CONSTRUCTIVISM AS A LEARNING THEORY APPLIED TO THINKING IN SOLVING PHYSICS PROBLEMS: AN INTERPRETIVE STUDY

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Abstract

This paper aims to understand how students think during solving problems in higher education in Saudi Arabia. The current study used an overall interpretive methodology. The instruments used for data collection were think-aloud protocols and semi-structured discussions. The 21 participants included eleven first-year and ten preparatory-year students. The data produced essential findings based on thematic analysis techniques. The findings revealed that students found difficulty in understanding problems; they did not seem to know how to implement the steps of problem-solving (understanding the problem, devising a plan, carrying out the plan and looking back). Also, the lack of basic physics knowledge, basic physics conceptual understanding and basic mathematical knowledge seemed to reflect negatively on students' understanding of physics and on their approach to solving physics problems. The study suggested that, if students were given the opportunity to participate, by explaining the problems and helping them to reach a solution, or allowing them to discuss among themselves, this would have a positive impact on their cognitive abilities and their performance in problem-solving.

Keywords: *Problem-solving, think-aloud, interpretive approach, collaborative learning, scaffolding, motivation*.

1. Introduction

Thinking is a complex process that includes mental activity, both cognitive and metacognitive; it also has a variety of functions. Guttami (2005, p.18-19) states that the variations in people's thinking patterns result from: "(1) differences among individuals in respect of the things they pay attention to, (2) differences in the social circumstances a child is exposed to, (3) differences in experiences and goals, and (4) differences in individual's abilities".

Competing theories of thinking have emerged, incorporating such notions as scientific thinking, creative thinking, and critical thinking. De Bono (1976) expands on this, stating that the variety of thinking levels results in diverse definitions and, therefore, it is not plausible to have only one definition of thinking. However, De Bono views thinking as "the deliberate exploration of experience for a purpose. That purpose may be understanding, decision-making, planning, problem-solving, judgement, action and so on" (1976, p.32).

Abojado and Novel (2015) argue that the perspectives of researchers and educators regarding the definition of thinking present different definitions relying on multiple theoretical foundations and orientations. This issue has led to a lack of consensus among researchers in regard to defining thinking, its characteristics, forms and methods.

Furthermore, there is a difference between the notions of thinking and thinking skills. According to Beyer (1988), on the one hand, thinking is a comprehensive course of action, in which “we mentally manipulate sensory input and recalled data to formulate thoughts, reason about, or judge” (p. 72), that is done in order to provide significance to life events. On the other hand, thinking skills are tactics the mind purposefully employs to solve problems and accomplish goals. Whilst Wilson (2000) believes that thinking skills are inconclusively defined, Vail (1990, cited in Owu-Ewie, 2008) contends that they relate to a group of skills, including both basic and advanced skills, which control an individual’s mental processes. These skills, according to Vail, involve knowledge, metacognitive and cognitive operations and dispositions. Swartz and Perkins (2017) argue that thinking skills are capabilities that aid some types of thinking.

2. Theoretical Framework

2.1 Problem-solving

Science teaching involves far more than the mere transmission of facts and information; rather, it aims at achieving a more crucial goal, which is to teach learners to use fundamental scientific concepts or facts in a flexible manner to be able to cope with unexpected situations, to adequately predict effects and solve problems (Reif, Larkin, & Brackett, 1976). The literature provides different definitions of the notion of problem-solving and, therefore, there is no clear definition of this concept (Jerwan, 2012). For example, Malik et al. (2019) defined problem-solving as a complex and very significant skill as part of the learning process in all specialties. Some refer to problem-solving as the knowledge gap between individuals and a particular goal they are trying to attain whereby people are faced with a problem and do not know how to bridge this gap in order to achieve a specific objective (Hayes, 1981).

To Zewdie (2014), problem-solving refers to “a process that entails the use of high-level cognitive skills, and involves various activities ranging from trial and error, gaining insight and establishing cause-effect relationship” (p.79). Nevertheless, if students know what to do when addressing a problem, this is not a problem anymore but a repetition exercise for what they have learned.

2.2 Physics and problem-solving skills

Students need to improve their ability to use thinking skills at a more advanced level, together with their critical thinking skills, which involves the ability to pose relevant questions and use arguments in discussions whilst being able to find a solution to a given problem (Hugerat & Kortam, 2014). According to Forawi (2016, p.54), “the science curriculum plays a major role in providing opportunities for students to use and acquire higher-order thinking skills”.

Physics can be seen as one of the scientific disciplines that provides students with a plethora of possible activities and tasks, thus playing a vital role in developing their thinking and problem-solving skills to gain further understanding of natural phenomena (UK Physical Science Centre, 2008). Moreover, physics requires learners to use their minds in an appropriate way in order to understand a given subject matter or solve a particular problem. Numerous studies have highlighted that physics and chemistry are subjects with which students usually struggle the most (Alsufyani, 2010).

Given the reported difficulties of students with physics and chemistry subjects, it seems evident that there are certain factors contributing to this phenomenon. One of the key factors in this regard is a problem known as ‘cognitive conflict’, which Adey (1999) identified as happening when students encounter a problem they find difficult to accomplish by themselves, but which they can solve or fully comprehend with the help of a more able peer or adult. When learning new physics concepts, students might not make connections to what they already know. Also, students have knowledge but lack understanding of the ways to apply it in physics problems and are thus unable to solve these problems (Zewdie, 2014). This can be explained by the fact that students may often merely memorise knowledge without thinking or because they are not being helped to follow the scientific steps that could guide them to the desired goal, such as, for instance, the problem-solving steps. In this regard, Chi, Bassok, Lewis, Reimann and Glaser (1989) pointed out that weak students are often unable to clarify example exercises to themselves and, in instances where they are able to do so, their clarifications tend to be detached from their comprehension of the principles and concepts in question.

Moreover, traditional teaching methods used in schools and universities in the Saudi context, as reported in the literature (e.g. Alhammad, 2015; Alkhowaiter, 2016), might play a role in encouraging students to memorise information or concepts without a deep understanding. Forawi (2016) mentioned that “many of our present education majors have come through systems where the curriculum was more fact-driven, that is, taught using traditional teacher-directed methods” (p.53). Thus, teachers should challenge their students with different levels and types of questioning, such as remembering, understanding, analysing and evaluating, in order to push them to think and assist them in solving physics problems.

In Saudi Arabia, there have been attempts to apply problem-solving skills with university students in order to find out the extent to which students acquire skills to solve problems. For instance, Aljebally (2013) conducted a study which aimed to identify the level of problem-solving skills among the university’s students and the differences between them according to gender, specialisation and academic level and used a test to measure the skill of problem-solving. The test was administered to 2182 students and the results demonstrated that the levels of problem-solving skills for university students were average. The study showed that there were no statistically proven differences between male and female students in problem-solving skills. The study suggested conducting further studies regarding problem-solving in Saudi Arabian universities.

In addition, Alshaya (2014) conducted a study at King Saud University about the difficulties facing preparatory year students in physics courses through asking faculty members to assess these difficulties and also through analysing students' answers to physics problems in final examinations. He found that the difficulties were related to verbal context, mathematical skills, physical laws, and knowledge of diagrams or graphs.

Moreover, problem-solving in physics might play an essential role in limiting misconceptions in physics in relation to physics concepts or abstract ideas, such as heat and temperature, energy or Newton’s laws. According to Yalcin et al. (2009), misconceptions are “preconceptions which are in conflict with the scientific view” (p.1083). In this regard, Stein, Larrabee and Barman (2008) emphasised that, compared with other areas of science, physics concepts such as, for instance, motion and force, or physical and chemical changes, seem to be too abstract to understand. Likewise, Gomez-Zwiep (2008) pointed out “misconceptions appear across all areas of science and within all age groups” (p.437).

Consequently, this issue needs to be further investigated, and more specifically in the Saudi context. Therefore, this study sought to respond to the research question:

> How do preparatory-year and first-year students think during solving physics problems and why?

3. Methodology

The current study adopted an interpretive approach, which is justified by the fact that this research cannot be built upon the realist principles that view social reality as existing independently of the knower, in order to shed light on the issues under investigation. Therefore, the current study used a set of data and an overall interpretive methodology to attempt to obtain an in-depth understanding of Saudi physics students' thinking and why they think in this way.

4. Data Collection

Data were collected by means of think-aloud protocols and discussions with students.

4.1 Think-aloud protocols

Various studies in education have used think-aloud protocols in order to investigate how students use problem-solving processes when they are given a task to solve (e.g Rose et al., 2017).

The current study used think-aloud protocols in order to understand how preparatory- and first-year students solved the mechanics problem which was given to them.

Leighton (2017) provides guidance for researchers wishing to employ think-aloud protocols to investigate problem-solving. For instance, he recommends making sure that the think-aloud is really based on problem-solving tasks and that it requires monitoring based on the level and ability of participants. In my study, the following mechanics problem was given to the students:

> A box weighs 562 Newton on a tilted surface at a 30-degree angle. The force of gravity has two components, one perpendicular and one parallel to the incline. Find the two components of the weight force.

According to Leighton, it is also essential to identify and adopt a cognitive framework established from research to be used with the targeted participants. Then, based on this framework, the researcher should be able to determine possible problems and challenges faced by participants in completing the chosen tasks, as well as the possible solutions. It is essential to identify these models prior to commencing the data collection process. In the current study, during discussions the students were asked to talk about the steps they were following to solve the problem. According to Leighton (2017), specific information about the participants with respect to level of knowledge and ability needs to be taken into account when selecting the task to be completed. In addition, when giving these instructions to the participants, the researcher must ensure they do not take the task as an evaluation, especially if such tasks are thought to be ability tests or achievement tests. Therefore, it is essential to minimise possible sources of stress and anxiety, by reiterating to the participants that the task at hand is not a measurement test. This is why, in this study, I was particularly concerned about building a friendly relationship with the participants to minimise their stress during the task; they were also informed that their attempt to solve the problem had no effect on their grades in physics. Finally, it is essential to clarify the objectives of the study and the task and take all precautions in terms of sampling and participant selection based on these objectives.

At this stage, all participating students were provided with a piece of paper and a pen. They were informed that their thinking aloud would be recorded, and they all gave their permission for this.

Then they were given the abovementioned mechanics problem. Also, they were informed that the researchers could not help them to solve the problem; rather that they were there to record their thinking aloud.

5. Sample

The total number was 21students from Taif University, made up of ten preparatory-year and eleven first-year students, for think-aloud protocols.

6. Data Analysis

In this study, thematic analysis was adopted as an approach to analyse the think-aloud protocols. The think-aloud protocols were recorded, transcribed and analysed. This study used inductive thematic analysis because this approach is a flexible one which does not have strict rules, but which helps the researcher to get a rich description of the data. In addition, the inductive approach was used because this study is not based on pre-set hypotheses. Qualitative data analysis software MAXQDA was used to facilitate the process of analysis. This software helped us to organise and store the data and therefore retrieve them easily. Moreover, it allowed us to generate codes and link them with the data.

As a result, think-aloud was read through the software interface and each emerging idea from the text was highlighted and attributed a new code. The same process was repeated for all think-aloud protocols. Where similar ideas emerged, they were included in the same code. The third step in the analytical process involved coding segments of data on the software by labelling and naming selected think-aloud extracts; therefore, various codes were generated from the data as shown in Table 1 below.

Table 1: Codes and segments of data

Segments of data	Coded for
“A lack of basic physics knowledge from school influences the level of students’ thinking when they want to understand solving problems in physics.” (discussion)	Lack of basic physics knowledge
What is this? This is the first time I see a problem like this, mmm…I do not understand the mechanics problem” (Think aloud)	Understanding the problem
“We directly start solving without any planning for the solving method". (discussion)	Devising a plan

Then we wrote the name of each code on a paper card to organise and sort them into potential themes. Some initial ideas formed categories that composed the main themes. Finally, when we generated a set of themes, they were reviewed and refined in relation to the coded extracts.

7. Findings

The results demonstrate how students solved the mechanics problem, from their think-aloud protocols.

7.1 Students’ thinking during solving the physics problem

This section focuses on how preparatory-year and first-year students dealt with the physics problem, drawing on data from the think-aloud protocols with respect to: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back.

7.1.1.Understanding the problem

One of the first-year students was labelled S1F (S=student, 1= number of student of participant, F= first-year). SIF started his thinking with imagining the problem. After that, he used a drawing, but he could not find the unknown in the problem, because the solution required more than one step to reach the unknown:

> I'm…. mmm I'm trying to imagine the problem in order to define the coordinates. First of all, ahh, okay, this coordinate is X with sine of the angle 30, and another one is Y with cosine of the angle 30. *mmm…* then, this is the tilted surface, *mmm*…what I have to do now is to find the required point which is… *mmm…* Find the two components of the weight force, but...ahh, I do not understand this […]. I feel that the solution requires something based on something else and this is a difficulty that confuses my understanding.

Meanwhile, another first-year student (S5F) began drawing a figure and wrote the problem data; he seemed to give much attention to understanding the problem but moved directly to finding the suitable law:

> Okay, mmm, the first thing I do is draw the physics problem like this, and this is coordinate X, and this is Y. I'm…. Okay, and this is a box that weighs 562 Newton on a tilted surface. Mmm..., I think I need to look for the suitable law, but honestly, I do not know because I do not remember the law.

When asked about his procedures in the previous mechanics problem, S5F mentioned clearly that he did not understand the problem although he started to imagine the problem in his mind:

> Well, I think about a box making an angle… nearly like that, and mmm…I'm supposed to find the weight…ahh, it is 562 Newton and… the gravity is its opposite. Ahh, but I do not understand this concept of the two components of the weight force … mmm I cannot complete the procedures of the solution of this problem, because I found difficulty to understand the problem.

In the same context, another first-year student (S7F) expressed his thoughts about understanding the problem in more detail; he drew the diagram and analysed two components correctly, but he found the result of each component of the weight force and he did not calculate the total of components of the weight force:

> Firstly, I have a box on a tilted surface, mmm... let's assume that this tilted surface and this box sits at an angle of 30 degrees and the weight... mmm is 562 Newton. Okay, I'm going to take the weight and multiply it by the sine of the angle 30, ahh, the result mmm... is 281 N. Okay, mmm... then I will find the perpendicular axis… ahh. I think with the perpendicular axis… mmm, I will take the weight and multiply it by the cosine of the angle 30 and, ahh the result mmm... is 486.71 N.

On the other hand, one of the preparatory-year students (S1P) (P= preparatory-year) was given the abovementioned mechanics problem and could not solve it; he declared: "What is this? This is the first time to see a problem like this, mmm…I do not understand the mechanics problem". When asked how he thought through the solution to the problem he could not describe his thinking because he had difficulty understanding the problem and because he did not understand the relevant concepts:

> I can see that the first part of the problem is understandable but, mmm… the second part poses a difficulty in understanding the problem, also the concepts of the physics problem. I mean that I do not understand 'Find the two components of the weight force' because it's the first time I hear this phrase. So, mmm…. I do not understand the problem clearly, ah… subsequently, I cannot think about the solution.

Similarly, another preparatory-year student (S6P) mentioned that he faced difficulties thinking about the problem; he could not understand it, so he stopped thinking about the solution:

> First, umm... I can see now from the problem the data which is represented in the weight and ahh... the angle, umm... and the requirement is 'find the two components of the weight force'. Umm…, through reading this physics problem, I do not get the meaning, I cannot think.

Another preparatory-year student (S9P) could not carry on thinking because he did not understand the problem: "umm …I think…umm … I am having trouble with this concept –the force of gravity– but what is this? …it's the first time I have heard of it […] and I do not have any previous background".

One of the noteworthy issues that appeared through the students' think-alouds was that they appeared confused between understanding the problem and devising a plan, and this was confirmed by other students from both years who mentioned that devising a plan meant to search for the data while solving the mechanics problem. For example, a first-year student (S6F) explained while attempting to solve the problem:

> Mmm, …I'm going to make a plan by finding the data which is 'weight=562 Newton' and the angle is… 30°…. The angle above is horizontal. Umm, after that…I need to find the directions of the force, mmm… I don't know.

Similarly, preparatory-year student (S10P) explained that devising a plan is to find the data from the physics problem, although he did not give much explanation about how he could understand the physics problem:

> Okay, my plan with this problem…umm is defining the data which is… ahh... the weight=562 Newton and…ahh... the 30° angle, then…mmm, I forgot what is the suitable law? … I do not know, sorry.

Interestingly, students from both years during the think-aloud protocols drew a diagram when they tried to solve the above problem; their diagram showed a lack of understanding of the physics problem whereby all preparatory-year students showed that they did not have a basic physics knowledge about "the two components of the weight forces" and could not draw the components of the weight forces correctly because they did not understand the concept (components of the weight force), whereas, the first-year students drew the components. This can be explained by the fact that first-year students can be considered as specialists in physics, unlike the preparatory-year students who do not specialize in physics, although the physics problem was taken from a secondary school physics book. However, first-year students (S3F, S5F) made a mistake when they tried to analyse the two components of the weight force on the diagram as they multiplied the weight by the cosine of the angle 30^{o} on the perpendicular axis. Moreover, five students (S1F, S4F, S9F, S8F, S11F) did analyse the two components correctly, but did not solve the problem because they did not understand what to do next.

7.1.2 Devising a plan

Through conducting discussions with all students and based on think-aloud protocols using the same mechanics problem given above, the results show that the students did not seem to know how to devise a plan to solve the problem given to them. Also, through the analysis, it appeared that they had the perception that extracting the data and finding the required parts of the mechanics problem is devising a plan.

7.1.3 Carrying out the plan

Through students' think-aloud protocols using the mechanics problem given to them, and as mentioned in the previous section (devising a plan), students had the perception that extraction of the required data from the mechanics problem was considered as part of devising a plan. Also, it appears from the analysis of the data that the students did not seem to know how to devise a plan for the problem given to them. Subsequently, from the statements of the participants through the think-aloud protocols, there was no clear indication that they were carrying out a plan to reach the solution of the problem. Indeed, during thinking about the previous mechanics problem, students were asked how they were carrying out a plan to complete the mechanics problem. Five first-year students and four preparatory-year students said that to carry out the plan is to apply equations to obtain the solution.

7.1.4 Looking back

The student participants in both the preparatory and first years, when presented with the previous mechanics problem, did not demonstrate that they implemented the step of looking back in their problem-solving. An exception to this was a first-year student (S9F) who, when discussing the solution during a think-aloud, mentioned: "Umm, it appears to me that the result I reached from this problem is too large for the data".

Based on the above results it appears that students get confused between devising a plan and understanding the problem and did not seem to know how to devise a plan to solve the problem. As for carrying out a plan and looking back, the students' think-aloud did not demonstrate evidence of this.

7.2 Lack of basic knowledge at different levels of the education system

The data show that students' lack of basic knowledge acquired from school and university could be divided into three aspects: (1) lack of basic physics knowledge, (2) lack of basic physics conceptual understanding, and (3) lack of basic mathematical knowledge, as Figure shows.

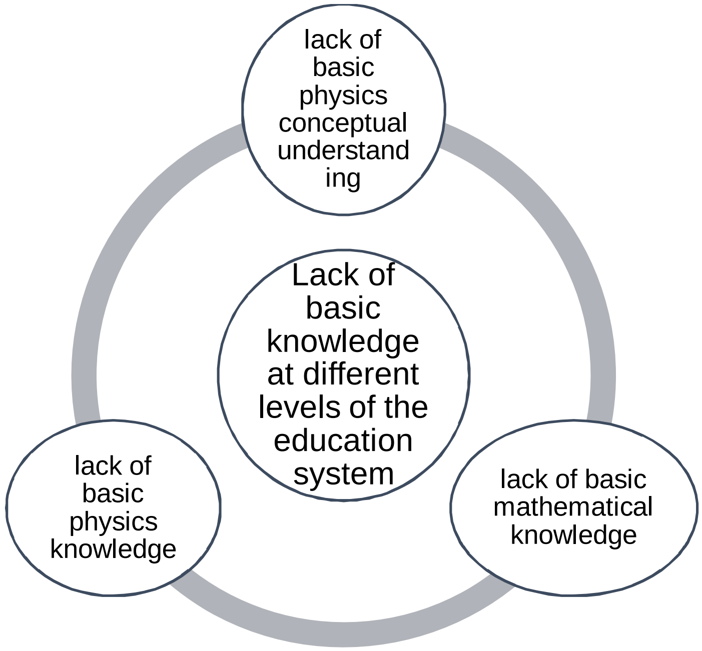

Figure 1: Lack of basic knowledge at different levels of the education system

7.2.1 Lack of basic physics knowledge

With regards to the school level, all preparatory- and first-year students discussed the lack of basic physics knowledge acquired from school that reflected negatively on their understanding of physics and their approach to solving physics problems. For example, preparatory-year student (S18P) mentioned that the reason behind the lack of knowledge related to the fact that students in schools were accustomed to memorising rather than using thinking.

Preparatory-year student (S6P) viewed this matter from a different perspective as he indicated that the type of school attended, whether a government school or private school, affected the lack of basic physics knowledge. He felt that he had not received good basic physics knowledge from school, which made him hate physics.

At university, a preparatory-year student (S5P) indicated that teachers believe that students have basic knowledge about physics problems from school; therefore, the university teacher might not pay sufficient attention to explaining the mechanics problems, which will be reflected negatively in students' understanding of physics.

A number of participants in the preparatory and first years indicated that they had not gained sufficient basic knowledge in secondary school regarding thinking and problem-solving skills in physics. For instance, one of the first-year students (S8F) indicated that he had not been prepared in secondary school for thinking and problem-solving skills while studying physics.

7.2.2 Lack of basic physics conceptual understanding

A number of students from both years referred to students' lack of basic physics conceptual understanding while solving physics problems in general and mechanics problems in particular.

A factor influencing students' understanding in solving physics problems is the multiplicity of physics concepts. A preparatory-year student (S4P) indicated: "when I see the multiplicity of physics concepts and the difficulty of understanding them on the board, this is considered the biggest factor affecting my understanding to solve physics problems".

7.2.3 Lack of basic mathematical knowledge

Ten of the student participants (four preparatory-year students and six first-year students) mentioned that another important aspect regarding the lack of basic knowledge is represented in the notion that most difficulties facing students while solving physics problems are caused by the lack of basic mathematical knowledge. This was one of the most frequently highlighted issues revealed by the results. For instance, one of the first-year students (S3F) stressed the importance of basic mathematical knowledge in order to solve physics problems and acknowledged his own shortcomings in mathematical knowledge: "the student should have a good basis in mathematics to be able to figure the mechanics problems. As for me, I have issues and weaknesses in mathematics". Also, one of the first-year students (S9F) was critical about his foundation in school regarding basic mathematical knowledge and agreed with S3F about weaknesses in mathematics.

8. Discussion

8.1 First step: understanding the problem

The data analysis of the think-aloud protocols with students revealed that students found it difficult to understand the given problem. Some first-year students gave explanations related to understanding the problem, whereas four preparatory-year students gave up trying to explain the problem, while other preparatory-year students tried to understand and solve the problem, but they could not. Researchers (e.g. Byun et al., 2010; Reddy & Panacharoensawad, 2017) have found that certain factors may hinder students' problem-solving skills in physics, such as the students' inability to fully comprehend the problem they are faced with. In a study conducted by Chi et al. (1989), it was found that weaker students struggle to give explanations and find it hard to explain additional features of the laws while solving a given physics problem, as they have a weak comprehension of what they read in the physics problem. Nevertheless, the problem which was given to the participating students was taken from a secondary school physics book.

It was noticed that, while they were solving the physics problem, students were not asking themselves a set of questions related to this step, as suggested by Polya (1957), which might facilitate the understanding of the problem. Rather, they seemed to focus on finding the data given and jumped immediately to substitution in the equations without putting enough focus on understanding the problem and its physics concepts. This was similar to Zewdie (2014), who found that students do not spend much time understanding a physics problem. Moreover, Docktor et al. (2015) pointed out that students actually perceive the equations as the fundamental key to solving physics problems and tend to ignore physics concepts. In this regard, students need to ask themselves appropriate questions in order to engage their cognitive processes in relation to problem solving (Özsoy & Ataman, 2017), as problem-solving requires using high-level cognitive skills (Zewdie, 2014). Consequently, cognitive and metacognitive skills need to be given great importance in order to boost students' awareness of their learning processes when dealing with physics problems.

Also, during the think-aloud protocols, students from both years drew diagrams that revealed their lack of understanding of the physics problem. Thus, preparatory-year students showed that they did not have basic physics knowledge about "the two components of the weight force" and they could not draw the components of the weight force correctly because they did not understand the concept (components of the weight force). On the other hand, the first-year students did manage to draw the components. This can be explained by the fact that first-year students are considered as specialists in physics unlike the preparatory-year students who do not specialise in physics, even though the physics problem was taken from a secondary school physics book. However, first-year students made a mistake when they tried to analyse the two components of the weight force on the diagram; they multiplied the weight by the cosine of the angle 30^0 on the perpendicular axis, except for four students who analysed the two components correctly but did not find the solution because they said that they did not understand what to do next. This might be related to students' lack of basic knowledge of physics concepts, which might hinder their understanding of physics problems. Students during think-aloud protocols found difficulty in understanding the problem, and none of the students could solve the physics problem provided. These findings were found to be consistent with what is reported in the literature (e.g. Zewdie, 2014) that students have difficulties in understanding basic concepts of mechanics when they deal with physics problems, emphasising the importance of physics concepts in relation to solving physics problems. Also, Chi et al. (1989) pointed out that weak students are often unable to clarify example-exercises to themselves. In instances where they are able to do so, their clarifications tend to be detached from their comprehension of the principles and concepts in question. Eshetu and Assefa (2019) emphasised that students need to possess physics concepts used for solving problems in order to enhance their understanding of physics problems.

Ates and Cataloglu (2007) mentioned that traditional teaching methods do not help students to understand mechanics problems, despite the fact that such interaction may contribute to the development of the cognitive ability to understand physics problems, because social interaction develops cognitive abilities (Wallace et al., 2012). According to sociocultural theory, through a process of interaction and transformation between people within the context, individuals change their responses to establish different kinds of meaning (Stevenson, 2004). In the Saudi context, a number of studies (e.g. Alghamdi, 2013; Alqhatani, 2013) have confirmed that teachers rely mainly on traditional practices such as assisting students to memorise physics information rather than encouraging them to ask questions or interact with their teachers during physics lessons. Also, the lack of basic physics knowledge acquired from school (as discussed later in this article) may, in this study, be related to the teaching methods which rely on memorisation, as students merely memorise knowledge or procedures and try to replicate the same procedures with any physics problems they face, without proper thought. In the Saudi context, Alqhatani (2013) found that physics teachers rely on traditional teaching methods, which is one of the reasons for the weakness of students in the acquisition of physics concepts.

8.2 Second and third steps: devising a plan and carrying out the plan

Through observation during the think-aloud protocols using the same mechanics problem, the results show that the students did not seem to know how to devise a plan to solve a problem.

Furthermore, the findings of the current study concur with Al-Qahtani's (1995) study which investigated the factors preventing the teaching of thinking skills in the Saudi context; the study found that one of these factors is the concentration on the examination and that the examinations themselves encourage students to recall and memorise rather than think. Also, Mansour (2010) in his study in Egypt found that science teachers at the beginning of the school year are concerned about the examination, which makes students worried and forces them to concentrate on remembering knowledge. However, science lessons should aim at engaging students in a process that allows them to think, innovate and enhance their thinking skills in order to resolve issues and problems that they encounter, rather than just providing information (Yaseen, 2013). In turn, students may be more likely to make the most of these skills and be ready to make valuable contributions to society's progress (Alsayeh, 1997). Accordingly, it is necessary for educational systems to transition from merely providing information to enhancing thinking skills and focusing on them, which in turn may help students to solve physics problems. In this context, McGregor (2007) confirmed that there is strong evidence that programmes which concentrate on teaching thinking skills can improve students' problem-solving abilities, their academic performance and cognitive processing skills.

Furthermore, students have weaknesses in other thinking skills, such as analysis, comprehension and evaluation, which should be developed with these important age groups (primary education). This weaknesses in other thinking skills has lowered the academic achievement of students in the primary stages and, therefore, may have negatively impacted on the subsequent stages (Alqurashi, 2011; Al-Sadawi, 2011). Moreover, in 2015 the results of eighth grade students in Saudi Arabia on the Trends in International Mathematics and Science Study (TIMSS) confirmed this weakness in terms of achievements in science and mathematics, as Saudi Arabia ranked 35 out of 39 countries.

Thirdly, another aspect that may explain students' lack of basic knowledge in physics relates to the transfer of students from different educational contexts, for example from school to university, which could affect their identity as learners of physics. Participating students discussed their experiences at school, saying that they were accustomed to memorising without a challenge to their thinking and that they were accustomed to having physics units and topics removed from the syllabus. Therefore, students anticipated finding themselves novice learners in physics when they moved to the university context, because they were required to reshape their learning identity to gain the ability to make changes in their practices while learning physics and to become active learners using reasoning skills while dealing with physics problems. This idea is supported by Wingate's (2007) argument that an understanding of the role of the learner and the implications of this in higher education is required of students. Students must aspire to learn independently and be responsible for their learning. Furthermore, instead of being passive recipients of knowledge, as is common in secondary schooling, learners must seek to engage in an active and critical manner.

Perhaps the traditional teaching approach used in schools is one of the causes of students' lack of basic mathematical knowledge, as suggested by studies conducted in Saudi Arabia (e.g. Almalki, 2012; Alzahrani, 2017) that found that the traditional methods used in the teaching of mathematics play a vital role in hindering students' learning. Moreover, the mathematics results of Saudi students on the TIMSS in 2015 in grades four and eight confirmed this weakness in mathematical achievement, as Saudi Arabia ranked 39 out of 39 participating countries for the eighth grade and 46 out of 49 countries for the fourth-grade. Thus, the weakness of students in mathematics at all school stages is reflected in their weak understanding of physics problems at university, as physics problems in general and mechanics problems in particular rely on mathematical knowledge and skills such as calculus, trigonometry and the use of a scientific calculator.

I believe there are many reasons behind the lack of basic physics conceptual understanding in this study. Firstly, students come to class with previous ideas and experiences based on what they have learned in their schools and their daily lives or perceived about natural phenomena. In the Saudi context, Alhammad's (2015) study argued that "the local Saudi society and culture affected students' understanding of scientific concepts which contradict with the scientific perspective" (121).

Secondly, teachers might introduce physics concepts or ideas without giving their students enough time to ponder or ask what these concepts or ideas mean. Meanwhile, students may give wrong answers without being corrected by teachers and, therefore, this might create confusion or misconceptions among students about their learning. This does not constitute good practice in terms of scaffolding, in addition to the fact that it may not confirm their understanding of physics problems or build their knowledge of physics. It has been argued by Bigozzi, et al. (2014) that physics should be taught in a slow, gradual manner in a way that is adapted to the developmental characteristics of the learners. While they do not call for reducing the content covered, they argue for focusing less on definitions and formulae and paying more attention to developing students' conceptual understanding (ibid). Here, the teachers could employ collaborative learning by synchronous and asynchronous technologies. This in turn would give students an opportunity to discuss with peers and understand the problem well.

Thirdly, findings from the observations and discussions with students revealed that most teachers used traditional practices such as a lecturing approach in delivering information to the students. These traditional teaching methods, widely used today in schools and universities in the Saudi context, as reported in literature (e.g Alkhowaiter, 2016), play a role in encouraging students to memorise information and concepts without a deep understanding of what these concepts mean. According to Alhammad (2015), science education in Saudi Arabia still used traditional teaching methods, and students mainly relied on textbooks and teachers, whereas science education in western countries had moved to using constructivist approaches which give students the opportunity to use their experience and knowledge in understanding scientific concepts. Instead, the teacher should use different teaching methods such as cooperative learning (as suggested by two students from both years) when working on physics problems to encourage students to share their ideas with each other because this kind of learning might make the most of students' Zone of Proximal Development (ZPD).

According to Harskamp and Ding (2006), collaborative learning, in comparison with individual learning, significantly enhances problem-solving skills in physics, whereby the participants in their study (99 secondary school students from Shanghai) were administered a pre-test and a post-test and were asked to solve six physics-related problems. The results showed that students who learnt to solve physics problems in collaboration with others reached higher scores than those who learned these skills individually. However, a certain knowledge of physics concepts is necessary for students in order to approach problems adequately in a group discussion, but such discussions present productive opportunities and aid students' learning and comprehension of physics principles and concepts (Benckert & Pettersson, 2008).

According to sociocultural theory, the use of a diversity of teaching methods such as cooperative learning or brainstorming, would help students to achieve improvement in their Zone of Proximal Development. This could happen through the use of various teaching methods, including discussion and teacher support for students, and encouraging students during the explanation of physics problems, particularly mechanics problems. Clapper (2015) notes that the instructor in the ZPD can help students to solve problems through the use of case studies, discussions or demonstrations. Also, the teacher, through discussions and interactions (between the teacher and students and between students themselves), can explain to the students the steps of problem-solving using charts and physical symbols and by linking physics problems to students' daily life. This would constitute good practice in terms of scaffolding. This is supported by Andersen and Nielsen's (2013) claim that teachers can promote students' motivation in several ways, such as teaching through the use of real-life examples to demonstrate scientific concepts, challenging students' thinking through dialogue involving questions and comments to responses, making assessments which motivate risk taking and support reflection on mistakes, and assisting students through modelling and scaffolding.

Moreover, when students work together to solve problems through exchanging ideas and viewpoints, this will help their comprehension of the problem (Alrababah, 2017). This is supported by Vygotsky's theory which shows that social interaction plays an important role in the learning process. By not offering the opportunity for students to ask questions or discuss solutions to physics problems, the teacher impedes social interaction. In the absence of interaction between teachers and students or between students themselves, students might not get the opportunity to fully develop their cognitive abilities (Wallace et al., 2012). In this regard, Eun (2019) emphasised that the forms of dialogic interactions used by individuals involved in collaborative activities, affect the individual's mental processes.

According to sociocultural theory, through this process of interaction and transformation between people and context, individuals change their responses to establish different kinds of meaning (Stevenson, 2004). Al-Nassar (2011) claims that students derive meaning not only through personal experience but also through social interaction. According to Cole et al. (1978), Vygotsky notes that the functional cultural development of a child can be influenced both socially and individually. This means that this development first takes place at the social level, the "inter-psychological", and progresses within the child to the individual level, "the intra-psychological". Thus, physics lectures are the context for social interaction and, if a teacher gives students the opportunity to participate while explaining the physics problems by helping them to reach a solution or allowing students to discuss among themselves, this would positively impact on their cognitive abilities and their performance in problem-solving.

Eun (2019) mentioned that when students interact in a joint activity, this leads to psychological development because the less competent students internalise the interactional patterns; the more competent students, in turn, develop as well. Based on Vygotsky's sociocultural theory, knowledge received from a more able or knowledgeable peer provides support to lower ability students through correcting misunderstandings, filling potential gaps in knowledge, reinforcing the links between new and prior knowledge and enhancing students' problem-solving knowledge and skills (Fawcett & Garton, 2005).

9. Conclusion

Several findings were drawn from the data of this study, as follows: the data analysis of the think-aloud protocols with students revealed that students from neither year seemed to use the steps of problem-solving to help them understand the problem; rather, they focused on finding the data given. They often found difficulty in understanding the problem which was given to them during the think-aloud protocols. In addition, during think-aloud protocols, the students did not pay enough attention to understanding the physics problems as they immediately jumped to thinking about the physics laws and the substitution rather than understanding the problem. This suggests that they should be trained and guided in order to understand physics problems. Also, the findings of the think-aloud protocols confirmed that there was no clear indication that students were carrying out a plan to reach the solution to the problem.

Finally, the current study can contribute to improving teaching and learning in the field of physics education by informing physics teachers about the perspectives of students in relation to learning and teaching physics and the factors that encourage or hinder students to use problem-solving skills in physics.

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