes. On the other hand, third-year students showed more favourable attitudes than second-year students. However, no significant differences were identified in the cognitive or affective domains.

Qualitative Analysis

The importance of practical work

All of the students involved in the interview agreed that practical work plays a fundamental role in developing a conceptual understanding of science. Moreover, there is an element of suspense associated with practical work that motivates students to participate. The students believed that practical experiences are more interesting to students, and therefore that they are able to maintain focus more easily when carrying out a practical task. Most students agreed that laboratory learning is more beneficial, and makes it easier for them to understand and assimilate information, whilst the applied educational process enhances their enthusiasm to learn science. On the other hand, a few students did not believe that the applied process was too important, and they indicated that it could have significant limitations.

The interest in practical work

Most participants reported a preference for practical tasks over theory work because it gave them an opportunity to connect information and learn new things. It also enhanced their self-esteem, and taught them how to behave safely and responsibly at home. Thus, they believed that practical lessons and experiments were highly applicable to real-life situations.

The requirements of practical work

Participants in the interview agreed that there are two types of safety that must be considered before carrying out practical tasks, namely the personal safety of the experimenter (i.e. wearing protective clothing and goggles)and public safety (i.e. ensuring that a fire extinguisher, emergency exit and safety tools are within easy reach). They also acknowledged the importance of understanding the theory behind the experiments before carrying them out, as this ensured that they could effectively perform the tasks in the laboratory. The students agreed that they would start by identifying the problem at hand, and then carry out an experiment to solve the problem. They also made sure to inform their supervisor whilst carrying out the experiment for safety purposes.

Several factors were identified by the students as being crucial in ensuring safety in the laboratory setting, including the presence of a fire extinguisher, first aid kits, gloves, goggles, protective clothing, locks, alarms, instruction boards, ventilation, and emergency exits.

Moreover, the students stated that practical experiments can support and reinforce the learning of theoretical scientific materials because it is generally easier to absorb information in this way. They also believed that information learned in this way stays in the mind for a longer period of time than when read in theory form.

Most students also believed that science education programmes are boring and difficult to understand when taught without the aid of practical experiments. This is because the information provided by the teachers lacks a tangible context. This is less effective because learning is limited to indoctrination when practical experience is not involved.

Discussion

In general, the students involved in the present study believed that practical work in science lessons was beneficial. First of all, in terms of the cognitive domain, students in different year groups had different opinions. For example, those in the first grade believed that practical work had cognitive value because it enhanced their problem-solving skills, encouraged them to think practically, and enabled them to interpret results logically. With regard to the affective domain, a majority of students reported their enjoyment of learning when their teachers took them into the laboratory for practical lessons. In addition, students valued practical work in the psychomotor domain because it enabled them to carry out scientific experiments with their classmates. However, those in the second grade indicated that they could describe the steps involved in laboratory experiments, and those in the third grade believed that laboratory tasks helped them to understand biology/chemistry/physics.

Nonetheless, Alshehri and Alabdulkareem (2016) revealed a major weakness by reporting on how Saudi students indicated shortcomings in the implementation of laboratory-based learning activities, which negatively impacted students' understanding of practical tasks. Sharpe (2012) investigated the cognitive domain, and found that students generally believed practical work helped them to understand scientific phenomena because they were able to see them with their own eyes. This enabled them to relate theory to practice. Additionally, several students indicated that they found it difficult to learn science without practical work, whilst others highlighted concerns that practical work could provide wrong answers which could affect their examination results in future. Nonetheless, with regard to the affective domain, Sharpe and Abrahams (2020) discovered that British students typically favour practical work over other non-practical tasks, and that students felt that they were being given more autonomy when participating in practical work. For example, they could talk to their classmates whilst working. In cognitive terms, research findings showed that practical work affects students' conceptual and procedural understanding, with many students feeling that practical work allowed them to witness theory in action. As a result, students should be encouraged to engage in practical work.

On the other hand, significant differences were revealed between the attitudes of the first- and third-year students in the psychomotor domain, with the former showing more favourable attitudes. On the other hand, third-year students showed more favourable attitudes than second-year students. However, no significant differences were identified in the cognitive or affective domains. Even though year 7 students come to science lessons displaying substantial enthusiasm for carrying out practical work, Sharpe (2012) found that this enthusiasm had dwindled significantly by year 10 as students realised that they would need to learn theory for their examinations, and that they would soon be finishing their compulsory educational journey.

The study carried out by Sharpe and Abrahams (2020) showed that the affective value of practical tasks differed largely by subject. However, this value gradually decreased in all three sciences as students approached their General Certificate in Secondary Education examinations (GCSE) at the age of 16. This highlights the importance of understanding that students' attitudes to practical work can change over time, and to a greater extent than was previously assumed. It is thus inaccurate to assume that these students' attitudes to practical work will always remain the same, and further investigations should be carried out to understand how age impacts students' attitudes towards practical/experimental tasks (Sharpe, 2012). Also, students' enthusiasm to engage in virtual practical work should be considered, especially after the consequences and challenges imposed on educational systems by the COVID-19 pandemic (Khalaf, 2020).

Most students agreed that laboratory learning is more beneficial, and makes it easier for them to understand and assimilate information, whilst the practical work enhanced their enthusiasm to learn science. Moreover, these findings are in line with those of Lee and Sulaiman (2018), who found that practical work creates an environment conducive to serious science learning. In such settings, students can take control of their own learning, and enhance their understanding of practical work.

Most participants reported a preference for practical tasks over theory work because it gave them an opportunity to connect information and learn new things. It also enhanced their self-esteem and taught them how to behave safely and responsibly at home. Thus, they believed that practical lessons and experiments were highly applicable to real-life situations. The results are also consistent with those found in Sharpe's (2012) research, which revealed that most students enjoy practical work and understand its importance, although they rarely consider undertaking a career in science. Most students also believed that science education programmes are boring and difficult to understand when taught without the aid of practical experiments. This is because the information provided by the teachers lacks a tangible context. This is less effective because learning is limited to indoctrination when practical experience is not involved.

Dagnew and Sitotaw (2019) also discovered that practical experimentation plays a vital role in developing students' learning skills by motivating them to take part in classes. They also provide teachers with a wide range of teaching tools that extend beyond textbooks. Furthermore, many studies have shown that practical lessons positively impact students' academic achievement. When students are interested in a lesson, they typically make more effort, which in turn translates into higher achievement. Therefore, this implies that Saudi teachers would benefit from adopting new strategies to increase students' interest and motivation in science subjects. It is crucial that teachers give students a chance to take part in practical tasks that are relevant to the topics that they are studying, as this will develop positive attitudes to science amongst the students. In turn, this will improve their academic achievement, not only in secondary school but also in higher education (Hinneh, 2017). Additionally, all students agreed that there are two types of safety that must be considered before carrying out practical tasks, namely the personal safety of the experimenter (i.e. wearing protective clothing and goggles) and public safety (i.e. ensuring that a fire extinguisher, emergency exit, and safety tools are within easy reach). However, Dagnew and Sitotaw (2019) also found that a lack of technical knowledge and students' behaviour can reduce the amount of time spent in laboratories undertaking practical science tasks, whilst high demands are also damaging practical science.

The findings of Alshehri and Alabdulkareem (2016) showed that note cards and experiment evaluation tools are not distributed frequently enough. Morever, Alanzi (2014) found that science teachers in Saudi Arabia are reluctant to take students into the laboratory due to a lack of manuals and poor training in how to carry out experiments. The current research recommends that the administration of Saudi schools should supply all essential equipment to facilitate the practical work for most topics in chemistry, biology, and physics.

Conclusion

In Saudi Arabian secondary schools, practical tasks are a fundamental component of science education programmes. The present study has shown that Saudi students generally have positive attitudes towards practical lessons in the cognitive, affective, and psychomotor domains. Moreover, the findings revealed that a majority of Saudi students understood the importance of practical work in science education, as it enabled them to see things for themselves. Nonetheless, it is important to note that Saudi teachers need special training to develop their own competence, skills, and knowledge when carrying out practical lessons with their students. The findings of the present study also highlight the importance of ensuring that laboratory facilities are fully equipped and furnished, with all necessary tools being available. The necessary measures should also be taken to ensure that teachers and students understand how to carry out the experiments. Curriculum developers, policymakers, and textbook authors in Saudi Arabia must consider the attitudes of students when developing new materials. In future, researchers should focus on the impact of practical work on science education at different levels (i.e. primary and secondary). It is also recommended that researchers explore the attitudes of science teachers towards practical work.

Acknowledgements

The authors extend their appreciation to the Deanship of Scientific Research at Jouf University for funding this work through research grant No (DSR- 2021-04-0122).

References

Abrahams, I., & Saglam, M. (2010). A study of teachers' views on practical work in secondary schools in England and Wales. *International Journal of Science Education, 32*(6), 753–768. https://doi.org/10.1080/02635143.2019.1597696

Alanzi, S. S.(2014). *Obstacles to using the laboratory in teaching science to the upper classes at the primary stage from the point of view of teachers and their supervisors in Buraidah* [unpublished master's thesis].Umm Al-Qura University, Saudi Arabia .

Alharthy, A. D. (2015). The role of school administration in activating science laboratories in the primary stage in Riyadh. *Journal of the College of Education*, *31*(4), 183-219.

Aljabr, J.M. (2009). Obstacles to the use of the school laboratory in general education from the point of view of teachers of natural sciences in the secondary stage in Riyadh in the Kingdom of Saudi Arabia .*Egyptian Journal of Science Education, 12*(3), 116-150.

Alshaya, A.A. (2011). *Evaluating the reality of the project of activating school laboratories in the Qassim educational region from the point of view of teachers and supervisors of natural sciences*. [Unpublished master's thesis]. Qassim University, Saudi Arabia.

Alshamrani, A.A. (2018). The effectiveness of a 3D virtual environment (soodle) in the development of the practical experiments skills in physics of secondary students in Jeddah. *The Journal of Educational and Psychological Sciences, 8* (2), 56-73.

Alshehri , M. J., & Alabdulkareem, S.A. (2016). The current situation of the implementation of the program of school laboratories activation in the educational process in Riyadh city. *Journal of Education and Psychology, 53*, 89-117.

Cohen, L., & Manion, L. (1994). *Research methods in education* (4th ed.). London: Routledge.

Creswell, J. W., Plano Clark, V. L., Gutmann, M., & Hanson, W. (2003). *Advanced mixed methods research designs*. Thousand Oaks, CA: Sage.

Dagnew, A. & Sitotaw, C. (2019). The effect of practical work to enhance ninth grade achievement in biology class: The case of diaspora secondary school, Ethiopia. *Global Journal of Guidance and Counseling in Schools: Current Perspectives, 9*(3), 95–105. https://doi.org/10.18844/gjgc.v9i3.4253

Hamdan, A., & Alsalouli, M. (2013). Saudi elementary school science teachers' beliefs about teaching science in the new millennium. *International Journal of Science and Mathematics Education*, *11*(2), 501–525. https://doi.org/10.1007/s10763-012-9353-0

Hinneh, J.T. (2017). Attitude towards practical work and students' achievement in Biology: A case of a private senior secondary school in Gaborone, Botswana. *IOSR Journal of Mathematics (IOSR-JM), 13*(4), 6-11. DOI: 10.9790/5728-1304010611

Jokiranta, K. (2014). *Effectiveness of practical work in science education* [Unpublished doctoral thesis]. University of Jyväskylä, Finland. https://jyx.jyu.fi/bitstream/handle/123456789/42979/URN:NBN:fi:jyu-201402181251.pdf

Khalaf, M. A., & Abulela, M. A. (2021). The academic buoyancy scale: Measurement invariance across culture and gender in Egyptian and Omani undergraduates. *European Journal of Educational Research, 10*(4), 2121-2131.

https://doi.org/10.12973/eu-jer.10.4.2121

Khalaf, M. A, & Al-Said, T. T (2021). The Egyptian validation study of the resilience scale for adults (RSA) and its utility in predicting depression. *The Open Psychology Journal, 14*, 83-92. DOI: 10.2174/1874350102114010083

Khalaf, M. A. (2020). Psychological consequences of COVID-19 and challenges for post-traumatic interventions. *Psychology Research, 10*(1), 24-29. Doi:10.17265/2159-5542/2020.01.003

Khalaf, M.A. (2016). The relationship between emotional intelligence and academic achievements in

males and females in Egyptian context. *Psychology Research, 6*(10), 567– 578.

Doi:10.17265/2159-5542/2016.10.002

Khalaf, M.A. (2014). Validity and reliability of the academic resilience scale in Egyptian context. *US-China Education Review B, 4*(3), 202– 210. http://www.davidpublisher.com/Public/uploads/Contribute/551219868b17e.pdf.

Lawson, A.E. (1995). Science teaching and the development of thinking. Wadsworth Publishing Company.

Lee, M., & Sulaiman, F. (2018). The effectiveness of practical work in physics to improve students'

Academic performances. *People: International Journal Of Social Sciences*,*3*(3), 1404-1419.

DOI: 10.20319/pijss.2018.33.14041419

Millar, R. (2011). Practical work. In J. Osborne & J. Dillon (Eds). *Good practice in science teaching: What research has to say*(pp.108-134). Maidenhead: Open University Press.

Monica, I., Nicholas, T. & David, K. (2015). Chemistry teachers' role in changing practical work from simple 'hands on' activities to more of 'minds on' activities. *International Journal of Humanities and Social Science,5*(10), 110-118. http://www.ijhssnet.com/journals/Vol_5_No_10_1_October_2015/13.pdf

Okam, C. C., & Zakari, I. I. (2017). Impact of laboratory-based teaching strategy on students ' attitudes and mastery of chemistry in Katsina Metropolis, Katsina State, Nigeria. *International Journal of Innovative Research and Development*, *6*(1), 112121.http://www.internationaljournalcorner.com/index.php/ijird_ojs/article/view/136776/95899

Osborne, S., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199

Reid, N. (2003). Gender and physics. *International Journal of Science Education, 25*(4), 509–536. https://doi.org/10.1080/0950069022000017270

Shana, Z.J., & Abulibdeh, E.S. (2020). Science practical work and its impact on students' science achievement. *Journal of Technology and Science Education, 10*(2), 199-215. http://dx.doi.org/10.3926/jotse.888

Sharpe, R. M. (2012). *Secondary school students' attitudes to practical work in school science*. University of York Education.

Sharpe, R., & Abrahams, I. (2020). Secondary school students' attitudes to practical work in biology, chemistry and physics in England. *Research in Science & Technological Education, 38*(1), 84- 104. https://doi.org/10.1080/02635143.2019.1597696

Singer, S.R., Hilton, M.L., & Schweingruber, H.A. (2006). *America's Lab Report: Investigations in High School Science*. Washington, DC:The National Academies Press.

Smith, L., & Abouammoh, A. (Eds.). (2013). *Higher education in Saudi Arabia: Achievement challenges and opportunities*. New York: Springer.

Trumper, R. (2006). Factors affecting junior high school students' interest in physics. *Journal of Science Education andTechnology*,*15*(1), 47-58.

DOI: 10.1007/s10956-006-0355-6

Wellington, J. (2005). Practical work and the affective domain: What do we know, what should we ask, and what is worth exploring further? In S. Alsop (Ed.), *Beyond Cartesian dualism: Encountering affect in the teaching and learning science*(pp.99-109). Dordrecht, The Netherlands: Springer.

Yager, R., & McCormack, A. (1989). Assessing teaching /learning successes in multiple domains of science and science education. *Science Education*, *73*(1), 4558. https://doi.org/10.1002/sce.3730730105

Yager, R. (1996).*Science/technology/society as reform in science education*. Albany,

.