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Development of Relationship Model Between the Understanding of the Nature of Physics and Students' Preference of Physics in Oman

Dr. Ghanim Dhiyab Ya'qoub Al Saadi

Ministry of Education (Sultanate of Oman)

ABSTRACT
The purpose of this study was to develop the relationship model between understanding the nature of physics (NOP), and students' preference of physics (SPP) in the Sultanate of Oman. The study also aimed to determine if Achievement motivation (Am) mediates the relationship between Independent Variables (understanding of the nature of physics (NOP), and students' preference of physics (SPP). A total of 523 teachers from both genders have been selected as a sample for this study using a random stratified technique from all governorates of the Sultanate of Oman. The study instrument was adapted from literature reviews related to this study. A single questionnaire was used to collect data consisting of the study variables (NOP, SPP, and Am). The gathered data was analyzed by using Structural Equation Modeling (SEM). The findings revealed that significant relationships existed between the NOP, and SPP. Meanwhile, the gender and specialization of respondents were found to have a significant moderating effect on the relationship between NOP and SPP. In contrast, the teaching experience was found not to have a significant moderating effect on the relationship between NOP and SPP. The relationship between NOP and SPP was successfully modeled and represented as The Relationship Model of Nature of Physics, and Students' Preference of Physics in Physics Education. The Model provides significant and valuable contributions to theoretical, methodological, educational practice, and knowledge in the field of physics education research in the Sultanate of Oman. The implications of this study suggest that the model can be used to determine the quality of understanding the nature of physics based on the teachers' achievement motivation in the students' preference of physics.

Keywords: Nature of Physics (NOP), Preference of physics (SPP), and Achievement motivation (Am).

1. Introduction

In recent years, the world has witnessed a wide revolution in the evolution of physical science through its theories and applications to meet the requirements of human life and the human's need to describe, interpret and control natural phenomena and to invest those processes in achieving his needs, meeting the challenges, and making progress in different sectors.

Education is essential to all people and societies, and it defined as the process by which the aspects of the human personality are developed in all its aspects, whether cognitive, emotional, or psychological. When crises emerge in a society, many calls and movements call for the need for reform and renewal for community institutions and activities to move in new directions in response to those crises. The educational system in the world has recognized the importance of the role of the teacher in the educational process. They are keen to provide all the necessary resources for preparing him, including educational and professional qualifications, as well as pre-service and in-service training, regardless of the state of the schools. Although all these elements are essential, they remain of limited utility if there is a lack of efficient teachers. Therefore, it is necessary to pay attention to the conditions of the teacher and his training and qualifications (Hussein, 2014). The teacher is the first to be taken care of in such circumstances, where preparing the teacher academically is one of the most critical demands for the profession. Scientifically, Caring for the teacher is one thing that is a must in all stages of education and scientific disciplines (Physics, Chemistry, Biology and Earth Science) because the teacher is the central pillar and factor in the educational process on which success is dependent (Gharaiba, 2006).

Educationally, the process of teaching science is generally based on a broad base of knowledge, combining knowledge with science and knowledge of educational principles (Van Dijka & Kattmann, 2007; Puteh at el., 2015). Carter defines the teacher's knowledge as the overall knowledge of the teacher at a specific moment, the underlying behaviour, and the teacher's knowledge of the nature of his work, and it lies in everything related to his educational activities, inside and outside the classroom (Verloop, Van Driel, & Meijer, 2002; Van Driel et al., 1998).

The effectiveness of education lies not in the teacher's personal knowledge, but in how this knowledge is used in class. This was demonstrated in a comparative study of the teachers of the United States and China conducted by Ma (1999) on teachers' understanding of the fundamentals of mathematics in China and the United States in order to investigate the causes of decline US students while Chinese students have passed the Trends in International Mathematics and Science Study (TIMSS) exam for several years. The results of the study indicate that the reason for this decline is related to the understanding of teachers, noting that the understanding of teachers in the United States was superficial compared to the Chinese teachers were more understanding of the mathematics and teaching methods. This is despite the knowledge of teachers in the United States was higher than the knowledge possessed by Chinese teachers. It also showed that each teacher, whether a beginner or experienced, has a degree of this knowledge and affects the amount and type of knowledge the teacher possesses in everything he teaches, how he teaches him, and how effectively he communicates with his students (Mohlouoa et al., 2012). Several educational studies have agreed, including (Ambosaidi, Al-Hajri, 2013 & Verloop et al., 2002), that knowledge of the pedagogical content of the teacher influences student achievement and increases their motivation to learn the material. Generally, many countries, such as the European Union, China, Japan, Malaysia and Thailand, have adopted a new concept in their educational system: "lifelong learning for the teacher". So, in order to make the teachers professional and knowledge-based they must engage in continuously developing professional practice (Siyam, 2014; Al-Khubati, 2003). In view of Omani economy 2020 vision, the Sultanate has been keen on developing advanced Omani human resources with capabilities and skills in line with technological development and management of change in all fields, especially the field of education (Ambosaidi & Al-Shuaili, 2010). It may be noted that confirmed by the ' vision of Oman 2040 ' in continuing to focus on the educational system as a whole, starting with the teacher and paying particular attention of the teaching of science (Future Foresight Forum, 2017). Moreover, Ministry of Education in Oman has focused on scientific subjects, developing them and keeping them in line with the modern orientations in science education.

To sum up, the science curriculum in the Sultanate of Oman is based on modern scientific methods such as exploration and investigation and focused on the students (Ministry of Education, 2013). It also sought to take care of the teacher from the early stages of preparation in the institutions of higher education before service, and follow-up training during the service, through the development of training programs well-considered and effective, working to guide the teacher, and guidance to methods and appropriate methods of teaching, and how to deal with the learner and the curriculum. These programs include academic and professional knowledge related to aspects of psychology, assessment, classroom management, curricula, teaching methods, and the use of modern technology in teaching (Ambusaidi and Al-Shuaili, 2009).

In the same topic of the nature of physics, the American Association of Physics Teachers (AAPT, 2002), published the basic lines of physics programs in the secondary stage based on the standards of science teaching, pointing out that the physics teacher must possess a strong physics knowledge in the topics of physics. In 2015, the PRAXIS group published standardized tests of the physics skills, concepts, and knowledge that a physics teacher needs to teach physics. The most important topics are mechanics, electricity and magnetism and their applications, light and sound waves, thermal energy and thermodynamics, modern physics, knowledge of scientific inquiry and methods of research (Educational Testing Services ETS, 2015).

In order to have excellent students in physics, teachers must know about the nature of physics. Physics education is a basic science that contains many abstract concepts, which are difficult for students to fully understand as these concepts mean. Physics is based on the study of behaviour and relations between a wide range of physics concepts and phenomena. By learning physics, students acquire these concepts and attitudes toward physics (Bates, & Galloway, 2012; Bajpai, 2012). Many educators pointed out that one of the most important reasons for students' reluctance to study physics, have no interest and to avoid studying it is the lack of using modern and varied teaching methods (Keller; Neumann, & Fischer, 2017). Generally, teaching of physics is no less than being filled with students' theoretical knowledge through memorization. For that, most of teachers and curriculum developers have sought to find new ways to help students understand difficult concepts (Almazidi, 2017; Abdul Hamid, 2015; Cohen, 2013; Abasa, 2012). Basically, with given the reality of physics teaching and the disparity between science teachers in general and physics teachers in particular, it is not necessary for a teacher to has a great deal of intelligence or excellence to be successful in teaching and his ability to communicate information to students and communicate effectively with them in academic intelligence and excellence (Reif, 1995). In contrast, they enjoy the admiration of their students and their satisfaction and passion for their participation and good behaviour in critical situations and social relations with their colleagues and students alike. This discrepancy can be attributed to the understanding of the nature of physics and mastery of scientific subject, and diversity in teaching methods (Mohammed, 2013; Mistades, 2008).

As confirmed by some educational research that, when physics is made inaccessible to school students, almost always through information overload, they tend to resort to memorization to pass examinations and this, in itself, seems to generate negative attitudes towards physics" (Mbajiorgu, & Reid, 2006). Therefore, the researcher believes through his observation of his supervisory visits to physics teachers as a senior teacher of physics, these preferences and attitudes may be well-formed in the early stages of secondary education because of a weakness in the level of the concept of the nature of the science of physics among physics teachers**.** Thus, the researcher sees the importance of further studies and research that will raise the level of understanding of the physics teachers of the nature of physics.

According to some studies, this study agrees with Ali, & Mumni (2010); Etkina (2010); Ornek, Robinson & Haugan, (2008); Abd-El-Khalick, & Lederman (2000), that the educational systems that bear the responsibility of preparing the emerging need to be continuously reviewed, in order to improve their internal competencies by choosing the best inputs consistent with the educational reality. This is to allow the outcomes of the systems to meet the level of ambition of the society. The movement based on competencies is relatively valid for all stages and subjects, an active movement that makes teachers more positive and effective in influencing their students, which is due to their large and important role within the school. In addition, the researcher also believes that the teacher and the nature of science and teaching strategies and methods of implementation of an important impact on the learning of students and the development of their preferences and their attitudes towards the subjects and their motivation towards learning. To confirm that specialists in educational psychology believe that the motivation of students to learn influences teachers, both in terms of the relationship between them and the learner, or in terms of their role in promoting students' attitudes and preferences to learning, the immediate intervention of the teacher in classroom situations has to do with the motivation of achievement (Orpen, 1994). The weakness of the teacher's skill in presenting the scientific subject is often a source of reduced motivation for students towards learning (Al-Dho, 2010 Groham, & Millette, 1997). Gorham and Christophel (1992) conducted a study on a sample of 308 students. The study found that 20% of them attributed the motivation to learning to teacher behaviour and 19% to the design of the lesson and the situation in which it is presented. In the same study, when analyzing the responses of the sample regarding the factors that reduce the motivation of students and their preferences towards learning, it was found that 37% of the respondents attribute motivation to the teaching method, 34% to teacher behavior and 29% to personal factors. The researcher concludes that students' preferences, attitudes and motivation toward learning can be influenced by the teacher's behavior, experience and interaction with students within the classroom environment.

In addition, other factors that can play a role are the type of educational environment, the need to specialize in a particular field and the diversity of classroom activities. The student's direct feedback, accepting friends and colleagues, and providing information about the progress of the learner, are important factors as well as pointed out by (Gorham and Millette, 1997). Therefore, the researcher is interested in studying the variables of the current study to see their effect on the process of education in general and physics education in particular.

Educationally, understanding the nature and philosophy of science, and understanding the origins of science education are inextricably linked and form part of the basic knowledge base that a science teacher is supposed to possess to teach science well. Thus, the present study agrees with some studies in this area, such as Al-Omri Study (2006), that science education requires a science teacher to have an appropriate understanding of the nature and philosophy of science and to recognize his or her role and that of his or her students in the study of science. Educators emphasize the need for the science teacher training programme to encompass three key areas. The first is scientific preparation, which includes scientific materials to be studied by a science teacher and fall within his scientific specialization, which he will be taught; the second is professional preparation, which includes courses on science teaching methods; and the third is general cultural preparation.

2. The current study and hypotheses

This study also gives an essential and valuable contribution to knowledge in the field of education in general and teaching physics in particular. Firstly, this study deals with an important field in science education from the point of view of constructivism philosophy in the field of the nature of science. The nature of science is one of the most critical contemporary issues that emerged with scientific development and the fourth industrial revolution. Secondly, understanding the nature of physics has become a fundamental goal sought by all members of society and its institutions. Historically, a society can only keep up with technological, industrial, medical, and agricultural developments with its members having a clear understanding of science and its methods. Therefore, this study's importance is in understanding the nature of physics, and students' preference of physics.

3. Theoretical Framework and Conceptual Framework

Based on one of the essential aims of physics teaching is to provide the learner's knowledge and scientific culture and link him to the world in which he lives and to the realities of its environment, and his daily life and interests for feel the value of what he learns that leads to increases his motivation and its tendencies, scientific trends and preferences grow. In this context, the Federal Commission responsible for the Development of Science Education in the United States of America has considered that one of the most important aims of teaching science is the preparation of a scientifically educated citizen (Ghassan, 2020). On the other hand, the current study emphasizes that the aims of education must include changing the learner's cognitive path through knowledge and information provided to him, which is known as an individual's cognitive preference and which usually guides the learner towards accepting or rejecting the content of a subject.

Majeed (2001) emphasized that a learner's preference has an important impact on the study of different subjects, which leads to the development of his knowledge environment. Also, Majeed's (2001) study considered that preference is an indicator of the teaching method and educational attitude created by the teacher in the classroom that helped to organize the appropriate educational process. Therefore, the current study indicates that the study of preferences and attention to them has become an urgent need to help the learner accept the study of different subjects of study. The present study confirms that this depends on the teacher's understanding of the nature of his subject and his pedagogical content knowledge of the subject, as well as the knowledge of the strategies and teaching methods appropriate for each educational situation and the teacher's knowledge of the psychological characteristics of learners, in turn, helps to promote and encourage learners to prefer to study the content of the subject. Majeed study (2001) also referred to a teacher's motivation, which also helps to promote the preference of learners towards studying the subject.

According to studies based on constructional theory, this study found that constructivism influences science and mathematics teaching. It has significantly impacted the development of science curricula, teaching methods, and programs to prepare teachers. Although construction began as a learning method, it expanded and became a theory in education and scientific knowledge, as confirmed by the study (Matthews, 2000). According to the literature review, the principal founder of the constructivist theory is Jean Piaget, who considered that knowledge is Based on building or reconstructing the subject of knowledge. In short, the constructivist theory is based on the individual building his knowledge through his interaction and his adaptation to the environment right up to the occurrence of cognitive balance. According to Jean Piaget's theory, the balance occurs when the individual acquires a specific experience and adapts it to his previous cognitive structure, which leads to imbalance changes. Then the subsequent balance develops intellectual structures merge with previous intellectual constructs, resulting in the construction of new, more sophisticated knowledge (Al-Atwi, 2007). In educational terms, the structural theory is an educational philosophy concerned with the active role of the learner in building his knowledge through his previous experiences and social negotiation with his colleagues in the presence of a teacher helping the learner to build his knowledge through activities and experiences and experiences directly and indirectly. The International Dictionary of Education defines that as "a vision in the theory of learning and child development based on the child being active in building his thinking patterns as a result of interacting his innate abilities with experience" (Zayton, 2013, p. 17). It was also defined as "an educational theory that focuses on the direct impact of knowledge-building experiences, where it is assumed that learners build their mental models by interacting with their environments (Weeks, 2013). Learning in the constructivist perspective means the adaptations occurring in the functional cognitive systems of the individual, which occur to offset the contradictions resulting from his interaction with the empirical world data (Almazidi, 2017).

All in all, this study will depend on the constructivist theory, which focuses on the idea that knowledge is constructed to meet the needs of the person and is based on Piaget's theories of cognitive development (Bodner, Klobuchar, & Geelan, 2001). The theory assumes that the conscious person builds his knowledge based on his own experience and does not receive it negatively from others as if he is already transmitting information ready for use (Phillips, 1995), where the person builds his knowledge by reason and experience. All in all, this means that knowledge is related to the learner's experience, practice, and activity in dealing with the components of the world around him, including sense, perception, attention, remembering, judgment, reasoning, and others (Alsaadi, 2015).

In this study, the researcher used the survey method for collecting the data, which can be described as a structured way to collect information from the respondents' science teachers in the 10th grade. In addition, the study instrument was adopted through a literature review related to this study and its variables, which was, in final a single instrument that included the understanding of the nature of physics, pedagogical content knowledge, students' preference of physics from the point of view of teachers, and achievement motivation for teachers. The researcher chose this methodology to conduct this study because it has several advantages, such as it focuses on studying the phenomenon as it is, in fact, without the researcher's intervention in controlling their variables. Also, it helps to search for the reasons, facts, and relationships related to the problem of study in broader and more profound. Moreover, this methodology has been adopted in most of the previous studies similar to this study (Lucenario et al., 2016; Alhosenih, 2016; Al Janabi, 2016; Van, Verloop, & De Vos; 1998).

4. Study Questions and Corresponding Hypotheses

This study is designed to seek answers of the outlined research questions. To achieve the previously mentioned objectives, the study needs to address the following research questions and test their corresponding hypotheses, as tabulated in Table 1.

Table 1: The summary of research questions and the main hypotheses

Research Question 1: Is there a significant relationship between the understanding of the nature of physics and the students' preference of physics?
Main Hypothesis 1: causal effect
H1: The understanding of the nature of physics has a significant effect on the students' preference of physics.
Research Question 2: Does achievement motivation mediate the relationship between the understanding of the nature of physics and students' preference of physics?
Main Hypothesis 2: mediates effect
H2: Achievement motivation mediates the relationship between the understanding of the nature of physics and students' preference of physics.

Research Question 3: Does gender, specialization and teaching experience moderate the relationship between the understanding of nature of physics and students' preference of physics?
Main Hypothesis 3: moderation effect
H3 : Gender moderates the relationship between the understanding of nature of physics and students' preference of physics. H4 : Specialization moderates the relationship between the understanding of nature of physics and students' preference of physics. H5: Teaching experience moderates the relationship between the understanding of the nature of physics and students' preference of physics.

Figure1: The main hypothesis among constructs in this study

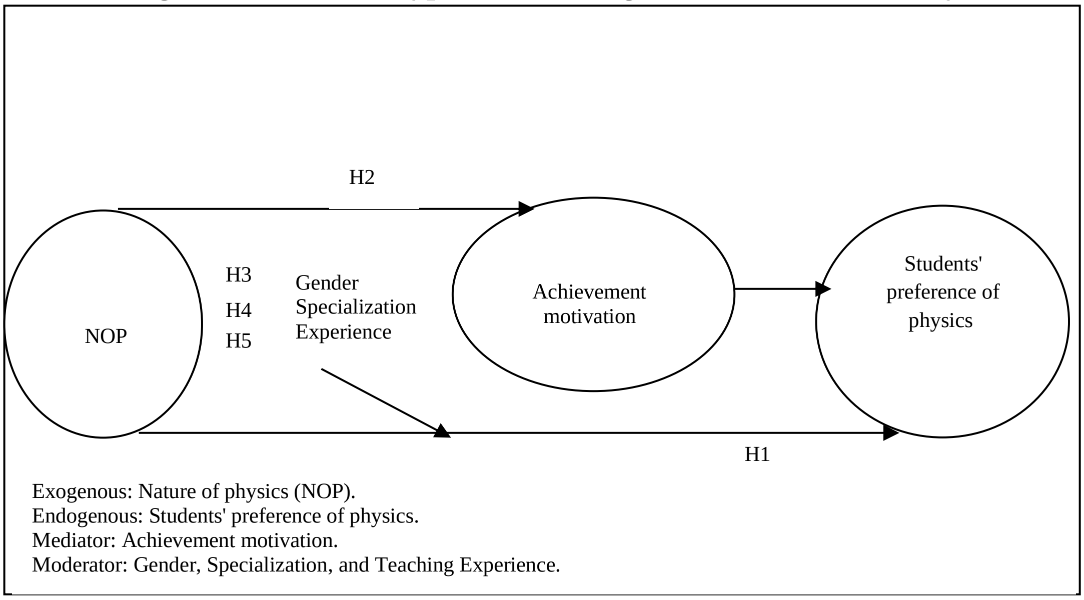


Fig. 1. The hypothesis model given the reality of teaching science in general and physics in particular, there is a discrepancy between science teachers in general and physics teachers in particular in their knowledge of PCK, as there are several studies, models, and experiments dealing with NOP and some variables such as years of experience, gender, and specialization where: The results of the Alswelmyeen & Al Olimmat study (2013) indicated that the level of understanding of the nature of science among physics teachers was average, as well as the existence of function differences attributable to gender variables. The model Awadah and Al-Saadni (2007) determines the relationship between the teacher's knowledge of the nature of science and his relationship to his teaching practices. The model found a strong correlation between understanding the nature of science and the teaching practices of the science teacher within the classroom. In addition, the study of (Yao Liu, & Lederman, 2007) aimed to determine the relationship between knowledge of the nature of science and teaching. Its findings showed a link between teachers' beliefs and concepts of the nature of science and recommended that subjects of the nature of science should be included in the curriculum.

Also, Al-Shuaili study (2008) aimed at determining the level of understanding of the nature of science by chemistry teachers in the light of gender variables and teaching experience, and the results of the study found that the level of teachers' understanding of the nature of science was (41%), there were no function differences attributable to gender variability and teaching experience. The study of Buabeng, Conner, & Winter (2015) confirmed that teachers' beliefs influence their teaching. The experience of Hashweh (1987)

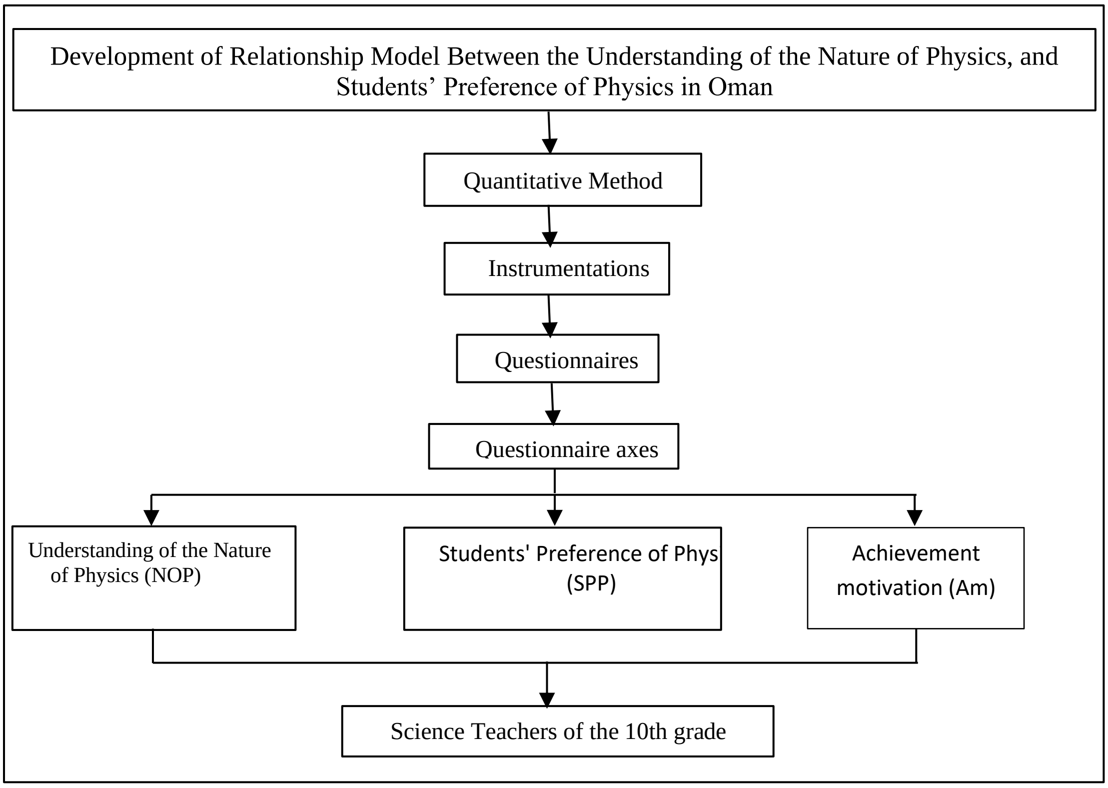
showed that teachers who teach subjects different from their main specialization are more likely to present the subjects with misconceptions to students than teachers who teach the subjects in their main specialization.
In addition to the above, the study by Asherfaat & Qataysh (2017) indicated that there are statistically significant differences in the motivation of achievement but indicated that there are no statistically significant differences in the level of motivation of achievement for teachers attributable to gender. By examining the implications of teacher motivation and innovation indicators towards professional growth and achievement, the findings of the Maya Angelou study (2013) reached several results: achievement and acceptance are essential internal catalytic factors leading to career and professional development. The study also showed that teachers with achievements are affected most by encouragement and motivation, that teachers have a self-desire to pursue permanent professional growth, and that there are no statistically significant differences in the motivation of achievement between experienced teachers and non-experienced teachers. Korur & Eryilmaz (2018) experiment aimed at detecting the impact of physics teacher characteristics on students' motivations in terms of achievement in attainment and readiness to study physics, and the results of this experiment showed that teachers' characteristics such as enthusiasm and giving examples of everyday life increased the motivation of students, by increasing their interest and willingness to participate in the discussion within the classroom, It also showed students' tendency to generally oppose teacher behaviors or characteristics when teachers showed inappropriate behavior.

5. Study Design

The research design describes the required process to obtain information to construct or solve a research problem (Malik, 2018; Siyam, 2014). This study followed a quantitative approach, which can be defined as a form of scientific analysis and interpretation to describe a particular problem or phenomenon so that it can be expressed in quantitative terms by collecting information and data on the studied phenomenon and then collating, analyzing and closely studying it (Abu Rizaq, 2011). This curriculum is commensurate with the current study, as it describes teachers' understanding of the nature of physics and their pedagogical content knowledge, and the study tries to link study variables with the motivation of achievement for the teacher and their view of students' preference of physics, which helps in developing a model linking current study variables.
Educationally, Abu Rizaq (2011) and Creswell (2003) claimed that educational research must be systematic, organized, data-based, precise, objective, and carried out to find solutions to problems. This research seeks and provides the information needed to guide decision-making and effectively deal with the problem. This present study mainly focuses on the quantitative method to achieve the study objectives. Quantitative approaches, which use statistical techniques, are frequently used to test or verify theories or explanations, identify study variables, and relate variables in questions or hypotheses (Malik, 2018: Creswell, 2003). According to claims of Lakshman, Sinha, Biswas, Chales, & Arora (2000), a quantitative research design is used because it helps the researcher thoroughly examine the enormous sample of respondents' opinions about the suggested phenomenon.
In addition, quantitative research is also capable of a more comprehensive representation of the study population with a considerably huge sample size compared with qualitative studies (Bryman, & Bell, 2007; Lakshman et al., 2000). This method is appropriate to the current study, as it helps to explain and accurately describe the teacher's understanding of the nature of physics and to express it quantitatively. In addition, this approach is considered suitable for this study because it enabled the researcher to collect the

quantitative information required for the study. Moreover, this method also helps to describe and analyze the relationship between NOP and their view of students' preference of physics (SPP) in the Sultanate of Oman and its relationship to their achievement motivation (Am), which helped to build a model that combines these variables in one educational model. The researcher selected this method after reviewing the theoretical framework of the previous studies relevant to the study topic, such as Malik's (2018), Frank, Kessler, Mitterer, Sammer, 2012; and Lakshman et al., 2000).

Fig. 2: Design of the study



6. The Research Model

In scientific terms, Ibrahim (2018) and Lawrence (2014) noted that systematic planning for any research must be based on systematic and specific planning toward the conceptual composition of the relationship between variables so that the research can be described according to the scientific data based on them. Therefore, developing clear and systematic procedures is essential before any research is initiated, which the researcher relied on in the present study. The previous chapter assisted the researcher in many matters related to the current study, where the researcher benefited from a literature review and previous studies addressing the concepts of the current study and its variables in enabling the researcher to build the structure of the study, supporting questions, and building study instruments.

To discuss the theoretical development of the study model and hypotheses for the inter-relationship among constructs leading to the development of the relationship model between the understanding of the nature of physics, students' preference for physics in the Sultanate of Oman, and the relationships of constructs with study variables. Educationally, the literature and theoretical framework followed the steps by which the study's model and variables were developed.

7. Participants and procedures

This study relied on the scientific method of determining the sample size of the study's original population and its number (2013) teachers of both genders, with a level of accuracy of at least (0.05) and a degree of confidence score of (95%), according to the table of determining the sample size for Krejcie & Morgan, 1970***(c 3),*** the sample size becomes (322) teachers of both genders was selected in a random stratified technique from all governorates of the sultanate of Oman, which is (11) governorates, using the statistical equation below of Krejcie and Morgan. This manner allows for the current study of probability sampling, a process that assures every individual in the population has an equal probability of being selected as a sample with a non-zero probability of being selected from the population.

$$N = \frac{P}{n} \times m$$

The above equation was used to determine the sample size required from each governorate, as (N) sample size was determined from each governorate, (p) the number of teachers in each governorate, (n) size of the study population, and (m) sample size according to Morgan table. Table 2 shows the sample size required from each governorate according to the above equation. It also shows the study sample distribution to all Sultanate governorates following the Krejcie and Morgan equation.

Table 2: The distribution of the study sample to all governorates of the Sultanate of Oman following the Krejcie and Morgan equation.

No	Governorate	Total	Sample	Percentage %
1	Muscat	332	53	16.5
2	Al-Batinah North	349	56	17
3	Al-Batinah South	227	36	11.3
4	Al-Dakhlya	291	47	14.5
5	Al-Sharqiah South	156	25	7.7
6	Al-Sharqiah North	157	25	7.8
7	Al- Buraimi	49	8	2.4
8	Al-Dhahirah	147	23	7.3
9	Dhofar	234	37	12
10	Al-Wusta	41	7	2
11	Musandam	30	5	1.5
	Total	2013	322	100%

The table above shows that some governorates have represented a tiny proportion of the sample size required, which may mean that they may affect the accuracy of the data due to the small number required in those governorates, and given the researcher's desire for objective and accurate data and results; In line with some educational studies such as Al-Dhafri (2021), the researcher relied on an exclusion that the governorates, which received fewer percentages than (5 %) of the sample size, should be excluded. These governorates were Al-Buraimi, Al-Wusta, and Musandam governorates, distributing the study sample to (8) governorates instead of (11) governorates in the sultanate of Oman.

8. Instruments

The study used the survey instrument, the questionnaire, to attain the objectives of this study which were to collect data and answer the questions. The questionnaire consisted of (30) phrases divided into three axes (The questionnaire was used in two versions: the first version was the Arabic version, and the second version was the English version, which was translated from the Arabic version). The questionnaire 's phrases were presented on a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Table 3 provides the main contracts, an example phrase, and the number of phrases grouped in each contract.

Table 3: The constructs, sample phrases, and the number of phrases in each construct.

Construct	No. of items
Objectives and Characteristics of Physics (NOB)	5
Processes of science and its ethics (NPro)	5
Interaction with Physics, Technology, and the Community (NInt)	5
Students Preference of Physics (SPP)	8
Achievement motivation (AM)	7

The first axis is about the nature of physics, including the aims and features of physics, its nature and morals, and the interaction between physics, technology, and society (Mohammed, 2015). It will be expressed by the degree the science teacher will obtain by answering the questionnaire. The researcher benefited from the instruments used in the study Al-Kalbani & Al-Adili (2020); Al-Tamimi & Rawaqa (2018); Al Janabi (2016); Mohammed (2015); Lederman et al. (2013); Celike & Bayrakceken (2006); and Abd-El-Khalick, (2005), where they were developed and adapted to the purposes of this study.

The second axis is about the students' preference in physics, Which will include personal interests, the connection of physics to the real world, solving physics questions, and understanding the subjects of physics Almazidi (2017). It will be expressed by the degree the science teacher will obtain by answering the questionnaire. The researcher benefited from the instruments used in the study Al-Kalbani & Al-Adili (2020); Jawhar (2019); Almazidi (2017), and Ibrahim & Saleh (2011), where they were developed and adapted to the purposes of this study.

The third axis is about achievement motivation (Am), which is represented in one dimension consisting of a set of phrases aimed at knowing the science teacher's achievement motivation level. It is expressed by the degree the science teacher obtained by answering the questionnaire. The researcher benefited from the instruments used in the study Al-Dafry, 2021; Al-Adwan, & Al-Rababaah, 2018; Rudiniyah, 2017; Kaur & Sankhian (2017); Salih et al., 2016, where they were developed and adapted to the purposes of this study.

9. Data analysis

This study analyzed statistical data using Structural Equation Modeling (SEM). Statistically, SEM can simultaneously examine the relationship between a set of constructs represented by several variables while accounting for measurement error. SEM has two methods: (1) covariance-based SEM and (2) Partial least square SEM. In addition, a structural equation model (SEM) was developed, and the maximum likelihood estimation of path analysis was applied to investigate whether it is a significant determinant of the NOP and SPP. In SEM, the Model fit should be examined using multiple fit indices (Collier, 2020; Kabakci, 2018; Arbuckle, 2009; Blunch, 2008).

10. Result

In this study, skewness and kurtosis were used to examine the multivariate normal distribution. The values for asymmetry and kurtosis between -2 and +2 are considered acceptable to prove normal univariate distribution (George & Mallery, 2010). Mean, standard deviation (SD), skewness, and kurtosis are shown in Table 4.

Table 4: The Descriptive Statistics and Test of Normality

Items	Mean	Std. Deviation	Skewness	Kurtosis
NObj1	4.05	1.245	-1.431	0.956
NObj2	3.93	1.167	-1.280	0.840
NObj3	3.92	1.244	-1.307	0.672
NObj4	3.96	1.257	-1.337	0.713
NObj5	3.90	1.230	-1.263	0.611
NPro1	3.98	1.243	-1.299	0.575
NPro2	3.88	1.252	-1.220	0.418
NPro3	3.95	1.262	-1.309	0.579
NPro4	3.94	1.236	-1.343	0.769
NPro5	3.93	1.254	-1.383	0.832
NInt1	3.95	1.174	-1.397	1.130
NInt2	3.98	1.180	-1.301	0.774
NInt3	3.91	1.183	-1.316	0.859
NInt4	3.93	1.180	-1.276	0.750
NInt5	3.97	1.169	-1.413	1.229
SPP2	4.05	1.241	-1.421	0.920
SPP3	4.00	1.207	-1.373	0.928
SPP4	3.94	1.216	-1.268	0.617
SPP5	3.97	1.244	-1.364	0.819

Items	Mean	Std. Deviation	Skewness	Kurtosis
SPP6	3.95	1.205	-1.227	0.582
SPP7	3.86	1.254	-1.162	0.291
SPP8	3.85	1.251	-1.114	0.148
ACM1	3.77	1.357	-1.090	-0.130
ACM2	3.85	1.318	-1.126	0.025
ACM3	3.75	1.375	-1.030	-0.282
ACM4	3.75	1.336	-0.999	-0.277
ACM5	3.73	1.413	-0.900	-0.624
ACM6	3.70	1.382	-0.921	-0.483
ACM7	3.82	1.341	-1.117	-0.052

N=523

According to Table 4, all skewness and kurtosis indices were found in acceptable ranges from -2 to +2, indicating approximate normality. Overall, the results of the above tests indicate that the validity of data for analysis was confirmed for further analysis.

11. CFA analysis

To evaluate the reliability and validity of the observed items, confirmatory factor analysis (CFA) was conducted using AMOS (v.24). This section is divided into two parts. The first part describes the validity and reliability of First-order factors. All first-order factors in the proposed Model are reflective, and as such, their measurement quality was assessed based on their convergent validity, reliability, and discriminant validity. Similarly, the second part will discuss the results of the second-order factors' validity and reliability.

12. SEM analysis

Based on the discussed theoretical framework and research, first, we discussed the results of Structural Equation Modelling (SEM) and Hypotheses Testing, confirmatory factor analysis was carried out to refine the measurement scale. This analysis resulted in a scale consisting of 50 indicators for the measurement model, which shows higher levels of validity and reliability than the scale proposed initially. Hence, it was used to estimate the model (See Fig 3). After obtaining sufficient quality measurement models, we proceed to the assessment of the structural model.

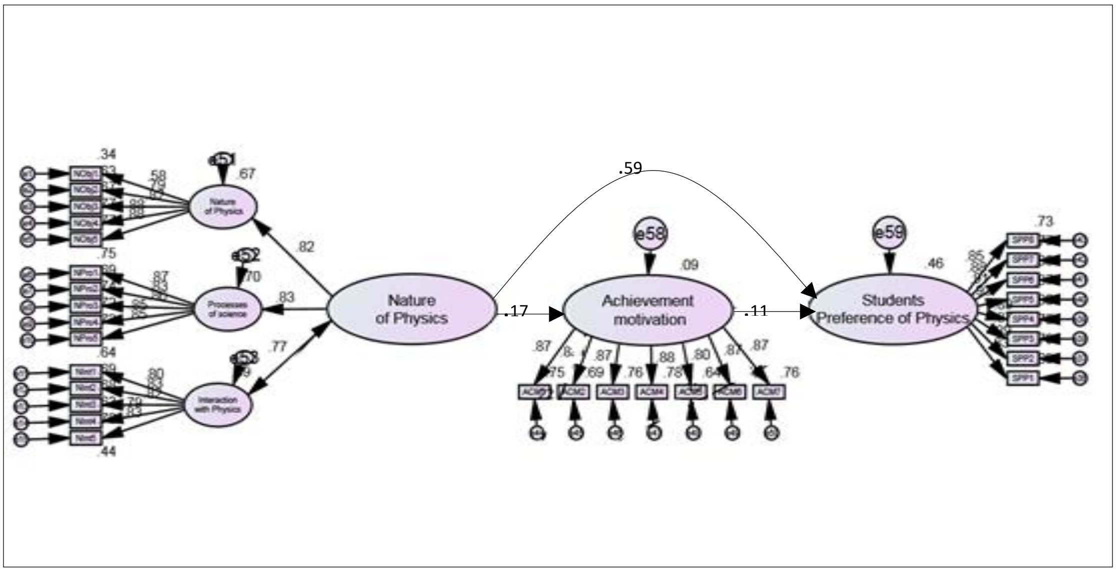


Fig 3. The Structural Model.

After running SEM, goodness-of-fit tests were examined to determine whether the models should be accepted or rejected. The fit indices of the SEM test for the proposed model are presented in Table 5.

Table 5: Overall Fit of Structural Model

Measure	χ2	DF	(χ2/DF)	CFI	SRMR	RMSEA	PClose
Suggested range	--	--	Between 1 and 3	>0.95	<0.08	<0.06	>0.05
Estimate	2056.983	1162	1.770	0.963	0.046	0.038	1.000

The model fit indices (χ2/DF = 1.770, CFI = 0.963; SRMR = 0.046; RMSEA = 0.038; PClose=1.000) indicate that the hypothesized structural Model provided an excellent fit to the data.

The coefficient of determination (*R^2)* is the primary criterion for the structural model assessment, which indicates the amount of explained variance of each endogenous latent variable (Hair, Ringle, & Sarstedt, 2012). According to (Cohen, 1998) R^2 values of 0.02, 0.13, and 0.26 point to weak, moderate, and substantial levels (Cohen, 1998).

Table 6: Results of coefficient of determination (R^2 values)

Constructs	R^2 values
Achievement motivation	0.093
Students' Preference of Physics	0.464

It can be seen from Table 6, that the squared multiple correlation coefficient or R^2 value for Achievement motivation is 0.093. It is estimated that the predictors of AM explain 9.3 % of its variance. In other words, the error variance of Achievement motivation is approximately 90.7 % of the variance of Achievement motivation itself. Based on Cohen's (1988) suggestion, the value of R^2 for achievement motivation is weak. The R^2 for Students' Preference of Physics is 0.464, which suggests that 46.4 % of the variance of Students' Preference of Physics can be described by The Nature of Physics and Achievement motivation. Furthermore, the results of the direct effects are shown in Table 7.

Table 7: Result of direct effect

Paths	β	S.E.	T value	p
NOP à AM[b]	0.169	0.082	3.367	0.001
AM à SPP[c]	0.110	0.035	2.857	0.004

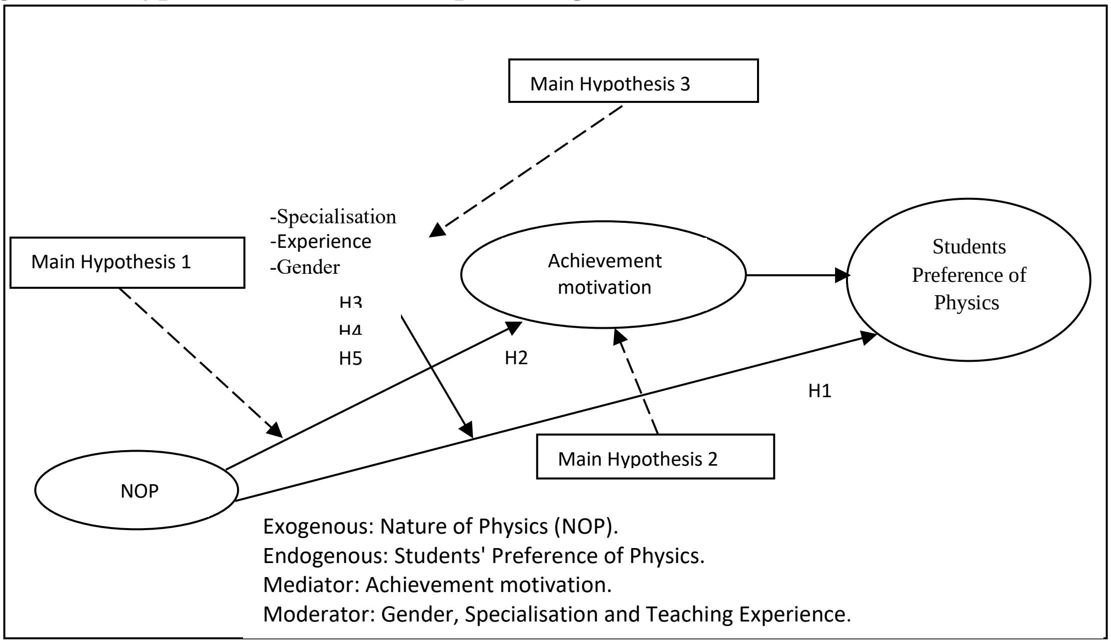
Note, β: Standardized estimate and S.E.: Standard error. Note 2: The Understanding of the Nature of Physics (NOP), Student's Preference of Physics (SPP); Achievement motivation (AM). "a, b, and c" are not hypothesized paths.

The analysis of the proposed structural model revealed that all direct paths are statistically significant.

13. Discussion

As mentioned, this study's theoretical framework consists of three main hypothesis sequences. Firstly, the construct of understanding the nature of physics by physics teachers in basic education schools has been hypothesised to significantly influence students' preference of physics. Secondly, Achievement motivation significantly affects the relationship between the understanding of the nature of physics and students' preference of physics. Thirdly, the study hypothesised that specialisation, teaching experience, and gender significantly moderate the relationship between the understanding of the nature of physics and students' preference of physics. Fig. 4. illustrates the schematic diagram showing the hypothesized relationships among the main constructs in the current study.

Fig. 4: The hypothesised relationships among the main constructs in the current study.



Furthermore, the result of the main hypothesis1 describes the mediating effect of achievement motivation on the relationship between the understanding of the nature of physics by physics teachers and students' preference of physics. This study found that achievement motivation mediates the relationship between the understanding of the nature of physics and students' preference of physics. This study confirmed that the achievement motivation of science teachers is an important mediator variable for students' preference of physics.

More specifically, the study found that the nature of physics by physics teachers gives a significant influence on achievement motivation. On the other hand, the indirect coefficient of pedagogical content knowledge on students' preference of physics through achievement motivation is significant ($\beta = 0.038$, 95% CI: 0.008 to 0.090, $p \leq 0.05$). In addition, the results of the direct effects of the understanding of the nature of physics on students' preference of physics were significant. Therefore, the indirect effects were found to partially mediate the relationship between the nature of physics and students' preference of physics. The result of this study is consistent with Al-Dhafri (2021), Rudiniyah (2017), and Salih et al. (2016). The result of this study is consistent with the study of Salamat et al. (2012). The study by Salamat et al. (2012), involved 108 teachers of both genders from the first level of the basic education school, selected in a simple random manner. The study's results indicated that there was a positive correlation in their level of achievement motivation.

In this study, the results revealed that in physics education, the Achievement motivation of science teachers is affected by their knowledge of their understanding of the nature of physics, which enhances the quality of the learning and teaching process. Thus, the achievement motivation of science teachers has been considered a significant element in the students' preference of physics.

The current study attributes this finding to the fact that the science teacher has an internal desire for continuous self-success achievement in his field of work, possibly due to favourable working environment conditions. In fact, in Oman, the educational institution administratively cooperates with teachers and encourages them to continue to achieve more achievement, as observed in the field. The educational administration in the schools of the Sultanate constantly honours the most distinguished teachers, and this may give the teacher more desire and motivation for further achievement and achievement of the goals. In addition, the theory of the need for achievement has confirmed that the need for achievement stems from the same human being and is reinforced by the conditions of the social environment in which he lives. Additionally, the theory of the need for achievement confirmed that whenever an individual is thriving in a field, he will have an urgent need to achieve more goals and success.

Educationally, this study agrees with the study of Al-Dhafri (2021) and Al-Rudiniyah (2017), which indicated that teachers had a medium level of achievement motivation.

On the other side, the result of main hypothesis 2 hypotheses were developed to test whether gender, specialisation and teaching experience of science teachers moderate the relationship between the exogenous structures of the understanding of the nature of physics and students' preference of physics. Indeed, three hypotheses were developed to examine these relationships H3, H4, and H5). In the present study, hypotheses 3 to 5 represent moderating effects. Gender, specialisation, and teaching experience are categorical variables. Thus, to examine gender, specialisation, and teaching experience differences in the effects of "understanding of the nature of physics" on "students' preference of physics," the analyses employed the multi-group analysis technique, where the effect of a moderating variable is characterised statistically as an interaction (Carolina et al., 2004; Mackinnon & Lockwood, 2010).

As a result, gender (β=0.173, p-value=0.049) does moderate the relationship between the relationship between understanding of the nature of physics and students' preference of physics, where it was the path coefficient (β=0.533) for the male group and (β=0.650) for the female group. The path coefficient was higher for the female group than the male group. This result proves the moderating impact of gender on the relationship between the understanding of the nature of Physics and students' preference of physics. Additionally, the result showed that specialisation moderates the relationship between the understanding of the nature of physics and students' preference of physics. Also, the path coefficients of Biology and

Physics are significant; the comparison shows that for the Physics group, the path coefficient has an enormously positive effect at the 0.01 significance level (β = 0.617). In this study, the result revealed that teaching experience (β = 0.182) does not moderate the relationship between the understanding of The Nature of Physics and students' preference of physics, where the study found the p-value for the chi-square difference between “Less than ten years” and “More than 11 years” is insignificant. The value of the standardised estimate for “Less than ten years” (0.615) is higher than “More than 11 years (0.598), and both are significant. On the other hand, the result of this study agreed with the Rolnik and Mavonga study (2012) that teachers' experience in teaching a particular subject improves their ability to teach the subject effectively, provided they have fundamental knowledge bases covering subject knowledge, learners, general pedagogy and context.

14. Conclusion

This study is a novel exertion to determine the relationships between understanding the nature of physics and student preference of physics in the Sultanate of Oman. The current model was developed based on the previous model studies contained in the educational literature regarding to the current study. In the current study, one construct consisting of six first-order reflective constructs was used as an independent variable. The understanding of the nature of physics and the student's preference for physics were used as dependent variables. Furthermore, achievement motivation was employed as a mediating variable, and gender, specialisation, and teaching experience were used as moderating roles between the understanding of the nature of physics, and student preference of physics. Significant contributions to theoretical, methodological, and educational practice are highlighted in this study's results. Moreover, the present study has also proposed future research direction as a concluding remark.

15. Results of Direct Effects

The results of direct effects are shown in Table 8.

Table 8: Result of direct effect

Paths	β	S.E.	T value	p
NOP à SPP	0.594	0.081	10.908	0.001
NOP à AM[a]	0.169	0.082	3.367	0.001
AM à SPP[b]	0.110	0.035	2.857	0.004

Note, β: Standardized estimate and S.E.: Standard error. Note 2: The Understanding of the Nature of Physics (NOP), Student’s Preference of Physics (SPP); Achievement motivation (AM). “a, and b” are not hypothesized paths.

The analysis of the proposed structural model revealed that all direct paths are statistically significant.

H1: The Nature of Physics has a significant effect on the Students' Preference of Physics.

As revealed in Table 8, the results suggest the significant effect of the Nature of Physics on Students' Preference of Physics. Supporting hypothesis H2 (β = 0.594, C.R. = 10.908, $p \leq 0.001$) implies that The Nature of Physics has a positive influence on Students' Preference of Physics.

16: Results of hypotheses testing (Indirect effects)

In order to examine the mediation relationships, the bootstrapping method with 5000 bootstrap resamples and 95 % bias-corrected confidence estimates was conducted for mediation analyses (Carolina, Hill, Carolina, & Hayes, 2004; Mackinnon & Lockwood, 2010).

Table 9: Results of hypotheses testing (indirect effects)

Path	Indirect Effects	S.E.	95% CI		p	Type
			Lower	Upper		
NOP à AM à SPP	0.028	0.015	0.005	0.069	0.011	Partial Mediation

Note: The Nature of Physics (NOP), Student's Preference of Physics (SPP); Achievement motivation (AM).

H2: Achievement motivation mediates the relationship between the understanding of the Understanding Nature of Physics and Students' Preference of Physics.

The indirect effects of "The Understanding of The Nature of Physics" on "Students' Preference of Physics" via Achievement motivation (B = 0.028, 95% CI: 0.005 to 0.069, $p \leq 0.05$) is significant. The results of the direct effects of "The Understanding of The Nature of Physics" on "Students' Preference of Physics" were significant (see Table 8); therefore, the indirect effects were found to partially mediate the relationship between "The Nature of Physics" on "Students' Preference of Physics."

17. Results of Moderation test for Gender, Specialization, Teaching experience

In the present study, Hypotheses 3 to 5 represent moderating effects. As Gender, Specialization, and Teaching experience are categorical variables, thus, to examine Gender, Specialization, and Teaching experience differences in the effects of "understanding of The Nature of Physics" on "students' preference of physics" multi-group analysis was conducted.

Therefore, the whole sample (N=523) is divided into two distinct groups based on Gender (Male and Female), Specialization (Biology and Physics), and Teaching experience (Less than 10 years and more than 11 years). Next, we simultaneously tested a model across "male and female," "Biology and Physics" and (Less than 10 years and more than 11 years) groups without imposing any equality constraints (Unconstrained Model). Then, the chi-square ($\chi 2$) difference between fully constrained and unconstrained for all five paths of the model is tested. Finally, to examine Hypotheses (3 to 5), two different multi-group models, with different sets of constraints between the Gender, Specialization and Teaching experience groups, were compared with the Unconstrained (baseline model), and $\chi 2$ tests were conducted. Tables 10, 11, and 12 present the series of nested models that were tested.

18. Results of Multi-group Moderation Test for Gender

Table 10: Results of Multi-group Moderation Test for Gender

Comparison between Male and Female		$\chi 2$ (df)	Difference $\chi 2$ (df)	β	
				Male	Female
Model	Unconstrained (baseline model) [a]	3531.858 (2324)	----	----	----
	Constrained (all five paths)[b]	3595.286 (2375)	63.428 (51); n.s	----	----
	Path Name NOP à SPP	3543.857 (2325)	11.999 (1); **	0.533**	0.650**

Note, [a.] Paths for the two groups were allowed to be freely estimated. [b.] The path specified was constrained to be equal across the two groups. The Nature of Physics (NOP), Student's Preference of Physics (SPP).

** $p < 0.010$. *$p < 0.050$.

The chi-square difference between fully constrained and unconstrained for all five paths of the model shows that the p-value is insignificant (0.088). Therefore, groups are not different at the model level.

H3: Gender moderates the relationship between the understanding of The Nature of Physics and students' preference of physics.

The results show that the path coefficient value (β=0.533) for the male group and (β=0.650) for the female group for the relationship between the understanding of The Nature of Physics and students' preference of physics. The path coefficient was higher for the female group than the male group. This result proves the moderating impact of gender on the relationship between the understanding of The Nature of Physics and students' preference of physics (H3).

19: Results of Multi-group Moderation Test for Specialization

Table 11: Results of Multi-group Moderation Test for Specialization

Comparison between Biology and Physics		**χ2 (df)**	**Difference χ2 (df)**	**β**	
				Biology	**Physics**
Model	Unconstrained (baseline model) [a]	3637.864 (2324)	----	----	----
	Constrained (all five paths) [b]	3637.864 (2375)	66.331 (51); n.s	----	----
Path Name	NOP à SPP	3642.431 (2325)	4.567 (1)); *	0.582**	

Note, [a.] Paths for the two groups were allowed to be freely estimated.

[b.] The path specified was constrained to be equal across the two groups.

The Nature of Physics (NoP), Student’s Preference of Physics (SPP). ** $p < 0.010$. *$p < 0.050$.

The chi-square difference between fully constrained and unconstrained for all five paths of the model shows that the p-value is insignificant ($\Delta \chi2$ (df) = 66.331 (51), $p > 0.05$). Therefore, groups are different at the model level.

H4: Specialization moderates the relationship between the understanding of The Nature of Physics and Students' Preference of Physics.

The moderating effect of Specialization in the relationship between the understanding of The Nature of Physics and students' preference of physics is confirmed (The variation of $\chi2= 4.567$, $p \leq 0.05$). Thus, H4 is accepted. The path coefficients of Biology and Physics are significant; the comparison shows that for the Physics group, the path coefficient has an enormously positive effect at the 0.01 significance level ($\beta = 0.617$ and $p \leq 0.01$).

20. Results of Multi-group Moderation test for Teaching experience
Table 12

Table 12: Results of Multi-group Moderation test for Teaching experience

Comparison between Less than 10 years and More than 11 years		$\chi 2$ (df)	Difference $\chi 2$ (df)	β	
				10 years	11 years
Model	Unconstrained (baseline model)[a]	3423.308 (2324)	----	----	----
	Constrained (all five paths)[b]	3469.578 (2375)	46.270 (51); n.s	----	----
Path Name	NoP à SPP	3424.191 (2325)	0.883 (1)); n.s	0.615**	0.598**

Note: [a] Paths for the two groups were allowed to be freely estimated.
[b] The path specified was constrained to be equal across the two groups.
The Nature of Physics (NOP), Student's Preference of Physics (SPP). ** $p < 0.010$. *$p < 0.050$.
According to the result of the multi-group analysis, $\chi 2$ of the unconstrained model is 3423.308, and χ 2 of the equally constrained model for 5 paths is 3469.578, so the difference between the two models is 46.270. The p-value at the 0.05 significance level (DF= 51) is above 0.05, implying that there is no significant difference between the two Teaching experience groups.

H5: Teaching experience moderates the relationship between the understanding of The Nature of Physics and students' preference of physics.

Hypothesis H5 is rejected since the p-value for the chi-square difference between "Less than 10 years" and "More than 11 years" is insignificant ($p > 0.05$). The value of the standardized estimate for "Less than 10 years" (0.615) is higher than "More than 11 years (0.598), and both are significant.

21. Study Summary

In this study, the results obtained from the data analysis revealed that significant relationships existed between the Understanding of the Nature of Physics, and the students' preference of physics. Mediation effects of achievement motivation were found in the relationships between the Nature of Physics. Meanwhile, based on the quantitative result, the gender and specialization of respondents were found to have a significant moderating effect on the relationship between the Nature of Physics and students' preference of physics. In contrast, the teaching experience was found not to have a significant moderating effect on the relationship between the Nature of Physics and students' preference of physics.

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