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Developing a scale of scientific sense for students at a private university.

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Abstract

The study indicates the importance of providing students with the scientific sense and its concomitant development. It aims to develop a scale of scientific sense for students at a Private University. This study is the first to develop a scale of scientific sense for students. The sample included (395) students enrolled during the Summer Semester 2019/2020. The results showed high psychometric properties of the scales of scientific sense. The indicators of conformity within the accepted standard confirm the construction validity of the scale of scientific sense. The scale of scientific sense in its cognitive and emotional aspects greatly contributes to the acquisition of scientific knowledge, life skills and the achievement of educational goals in higher education institutions. The study recommended using the final vision of the scale of scientific sense, and utilizing the scale to verify the scientific sense (Cognitive, Emotional) of the students.

Keywords: development; scale; scientific sense; cognitive; emotional; exploratory factor analysis; confirmatory factor analysis.

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1. Introduction

The development of students' positive attitudes towards knowledge is one of the most important goals of teaching different disciplines. Among these attitudes is that students possess a scientific sense, which enables them to enjoy study, and make them feel their own value. They will be able to build scientific knowledge according to their abilities and knowledge structure, expressing their opinions independently, possessing diverse thinking skills, activating mental practices, and positive mental skills.

There are several definitions of the concept of scientific sense. Al-Zaeem (2013) defines it as the mental activities that the student practices in a cognitive and emotional manner, through which he /she can achieve the required goals.

Habib (2016) defines the scientific sense as "the ability of the students to make a judgment by choosing correct methods and strategies through which he can solve the scientific problems facing them, and is measured by observing the behavior and practices of the student".

Zahir (2016) indicates that the scientific sense is the mental activities with a high level of understanding and perception practiced by the student cognitively via linking previous experiences with the present, the numerical sense, activating the majority of the senses. In addition to, metacognitive, emotionally through curiosity and mental alertness enjoying scientific work, perseverance, and controlling recklessness.

The researchers define the scientific sense of university students as the mental activities that they practice through their awareness and realization of what they have learned and acquired in cognitive and emotional aspects.

It is the responsibility of the teaching staff member at the university to develop the scientific sense of his/her students. Therefore, he/she must prepare and design learning situations full of activities through which students can practice thinking types and skills, implant and develop scientific sense practices, and seek to develop the emotional abilities of his/her students. In addition to the necessity of acquiring the scientific language, the teaching staff member should practice the cognitive and emotional skills while working with his/her students.

There are different aspects of scientific sense, but most studies have focused on two of them: cognitive and emotional. The cognitive aspect of the scientific sense consists of several skills, which are: presenting evidence, activating the senses, attention and focus, time management, scientific reasoning, speaking a scientific language, questioning and posing problems, the ability to inference, the ability to abstract visualization and generate ideas.

Regarding the emotional aspect of the scientific sense, it consists of several skills, including: patience in passing judgments, controlling recklessness, sensing, speed, scientific curiosity, inquisitiveness, flexibility in handling situations, self-regulation, initiative and bearing responsibility, enjoyment of scientific work, perseverance, independence of thinking and self-esteem (Ramadan, 2016; Abu Shama, 2017).

Many studies have indicated the importance of providing students with the scientific sense and developing it, because it's owing to its cognitive and emotional aspects, greatly contributes to the acquisition of scientific knowledge, life skills and the achievement of educational goals in general (Al-Saadi, 2019).

Despite the importance of the scientific sense and its development among university students, it is still below their required level. As many studies have shown, the teaching process is still concerned as it focuses on traditional strategies and indoctrination in teaching, and neglect the modern teaching strategies that develop among students aspects of scientific sense (Alsalamat, 2018; Ford, 2012; Zangori et al., 2013).

Many studies have been conducted in the construction of scientific sense and analysis, such as (Zahir, 2016; Alsalamat, 2018; Alosaimi, 2019; Saleh, 2011; Al-Shahri, 2011).

1.1. Goodness of fit indices

There are many indicators including: Normed Chi-Square, Goodness of fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI), Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Incremental Fit Index (IFI), Root Mean Square Residual (RMR), Root of the Mean Square Error Approximation (RMSEA), Standardized Loading Estimates, and Average Variance Extracted (AVE) (Gadelrab, 2004; Khatab et al., 1990; Eid et al., 2009; Hu et al., 1999; Schumacker et al., 1996).

It can be said that the best models for the quality of reconciling the data of the research sample are those that provide the best values for the largest number of evaluation indicators. In addition, the model should not be judged in the light of a single index without the other (Hair et al., 2010).

1.2. Study Problem and Questions:

Relying on the researcher's experience in the academic work in Jordan, the researchers were convinced that there is a lack of following-up and investigation regarding students' scientific sense. In addition, lack of an appropriate scale at Middle East University in Jordan is valid to verify the scientific sense for students.

Thus, this study seeks to develop a scale of scientific sense at Middle East University in Jordan, which will be a reference for the university to help the university officials in using the developed scale with a high degree of accuracy in measuring the scientific sense for students at the university. Thus, the study attempts to answer the following questions:

1. What are the psychometric characteristics of the scale's scientific sense for students at Middle East University in Jordan?
2. Do the dimensions of the developed scale's scientific sense fit the theoretical construction?

1.3. Importance of the Study:

It is the first study conducted by the researchers to develop a scale of scientific sense for students at the Middle East University in Jordan, which may be a reference for the university and other universities as well as researchers in future studies.

The applied importance of the study is to help the university official in using the developed scale with a high degree of accuracy in measuring the scientific sense of the student at the university.

1.4. The Objectives of the Study:

- Develop a scale of scientific sense for students at Middle East University in Jordan and enable other universities to benefit from it.

- Calculate the psychometric indicators of the new scale on a sample of university students.

- Using the scale in the university environment as one to measure scientific sense of student, in order to be one of the important scales that are used in the Jordanian environment.

2. Methodology

The researcher used the descriptive and analytical approach.

2.1. Research model

The research model included the following variables:

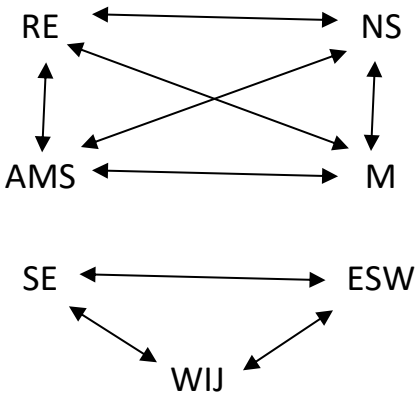

Figure 1: The research model for the scale's of scientific sense (Cognitive Dimensions, Emotion Dimensions).

2.2. Study Population

The size of the study population was (1843) students who were enrolled during the Summer Semester 2019/2020.

2.3. The Participants of the Study Sample

A simple random sample of participants was selected. The study sample comprised (395) participants who were enrolled in different faculties at the Middle East University, approximately (21.4%) of the university students.

2.4. Study Tool

The researchers reviewed the previous studies, scales, and references, which are related to the research.

The researchers benefited from the studies during the preparation of the items of the scale (Alsalamat, 2018; Alosaimi, 2019; Saleh, 2011).

The researchers developed a data collection tool (scale), which included two dimensions, determined in a manner consistent with the theoretical construction of the concept of scientific sense (Cognitive, Emotional) for students, which have appeared in the standards of previous studies.

The researcher wrote a series of items in Arabic, and rephrased some items in proportion according to the objective of the study.

The Likert scale, a five- point scale was used; (Very large, large, Medium, Low, very low).

The study tool consisted of two dimensions: (cognitive, emotional): The cognitive dimension (20 items); Requesting experiences to be used in new situations (RE) (5 items), Numerical sense (NS) (5 items), Activation of the majority of the senses (AMS) (5items), and Metacognitive (M) (5 items).

The emotional dimension (15 items); Scientific Exploration (SE) (5 items), Enjoying scientific work (ESW) (5 items), and waiting in issuing judgments (WIJ) (5 items).

2.5 Procedure

- Developing a scale by referring to the theoretical literature and previous relevant studies.
- Presenting the scale in its initial form to a group of specialists.
- The scale was applied to an exploratory sample. In order to verify the validity and reliability of the study tool before applying it to the participants.

- Analyzing the data and present the results and discuss it.
- Providing recommendations and suggestions.

2.6 Data analysis sub-titles

The statistical program (SPSS) and AMOS V.23 were used to perform the statistical analysis needed to answer the study questions. Since the theoretical scientific sense and its dimensions in this scale was derived from the theoretical literature, previous studies and related scales, the researcher used the method of exploratory factor analysis (EFA) using (SPSS) program, and used the method of Confirmatory Factor Analysis (CFA) using the AMOS-V.23 program.

The purpose of this analysis is to measure the scientific sense of each dimension of the scale in order to verify the validity of its construction and the extent to which the data fit to the theoretical construction of the measured feature, using statistical indicators to ascertain the quality of the conformity.

2.6.1 Validity

To verify the validity of the scale, the researcher presented the preliminary version of the scale to a group of (Ford, 2012). The researcher intended to know their views on the clarity of the items, the relevance of items to the proposed dimension and the possibility of adding or deleting items. The items were approved by (90%) of arbitrators.

Data was collected from (59) students. The psychometric properties of the scale were established. The construct validity of the scale was evaluated. The correlation coefficients ranged (0.44 - 0.62) for the cognitive dimension, and ranged (0.41 - 0.65) for the emotional dimension. All correlation coefficients were statistically significant at ($\alpha = 0.01$).

2.6.2 Reliability

Internal consistency of the scale was tested; Cronbach's alpha was (0.918). The dimension of the scale proved to be internally consistent (Requesting experiences to be used in new situations (0.871), the Numerical sense (0.894), the Activation of the majority of the senses (0.913), the Metacognitive (0.889), the Scientific Exploration (0.896), the Enjoying scientific work (0.908), and the waiting in issuing judgments (0.869), suggesting that the scale has a high level of internal consistency.

Results indicate that the scale met the standards of reliability and validity. Appendix (1) shows the scale in its final form.

2.6.3 Exploratory factor analysis (EFA).

An exploratory factor analysis was performed using the Principal Components Analysis method, using Varimax rotation. Table 1 shows the results:

Table 1. The results of Exploratory factor analysis.

Dimension	Factor	Items	Loading
Cognitive	Requesting experiences to be used in new situations.	1	0.865
		2	0.722
		3	0.825
		4	0.810
		5	0.909
	Eigen value		3.433
	KMO		0.791
	Bartlett's test of Sphericity		828.882
	Sig.		0.00

		1	0.800
	Numerical sense.	2	0.876
		3	0.921
		4	0.883
		5	0.766
	Eigen value		3.620
	KMO		0.878
	Bartlett's test of Sphericity		806.837
	Sig.		0.00
	Activation of the majority of the senses.	1	0.810
		2	0.868
		3	0.899
		4	0.902
		5	0.865
	Eigen value		3.780
	KMO		0.887
	Bartlett's test of Sphericity		880.315
	Sig.		0.00
	Metacognitive.	1	0.805
		2	0.840
		3	0.872
		4	0.909
		5	0.735
	Eigen value		3.478
	KMO		0.875
	Bartlett's test of Sphericity		701.581
	Sig.		0.00
	Scientific Exploration.	1	0.803
		2	0.877
		3	0.923
Emotional		4	0.887
		5	0.771
	Eigen value		3.649
	KMO		0.880
	Bartlett's test of Sphericity		827.791
	Sig.		0.00
	Enjoying scientific work.	1	0.813
		2	0.873
		3	0.901
		4	0.903
		5	0.865
	Eigen value		3.649
	KMO		0.880
	Bartlett's test of Sphericity		827.791
	Sig.		0.00
	Waiting in issuing judgments.	1	0.809
		2	0.858
		3	0.874
		4	0.911
		5	0.771
	Eigen value		3.580
	KMO		0.884
	Bartlett's test of Sphericity		754.090
	Sig.		0.00

It is noticed from the results of Table 1 that all Eigen Values were greater than one. All KMO values were greater than (0.50) (Hair et al., 2010).

All Bartlett's test of sphericity values were statistically significant at the level of statistical significance (α = 0.05).

In addition, all the factor values were loaded with one factor and their values were more than (0.40). The results of the exploratory factor analysis indicate that the study tool has a high degree of construct validity.

3. Results and discussion

To answer the first question: What are the psychometric characteristics of the scale's scientific sense for students at Middle East University in Jordan?

In order to verify the validity of the construction of the scale using the confirmatory factor analysis, the researcher designed the proposed model for the scale in all its dimensions.

Figure 2 shows the scale with its cognitive dimensions and the hypotheses that were assumed in the theoretical construction of the scale:

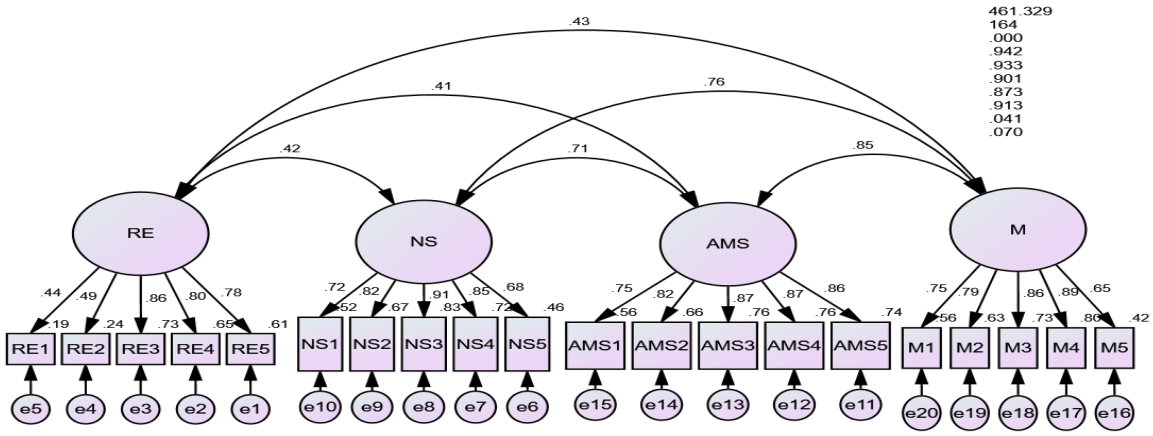

Figure 2. The proposed model for the scale's of scientific sense (Cognitive Dimensions).

Figure 3 shows the scale with its emotion dimensions:

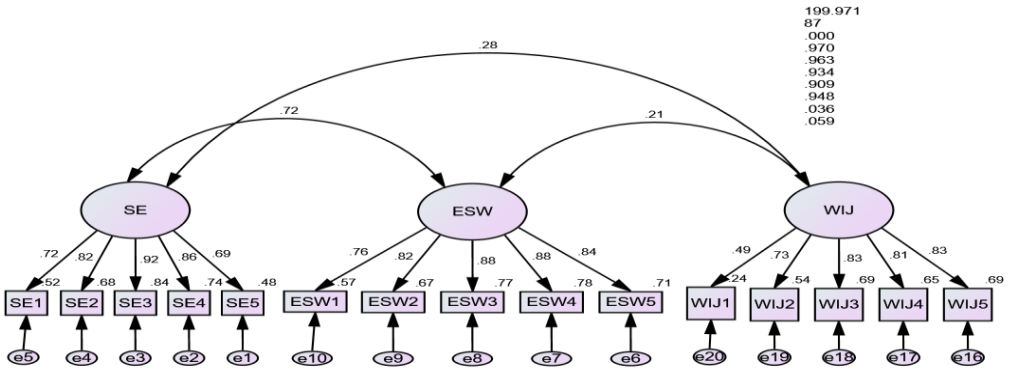

Figure 3. The proposed model for the scale's of scientific sense (Emotion Dimensions).

Table 2 shows the results of the estimates of the coefficients of the model and the statistical significance:

Table 2. Estimates of the coefficients of the confirmatory factor analysis Model and the statistical significance.

Dimension	Factor	Number of item	Estimate	S.E.	C.R.	Standard Estimate	P-value
	Requesting experiences to be used in new situations.	RE5	1.000			0.781	
		RE4	1.115	0.071	15.700	0.803	***
		RE3	1.089	0.066	16.520	0.857	***
		RE2	0.562	0.062	9.068	0.485	***
Cognitive		RE1	0.771	0.095	8.130	0.438	***
	Numerical sense.	NS5	1.000			0.682	
		NS4	1.523	0.102	14.916	0.851	***
		NS3	1.327	0.084	15.752	0.911	***
		NS2	1.205	0.083	14.449	0.82	***
		NS1	1.179	0.092	12.850	0.72	***
	Activation of the majority of the senses.	AMS5	1.000			0.86	
		AMS4	1.178	0.053	22.394	0.871	***
		AMS3	1.030	0.046	22.501	0.873	***
		AMS2	1.213	0.061	19.948	0.815	***
		AMS1	0.997	0.057	17.453	0.75	***
	Metacognitive.	M5	1.000			0.648	
		M4	1.447	0.100	14.418	0.892	***
		M3	1.337	0.096	13.987	0.855	***
		M2	1.043	0.079	13.167	0.791	***
		M1	1.132	0.090	12.599	0.748	***
	Scientific Exploration.	SE1	1.000			0.693	
Emotional		SE2	1.518	0.099	15.384	0.858	***
		SE3	1.316	0.081	16.25	0.916	***
		SE4	1.19	0.08	14.829	0.824	***
		SE5	1.158	0.089	13.071	0.72	***
	Enjoying scientific work.	ESW1	1.000			0.844	
		ESW2	1.214	0.055	22.016	0.883	***
		ESW3	1.059	0.049	21.781	0.878	***

	ESW4	1.249	0.064	19.487	0.82	***
	ESW5	1.026	0.059	17.248	0.757	***
Waiting in issuing judgments.	WIJ1	1.000			0.831	
	WIJ2	1.248	0.072	17.393	0.807	***
	WIJ3	1.021	0.056	18.078	0.834	***
	WIJ4	0.742	0.048	15.327	0.732	***
	WIJ5	0.557	0.058	9.567	0.494	***

*** Statistical significance at (0.01 = α)

Table 2 shows the following results:

1. All factor coefficients in the scale were statistically significant at (0.01 = α), as well as the low standard error ratio for each item. This indicates that all the items of the factors according to the criterion of statistical significance should be retained in full because of their ability to explain the phenomenon studied.
2. On the other hand, according to the standard parameter of the item or its standard weight, it refers to the saturation of the item on the factor, so that the proportion explained in item (40%), the researchers notes that all the weights of the items were greater than the standard (40%).
3. All loading coefficients of the observed variables on the underlying factors were statistically significant at (0.01 = α), which indicates the importance of the observed variables in measuring the phenomenon of scientific sense.

It is noted from the results of the analysis that the scale of scientific sense has the acceptable psychometrics' characteristics.

To answer the second question: Do the dimensions of the developed scale's scientific sense fit the theoretical construction?

Table 3 shows the results of the fit indicators for the scale:

Table 3. Results of fit indicators for the scale.

The Indicator value	Indicator	The Scale
461.329	Cmin	
164	Df	
0.00	P	
0.942	CFI	Cognitive Dimension
0.933	TLI	
0.901	GFI	
0.873	AGFI	
0.913	NFI	
0.041	RMR	
0.070	RMSEA	
199.971	Cmin	
87	Df	
0.00	P	Emotional Dimension
0.970	CFI	
0.963	TLI	
0.934	GFI	
0.909	AGFI	
0.948	NFI	
0.036	RMR	
0.059	RMSEA	

Table 3 shows that the majority of the fit indicators are within the accepted standard. All standard weights of the items, which represent the loadings of the factors, have exceeded (50%). Therefore, the explained variance ratio of each of the five factors is an acceptable criterion that confirms the construction validity of the scientific sense.

In terms of estimating the reliability of the scale of the scientific sense, the internal consistency method of the items was used, employing the Alpha-Cronbach coefficient. Table 4 shows the results of the analysis:

Table 4. Values of reliability coefficients.

The value of reliability coefficient	The Scale
0.912	Requesting experiences to be used in new situations
0.901	Numerical sense
0.889	Activation of the majority of the senses
0.896	Metacognitive
0.932	**Cognitive Dimension**
0.911	Scientific Exploration
0.925	Enjoying scientific work
0.896	Waiting in issuing judgments
0.913	**Emotional Dimension**
0.896	**The scale of the scientific sense**

Table 4 shows the high values of reliability coefficients on the dimensions of the scale as well as on the total scale, indicating the high internal consistency of the items corresponding to this scale. These reliability coefficients are high and acceptable for the application of the scale. The high values of reliability coefficients may be due to the fact that these items are the corresponding items of the model and the theoretical construction of the scale of the scientific sense.

4. Conclusion and Recommendations

The scientific sense scale in the Middle East University is characterized by high psychometric characteristics and the presence of strong indicators that support the compatibility of the dimensions of the scientific sense scale with the theoretical construction.

The research was limited to the students of the Middle East University (MEU) in Jordan.

As it is mentioned in the previous results, the researcher recommends the following:

1. Using the final version of the scale's scientific sense.
2. The scale can be used for the purpose of scientific researches, or to study and interpret the phenomenon.
3. Using the scale to predict the scientific sense of student.
4. Utilizing the Confirmatory Factor Analysis (CFA) method to verify the validity of construction of other scales, which were constructed at the University.
5. Increasing the cultural awareness of science teachers on the topic of scientific sense.

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Appendix 1. A scale of scientific sense for students at Middle East University in Jordan

Dimension	Factor	#	Item	Very large	large	Medium	Low	very low
Cognitive	Requesting experiences to be used in new situations	1	Trying to extract meaning from an experience, moving forward, and then applying it.					
		2	Striving to link two different ideas.					
		3	Cautiously transferring experience and placing it in different aspects of life.					
		4	Being able to write procedural steps that allow flexibility in implementation					
		5	Being able to generate unique ideas.					
	Numerical sense	1	Cautiously understanding the relationships between numbers and mathematical operations.					
		2	Dealing with the numbers in a flexible manner.					
		3	Representing numbers in different ways and having flexibility in switching between one representation and another.					
		4	Making sure to fit the facts by confirming relationships between the numerical data.					
		5	Being able to distinguish between the different uses of numbers.					
	Activation of the majority of the senses.	1	Using the sensory pathways carefully and attentively to gather information.					
		2	Understanding the surroundings.					
		3	Estimating the voices and choosing the appropriate ones.					
		4	Using my senses more when judging things.					

		5	Possessing sensory dominance and multisensory integration					
	Metacognitive	1	Getting out of the realm of reality and the tangible to the scope of influence with the meaning.					
		2	Being able to synthesize facts into new structures.					
		3	Having a sophisticated spoken language.					
		4	Having a developed culture.					
		5	Recalling and reprocessing ideas.					
Emotional	Scientific Exploration	1	Preparing to learn and participate actively at the university.					
		2	Looking for an explanation of mysterious scientific matters					
		3	Make self-scientific experiments					
		4	Reading a lot of information on interesting topics					
		5	Trying to solve scientifically provoking questions.					
	Enjoying scientific work	1	Being interested in participating actively in the activities of the university.					
		2	Enjoying thinking about solving the questions in the different courses					
		3	Feeling a pleasure in conducting practical experiments					
		4	Enjoy up the cooperative learning in understanding lectures.					
		5	Helping colleagues in the implementation of scientific activities					
	Waiting in issuing judgments	1	Having patience while performing scientific activities to avoid errors					
		2	Trying many times to solve correctly the issues raised.					
		3	Trying hard to understand my lectures to reach the correct answer					
		4	Participating in the discussion of thought-provoking questions					
		5	Presenting the suggested ideas and information to reach the correct answer					